Jurnal Ilmiah
MEDIA GIZI Indonesia
Accredited by SINTA Indonesia (SINTA 2)
SK DITJEN RISBANG KEMENRISTEKDIKTI RI NO 3/E/KTP/2019
(National Nutrition Journal)

p-ISSN 1693-7228
e-ISSN 2540-8410

Vol. 17 | No. 1 | Page 1 – 105 | January 2022

https://doi.org/10.204736/mgi.v17i1.11–20

PENGEMBANGAN RUTF (*READY TO USE THERAPEUTIC FOOD*) BERBAHAN SEREALIA DAN KEDELAI BAGI BALITA MALNUTRISI AKUT BERAT

Product Development of RUTF (Ready to Use Therapeutic Food) Using Cereals and Soybean for Children with Severe Acute Malnutrition

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ABSTRAK

Malnutrisi akut pada kelompok usia balita masih menjadi masalah gizi serius di Indonesia. Sebanyak 10,4% balita di Indonesia mengalami malnutrisi akut dengan 3,5% diantaranya tergolong malnutrisi akut berat. RUTF (*Ready to Use Theurapetic Food*) merupakan makanan pemulihan yang sudah terbukti efektif menanggulangi masalah malnutrisi akut berat. Pemberian RUTF di Indonesia belum menyeluruh dan masih diperoleh secara *import*, sehingga perlu adanya inovasi dalam mengembangkan RUTF dengan memanfaatkan pangan lokal. Tujuan dari penelitian ini adalah mengembangkan dan menganalisis zat gizi produk pasta RUTF berbasis pangan lokal yang terdiri dari beras, jagung, kedelai dan tempe untuk menanggulangi masalah status gizi balita yang mengalami malnutrisi akut berat. Desain dari penelitian ini adalah eksperimental menggunakan Rancangan Acak Lengkap Faktorial dengan dua kali ulangan. Terdapat dua faktor perlakuan, yaitu jenis serealia dan jenis kacang. Masing-masing faktor terdiri dari dua taraf, yaitu beras dan jagung (Faktor A) serta kedelai dan tempe (Faktor B). Penelitian ini terdiri dari empat formula, yaitu A_1B_1 (beras-kedelai), A_2B_1 (jagung-kedelai), A_1B_2 (beras-tempe), A_2B_2 (jagung-tempe). Formula dengan perpaduan beras dan kedelai (A_1B_1) dipilih sebagai formula terbaik berdasarkan hasil organoleptik, kandungan protein dan daya cerna protein *in vitro*. Hasil analisis kimia pasta RUTF terpilih mengandung kadar air 1,87%, abu 2,80%, protein 14,35%, lemak 32,50%, karbohidrat 45,29%, energi 531 kkal, serat pangan 3,19%, Fe 13,99 mg/100 g, Ca 395,73 mg/100 g dan daya cerna protein *in vitro* 95,47%. Secara keseluruhan, nilai zat gizi formula terpilih telah memenuhi persyaratan yang direkomendasikan oleh WHO, sehingga produk ini dapat menjadi alternatif untuk mengatasi masalah manutrisi akut berat pada balita.

Kata kunci: kedelai, malnutrisi akut berat, RUTF, serealia, tempe

ABSTRACT

Acute malnutrition among children still become crucial problem for Indonesia. As many as 10.4% of children under five years in Indonesia experience acute malnutrition which 3.5% of them classified in severe acute malnutrition. RUTF (Ready to Use Therapeutic Food) is effective in tackling severe acute malnutrition problem, however RUTF is still obtained from imports. Thus, innovation by utilizing local product is needed. The study aimed was to develop and analyze RUTF paste using selected local crops i.e. rice, corn, soybeans and tempeh to overcome severe acute malnutrition problem. This experimental study used a randomized factorial design with two repetitions. Treatments used in this experiment consisted of two factors based on different types of cereal and bean. Each factor consists of two levels, namely rice and corn (Factor A) as well as soybean and tempeh (Factor B). Four formulas were obtained, which were A_1B_1 (rice-soybean), A_2B_1 (corn-soybean), A_1B_2 (rice-tempeh), A_2B_2 (corn-tempeh). Formula with mixture of rice and soybean was selected based on the sensory evaluation result, protein content and in vitro protein digestibility. The nutrient content analysis showed that the product contained 1.87% moisture, 2.80% ash, 14.35% protein, 32.50% fat, 45.29% carbohydrate, 531 kcal energy, 3.19% edible fiber, 13.99 mg/100 g Fe, 395.73 mg/100 g Ca and 95.47% in vitro protein digestibility. Overall, the nutrition values of selected RUTF have fulfilled the requirements by WHO, thus it could be concluded that RUTF paste using cereals and soybeans can become an alternative to overcome severe acute malnutrition problem in children under five years.

Keywords: *cereals, RUTF, severe acute malnutrition, soybean, tempeh*

 Received 21-06-2020, Accepted 31-08-2021, Published online 30-01-2022

PENDAHULUAN

Masalah kekurangan gizi pada kelompok umur balita masih menjadi masalah penting bagi Indonesia sebagai negara berkembang. Gizi memiliki kontribusi besar terhadap kualitas sumber daya manusia di masa mendatang, sehingga permasalahan gizi perlu diperhatikan sejak dini. Malnutrisi akut merupakan salah satu masalah kekurangan gizi serius yang masih banyak dialami oleh balita di Indonesia. Berdasarkan data Riset Kesehatan Dasar, sebanyak 10,4% balita di Indonesia mengalami malnutrisi akut dengan 3,5% diantaranya mengalami malnutrisi akut berat (Kementrian Kesehatan Republik Indonesia, 2018). Malnutrisi akut didefinisikan sebagai akibat dari penurunan asupan makanan atau kualitas diet dalam periode yang relatif singkat dan seringkali dihubungkan dengan penyebab patologis (Lenters *et al*., 2016). Anak yang mengalami malnutrisi akut sedang ditandai dengan nilai *z-score* -3SD≤BB/TB≤-2 SD, sementara anak yang megalami malnutrisi akut berat ditandai dengan nilai *z-score* BB/TB <-3SD (Kementrian Kesehatan Republik Indonesia, 2020).

Kejadian malnutrisi akut berat rentan terjadi pada anak usia 6–59 bulan. Anak yang mengalami kekurangan gizi pada masa pembentukan otak, yaitu saat seribu hari pertama kehidupan, akan menghambat perkembangan fungsi otak yang bersifat *irreversible* dan berdampak pada penurunan kemampuan intelektualnya (Martorell *et al*., 2010). Kejadian malnutrisi akut berat pada balita dapat bermanifestasi dalam jangka pendek maupun jangka panjang yang akan berdampak pada kemampuan fisik dan kesehatannya di masa mendatang (UNICEF, 2013). Dampak yang terjadi pada anak yang mengalami malnutrisi akut berat, diantaranya rentan terhadap penyakit, rendahnya kemampuan kognitif dan menurunnya fungsi kekebalan tubuh. Jika kondisi ini berlangsung lama dan tidak ditangani secara cepat dan tepat maka akan meningkatkan risiko terhadap kematian (WHO, 2010).

RUTF (*Ready to use Therapeutic Food*) merupakan makanan pemulihan yang dicanangkan oleh UNICEF untuk mengatasi masalah malnutrisi akut berat tanpa komplikasi. RUTF memiliki densitas energi tinggi yang berbentuk padat atau berupa pasta (semi padat) dan diperkaya dengan vitamin dan mineral. Beberapa penelitian telah membuktikan efektivitas RUTF dalam menurunkan kejadian malnutrisi akut pada balita. Penggunaan RUTF sebagai *home-based therapy* meningkatkan tingkat pemulihan dari 40–50% hingga 80–90% (Ciliberto *et al*., 2005; Linneman *et al*., 2007). Sejauh ini, pemberian RUTF sebagai makanan pemulihan malnutrisi akut berat belum menyeluruh dan masih diperoleh secara *import*. Oleh karena itu, perlu adanya inovasi dan pengembangan produk RUTF dengan memanfaatkan pangan lokal yang umum dikonsumsi oleh masyarakat Indonesia.

Beras, jagung, kedelai dan tempe merupakan pangan serealia dan kacang-kacangan yang dapat diproduksi di Indonesia, umum dikonsumsi sehari-hari, mudah didapat, serta harganya terjangkau. Beras dan jagung juga merupakan pangan sumber energi dengan kandungan karbohidrat yang unggul, yaitu sebesar 77,1 g/100 g pada beras dan 72 g/100 g pada jagung (Kemenkes RI, 2017; Suarni, 2011). Sementara kedelai dan tempe kaya akan sumber protein, yaitu masing-masing sebesar 40,4 g/100 g dan 20,8/100 g (Kemenkes RI, 2017). Perpaduan antara kedua bahan pangan tersebut dapat saling melengkapi profil asam amino yakni serealia yang memiliki asam amino pembatas berupa lisin dan kacang-kacangan memiliki asam amino pembatas berupa metionin. Anak yang mengalami malnutrisi akut membutuhkan asupan makanan yang mudah dicerna. Daya cerna protein pada keempat bahan pangan ini cukup tinggi, yaitu 88% pada beras, 87% pada jagung, 90% pada kedelai dan 99,3% pada tempe (FAO, 2018; Astawan *et al*., 2015).

Balita khususnya anak yang mengalami malnutrisi akut berat direkomendasikan untuk mengonsumsi makanan yang memiliki tekstur lembut dan lunak agar mempermudah proses mengunyah dan meringankan fungsi saluran cerna. Konsistensi RUTF sebaiknya berbentuk semi padat atau padat dan memiliki tekstur yang lembut (WHO, 2007). Pasta adalah campuran bahan yang memiliki konsistensi akhir semi padat (kental). Oleh karena itu, pengembangan RUTF berbentuk pasta (semi padat) dirasa cocok untuk dikembangkan bagi balita yang mengalami malnutrisi akut berat.

Tujuan dari penelitian ini yaitu mengembangkan produk pasta RUTF (*Ready to Use Therapeutic Food*) berbahan dasar beras,

jagung, kedelai dan tempe guna menanggulangi status gizi balita yang mengalami malnutrisi akut berat, serta menganalisis komposisi zat gizi dan daya cerna protein *in vitro*.

METODE

Desain, Waktu dan Tempat

Desain dari penelitian ini menggunakan Rancangan Acak Lengkap Faktorial dengan dua kali ulangan. Perlakuan yang diberikan dalam pembuatan produk pasta RUTF terdiri dari dua faktor, diantaranya Faktor A berupa perbedaan jenis serealia, meliputi tepung beras dan tepung jagung serta Faktor B berupa perbedaan jenis kacang-kacangan, meliputi tepung kedelai dan tepung tempe.

Penelitian ini dilakukan pada bulan Desember 2020 hingga April 2021. Pembuatan produk pasta RUTF dilakukan di Laboratorium Pengolahan dan Percobaan Makanan Gizi Masyarakat IPB, uji organoleptik dilakukan di Laboratorium Organoleptik Gizi Masyarakat IPB, analisis daya cerna protein dan proksimat meliputi kadar air, abu, protein, lemak dan karbohidrat dilakukan di Laboratorium Analisis Zat Gizi, Gizi Masyarakat IPB, kandungan mineral zat besi dan kalsium dilakukan di Laboratorium Nutrisi Ternak Perah, Departemen. Ilmu Nutrisi dan Teknologi Pakan IPB, serta analisis aktivitas air dan serat pangan total dilakukan dilakukan Laboratorium Saraswanti Indo Genetech Bogor.

Bahan dan Alat

Bahan yang digunakan dalam pembuatan pasta RUTF, diantaranya tepung beras atau tepung jagung, tepung kedelai atau tepung tempe, susu skim, minyak kelapa, gula halus serta *premix* vitamin dan mineral. Sementara alat yang diperlukan dalam pembuatan pasta RUTF, meliputi timbangan, wajan, spatula kayu, spatula plastik, ayakan, *mixer*, *blender*, baskom, sendok, wadah plastik, *metalized plastic*.

Tahapan Penelitian

Tahapan penelitian diawali dengan penentuan formula dan pembuatan pasta RUTF. Uji organoleptik serta analisis protein dan daya cerna protein *in vitro* dilakukan pada setiap formula pasta RUTF untuk menentukan formula terpilih. Selanjutnya dilakukan analisis kandungan gizi lainnya pada formula pasta RUTF terpilih yang terdiri dari proksimat, serat pangan, Fe, Ca, dan aktivitas air.

Formulasi produk pasta RUTF ditentukan berdasarkan beberapa pertimbangan, yaitu perhitungan estimasi skor asam amino pada tiap formula yang dapat mendekati atau mencapai skor 100 serta perhitungan zat gizi pada tiap formula yang dapat memenuhi rekomendasi kandungan RUTF per 100 g sesuai acuan WHO (2007) dengan kandungan protein yang berasal dari susu minimal sebesar 50%. Terdapat empat formula yang diperoleh pada penelitian ini, yaitu A_1B_1 (beras-kedelai), A_2B_1 (jagung-kedelai), A_1B_2 (beras-tempe), A_2B_2 (jagung-tempe). Formulasi produk pasta RUTF disajikan pada Tabel 1.

Pembuatan pasta RUTF diawali dengan proses penyangraian. Masing-masing tepung disangrai hingga mencapai suhu 115–120°C. Menurut Agume (2017), penyangraian dengan suhu 110°C dapat menurunkan kadar fitat dan tannin secara

Tabel 1. Formulasi Produk Pasta RUTF

Bahan	Satuan	A_1B_1	A_2B_1	A_1B_2	A_2B_2
Tepung beras	g	17	0	20	0
Tepung jagung	g	0	17	0	20
Tepung kedelai	g	11,5	11,5	0	0
Tepung tempe	g	0	0	8,5	8,5
Susu skim	g	24	24	24	24
Minyak kelapa	g	32	32	32	32
Gula halus	g	14	14	14	14
Vitamin mineral mix	g	0,75	0,75	0,75	0,75
Total	g	99,25	99,25	99,25	99,25

Keterangan:
A_1B_1= beras, kedelai; A_2B_1= jagung, kedelai; A_1B_2= beras, tempe; A_2B_2= jagung, tempe

signifikan. Terdapat modifikasi penambahan suhu sangrai menjadi 115°C pada tepung beras, jagung dan tempe serta 120°C pada tepung kedelai. Hal tersebut dilakukan karena rasa tepung yang masih mentah dan langu saat disangrai pada suhu 110°C.

Proses penyangraian bertujuan untuk mengurangi aroma langu dan meningkatkan kualitas sensori produk. Selanjutnya pencampuran bahan mengunakan *blender* secara bertahap dimulai dari tepung serealia dan kacang-kacangan, lalu susu dan gula halus, kemudian minyak kelapa. Selanjutnya adonan pasta dihomogenisasi kembali menggunakan *mixer* bersamaan dengan penambahan *premix* vitamin dan mineral. Proses homogenisasi dengan *mixer* dilakukan dengan kecepatan rendah-sedang agar adonan tidak menjadi encer dan meminimalisir jumlah udara yang terangkap pada adonan pasta.

Uji Organoleptik

Uji organoleptik yang dilakukan pada penelitian ini berupa uji hedonik. Uji ini dilakukan untuk mengetahui tingkat kesukaan panelis terhadap produk yang disajikan, yakni pasta RUTF. Panelis yang terlibat dalam uji hedonik merupakan panelis semi terlatih dengan jumlah 30 orang yang sebelumnya telah menandatangani *inform consent* sebagai persetujuan. Penilaian uji hedonik menggunakan metode 10 cm *Hybrid Hedonik Scale,* yaitu menyajikan garis sepanjang 10 cm di setiap atribut dan memberikan keterangan pada ujung garis dengan skala yang paling ekstrem, yaitu sangat tidak suka hingga sangat suka. Panelis yang memberi nilai ≥5 memiliki makna panelis menyukai atau menerima produk (Villanueva *et al*., 2005).

Penentuan Formula Terpilih Produk

Penentuan formula terpilih didasarkan pada beberapa pertimbangan, diantaranya hasil uji hedonik, kandungan protein dan daya cerna protein *in vitro*. Penilaian analisis sensori merupakan aspek terpenting dalam pengembangan produk (Setyaningsih *et al*., 2010). Kandungan dan kualitas protein dalam diet juga merupakan parameter penting dalam perawatan anak yang mengalami malnutrisi. Jika kandungan dan kualitas protein rendah maka akan membatasi proses pertumbuhan dan pemulihan (Michaelsen *et al*., 2009).

Dari ketiga parameter tersebut, formula terpilih ditentukan berdasarkan hasil signifikansi uji statistik. Hasil organoleptik dijadikan sebagai pertimbangan utama, kemudian diikuti oleh daya cerna protein dan kandungan protein. Jika hasil organoleptik memberikan perbedaan yang signifikan pada keempat formula, maka dapat dipilih formula yang berbeda nyata (p<0,05) lebih tinggi dari formula yang lainnya. Begitupun juga dengan kandungan protein dan daya cerna protein. Namun, jika ketiga parameter tersebut tidak ada yang signifikan maka dapat dipilih dari nilai yang paling tinggi.

Analisis Sifat Kimia

Analisis kimia pada pasta RUTF, terdiri atas kadar air metode oven (SNI 01-2891-1992), kadar abu metode gravimetri (SNI 01-2891-1992), kadar lemak metode soxhlet (SNI 01-2891-1992), kadar protein metode mikro kjeldahl (SNI 01-2891-1992), kadar karbohidrat metode *available by difference* (Charrondiere et al., 2004), kadar serat pangan metode enzimatis gravimetri (AOAC, Official Method 991.43), kadar Fe dan Ca metode *Atomic Absorption Spectrophotometry* (ASS) (Nielsen, 2009), dan daya cerna protein *in vitro* (Saunders et al., 1973).

Analisis Data

Data hasil analisis kimia ditabulasikan dan diolah menggunakan Microsoft Excel 2016 dan SPSS 25.0 *for windows*. Data hasil uji hedonik, kandungan protein dan daya cerna protein *in vitro* dianalisis menggunakan uji *two-way* ANOVA dan diuji lanjut dengan Duncan (melalui *one-way* ANOVA) jika terdapat perbedaan signifikan dari interaksi kedua perlakuan (p<0,05), sementara hasil analisis sifat kimia pada formula terpilih disajikan dalam bentuk rata-rata.

HASIL DAN PEMBAHASAN

Analisis Sensori dan Kandungan Gizi untuk Menentukan Formula Terpilih

Data tingkat kesukaan berupa hasil uji hedonik disajikan pada Tabel 2. Uji hedonik dijadikan sebagai pertimbangan utama dalam menentukan

formula terpilih. Menurut Setyaningsih *et al*., (2010), selera manusia sangat menentukan penilaian dan penerimaan makanan. Atribut yang dinilai dalam uji hedonik, diantaranya warna, aroma, rasa, tekstur dan keseluruhan. Secara keseluruhan, pada setiap formula menunjukkan skor tingkat kesukaan ≥5 di setiap atribut, artinya sebagian besar panelis cenderung menyukai produk pasta RUTF dari semua aspek penilaian.

Berdasarkan hasil uji hedonik pada atribut warna, nilai rata-rata kesukaan berkisar 6,05–7,47, artinya sebagian besar panelis cenderung suka terhadap warna keempat formula pasta RUTF. Hasil uji *two-way* ANOVA menujukan terdapat adanya pengaruh nyata (p<0,05) dari faktor B (jenis kacang) terhadap tingkat kesukaan warna produk pasta RUTF, dimana tingkat kesukaan warna pada formula yang menggunakan kacang kedelai lebih tinggi secara nyata (p<0,05) dibandingkan dengan formula yang menggunakan tempe.

Tingkat kesukaan pada atribut aroma menunjukkan adanya pengaruh nyata (p<0,05) dari faktor B (jenis kacang), dimana tingkat kesukaan aroma pada formula dengan kacang kedelai lebih tinggi secara nyata dibandingkan dengan formula yang menggunakan tempe (p<0,05). Hasil perbedaan yang signifikan pada faktor jenis kacang terhadap tingkat kesukaan aroma produk pasta RUTF diduga disebabkan oleh aroma langu pada tepung tempe lebih kuat dibandingkan tepung kedelai. Menurut Kustyawati *et al*., (2017), sebagian besar makanan fermentasi berbahan dasar kedelai menghasilkan aroma langu. Aroma tersebut berasal dari campuran senyawa volatil, seperti methyl-1-butanol, hexanal, 2,4-decadienal, dimethyl disulfide yang dihasilkan selama proses fermentasi kedelai. Terlepas dari itu, hasil skor uji hedonik menunjukkan bahwa sebagian besar panelis cenderung suka terhadap aroma keempat formula pasta RUTF, yaitu dengan skor 6,52–7,28.

Rasa seringkali menjadi parameter utama yang menentukan konsumen untuk memilih dan mengonsumsi suatu produk. Nilai rata-rata tingkat kesukaan panelis terhadap atribut rasa berkisar 5,43–7,94, artinya sebagian besar panelis cenderung suka terhadap rasa keempat formula pasta RUTF. Hasil *two-way* ANOVA menujukan adanya pengaruh nyata (p<0,05) dari interaksi antara perlakuan jenis serealia dan jenis kacang terhadap tingkat kesukaan rasa. Berdasarkan hasil uji lanjut *Duncan*, formula A_1B_1 memiliki tingkat kesukaan rasa yang lebih tinggi secara nyata (p<0,05) dibandingkan dengan A_2B_2 dan A_1B_1, Selain itu, jenis kacang juga turut mempengaruhi secara nyata (p<0,05) terhadap perbedaan tingkat kesukaan rasa, dimana tingkat kesukaan rasa pada formula yang menggunakan kacang kedelai lebih tinggi secara nyata (p<0,05) dibandingkan dengan formula yang menggunakan tempe. Perbedaan yang signifikan pada faktor jenis kacang diduga disebabkan oleh adanya *aftertaste* (rasa pahit) yang lebih kuat pada formula yang menggunakan tepung tempe.

Menurut Kustyawati *et al*., (2017), rasa pahit pada tempe dapat berasal dari asam amino yang dihasilkan dari reaksi proteolitik selama proses fermentasi. Beberapa asam amino yang menimbulkan rasa pahit, diantaranya lisin, arginin, fenilalanin dan leusin. Tingkat kesukaan tekstur pasta RUTF tidak menunjukkan adanya pengaruh yang signifikan (p>0,05) baik dari interaksi kedua perlakuan maupun dari masing-masing perlakuan. Skor tingkat kesukaan pada atribut tekstur berkisar

Tabel 2. Tingkat Kesukaan Pasta RUTF

Formula	Warna	Aroma	Rasa**	Tekstur*	Keseluruhan
A_1B_1	7,47±1,53^{Aa}	7,28±1,65^{Aa}	7,94±1,47^{a}	6,34±2,11^{a}	7,35±1,47^{Aa}
A_2B_1	7,25±1,50^{Aa}	7,04±1,48^{Aa}	7,59±1,33^{ab}	6,95±1,63^{a}	7,08±1,35 ^{Aa}
A_1B_2	6,05±2,41^{Ab}	5,76±1,73^{Ab}	5,43±2,04^{c}	6,42±1,43 ^{a}	6,00±1,56 ^{Ab}
A_2B_2	7,12±1,73^{Ab}	6,52±1,77^{Ab}	6,86±2,32^{b}	7,11±2,10 ^{a}	6,85±1,77 ^{Ab}

Keterangan:
Huruf berbeda pada kolom yang sama menunjukkan perbedaan yang signifikan (p<0,05)
** Terdapat adanya interaksi perlakuan jenis serealia dan jenis kacang terhadap hasil uji hedonik
* Tidak terdapat perbedaan signifikan pada interaksi kedua perlakuan dan masing-masing perlakuan terhadap hasil uji hedonik
A-B faktor perlakuan jenis serealia, yaitu beras dan jagung (selain atribut rasa dan tekstur)
a-b Faktor perlakuan jenis kacang, yaitu kedelai dan tempe (selain atribut rasa dan tekstur
A_1B_1= beras, kedelai; A_2B_1= jagung, kedelai; A_1B_2= beras, tempe; A_2B_2= jagung, tempe

6,34 hingga 7,11, artinya sebagian besar panelis cenderung suka terhadap tekstur produk pasta RUTF.

Atribut keseluruhan merupakan kombinasi penilaian dari beberapa atribut, yaitu warna, aroma, rasa dan tekstur. Hasil skor uji hedonik pada atribut keseluruhan berkisar 6,00–7,35, artinya sebagian besar panelis cenderung suka terhadap produk pasta RUTF. Nilai skor tertinggi dari atribut keseluruhan terdapat pada formula A_1B_1. Hasil uji *two-way* ANOVA menunjukkan adanya pengaruh nyata (p<0,05) dari faktor B (jenis kacang) terhadap perbedaan tingkat kesukaan pada atribut keseluruhan. Kondisi ini menunjukkan bahwa secara keseluruhan formula yang menggunakan kedelai memiliki tingkat kesukaan yang lebih tinggi dari formula yang menggunakan tempe.

Kandungan dan daya cerna protein *in vitro* pasta RUTF disajikan pada Tabel 3. Protein merupakan komponen penting dalam makanan pemulihan. Protein pada makanan berkontribusi dalam memenuhi kebutuhan gizi melalui penyediaan nitrogen dan asam amino. Pada anak malnutrisi akut berat, protein tidak hanya dibutuhkan untuk menunjang pertumbuhan, melainkan juga untuk pemeliharaan (FAO/WHO/UNU, 2007). Kandungan protein pada keempat formula berkisar 14,35–14,78%. Nilai tersebut telah memenuhi rekomendasi kandungan protein RUTF yang ditetapkan oleh WHO (2007), yaitu 13-16,5 g/100 g. Berdasarkan hasil uji *two-way* ANOVA, baik interaksi kedua perlakuan maupun masing-masing perlakukan yang diberikan tidak memberikan perbedaan yang signifikan (p>0,05) terhadap kandungan protein pada keempat formula.

Tabel 3. Kandungan dan Daya Cerna Protein *In Vitro* Pasta RUTF

Formula	% Kadar protein	% Daya cerna protein *in vitro*
A_1B_1	14,35±0,04 ^{Aa}	95,47±0,16 ^{Aa}
A_2B_1	14,64±0,20 ^{Aa}	94,48±0,63 ^{Aa}
A_1B_2	14,64±0,20 ^{Aa}	93,32±1,53 ^{Ab}
A_2B_2	14,78±0,68 ^{Aa}	90,72±1,84 ^{Ab}

Keterangan:
Huruf berbeda pada kolom yang sama menunjukkan perbedaan yang signifikan (p<0,05)
A-B Faktor A (perbedaan jenis serealia)
a-b Faktor B (perbedaan jenis kacang)

Daya cerna protein merupakan salah satu faktor yang menentukan kualitas protein. Pemanfaatan protein oleh tubuh salah satunya dipengaruhi oleh seberapa besar kemampuan protein dalam makanan dapat cerna oleh enzim-enzim proteolitik. Besarnya nilai daya cerna protein dapat mengestimasi ketersediaan protein yang dapat diabsorbsi oleh usus (Ketnawa & Ogawa, 2019). Anak yang mengalami malnutrisi akut berat seringkali mengalami gangguan fungsi saluran cerna, sehingga membutuhkan asupan zat gizi yang mudah dicerna dan diserap oleh tubuh. Kualitas protein menjadi salah satu aspek yang perlu diperhatikan dalam mengembangkan RUTF, sehingga dalam menentukan bahan baku, daya cerna protein suatu pangan perlu dipertimbangkan (Michaelsen *et al*., 2009).

Bahan-bahan yang digunakan dalam penelitian ini, seperti tepung beras, tepung jagung, tepung kedelai dan tepung tempe memiliki daya cerna yang cukup baik, yaitu >80%. Hal tersebut sejalan dengan hasil analisis daya cerna protein *in vitro* pasta RUTF pada keempat formula, yaitu berkisar 90,72–95,47%. Menurut Sediaoetama (1991), nilai daya cerna protein yang tinggi berkisar ≥80%, artinya daya cerna protein pasta RUTF pada penelitian ini tergolong tinggi. Hasil uji *two-way* ANOVA menunjukkan terdapat perbedaan signifikan pada daya cerna protein yang disebabkan oleh jenis kacang, dimana formula A_1B_1 dan A_2B_1 lebih tinggi secara nyata dibandingkan A_1B_2 dan A_2B_2.

Formula dengan tepung kedelai memiliki daya cerna protein yang lebih tinggi dari formula dengan tepung tempe. Hal ini dapat disebabkan oleh adanya proses pemanasan pada kedelai saat pembuatan tepung dan penyangraian sebelum diolah menjadi pasta RUTF. Proses penyangraian ini dapat menurunkan zat antigizi yang dapat menghambat daya cerna protein. Zat antigizi seperti fitat dan tannin secara signifikan menurun setelah kedelai disangrai pada suhu 110°C selama 10 menit (Agume *et al*., 2017). Selain itu, denaturasi protein juga dapat terjadi akibat proses pemanasan. Hal ini menyebabkan terbukanya struktur protein sehingga lebih mudah dihidrolisis oleh enzim proteolitik. Namun denaturasi protein dapat memberikan efek positif dan negatif, hal ini bergantung pada intensitas pemanasan (Salazar-Villanea *et al*., 2016).

Pada tepung tempe, frekuensi perlakuan pemanasan lebih banyak dibandingkan tepung kedelai, yaitu saat perebusan pada proses pembuatan tempe, pengukusan sebelum tempe ditepungkan, pengovenan saat pembuatan tepung dan penyangraian pada tepung sebelum diolah menjadi pasta RUTF. Proses pemanasan dapat mendenaturasi protein sehingga lebih mudah dihidrolisis oleh enzim pencernaan, namun jika perlakuan pemanasan dilakukan secara berulang maka dapat terjadi denaturasi protein lebih lanjut yang menyebabkan struktur protein menjadi kurang responsif terhadap enzim proteolitik (Salazar-Villanea *et al*., 2016). Namun terlepas dari itu, daya cerna protein pada keempat formula RUTF baik yang menggunakan tepung kedelai maupun tepung tempe masih tergolong tinggi.

Berdasarkan hasil uji hedonik, kandungan dan daya cerna protein, secara keseluruhan formula A_1B_1 memiliki nilai paling tinggi dan juga secara statistik berbeda signifikan lebih tinggi dari A_1B_2 dan A_2B_2. Oleh karena itu, formula dengan perpaduan beras dan kedelai (A_1B_1) dipilih sebagai formula terbaik pada produk pasta RUTF.

Sifat Kimia Formula Terpilih

Kandungan gizi pasta RUTF terpilih disajikan pada Tabel 4. Hasil analisis sifat kimia pada formula A_1B_1 telah memenuhi standar zat gizi RUTF yang direkomendasikan oleh WHO (2007). Kadar dan aktivitas air (a_w) merupakan parameter penting yang perlu diperhatikan dalam pembuatan RUTF. Kedua komponen ini memiliki pengaruh terhadap stabilitas dan umur simpan produk. Kadar air dan aktivitas air yang direkomendasikan pada produk RUTF sangat rendah, yaitu maksimal 2,5% pada kadar air dan 0,2–0,45 a_w pada aktivitas air. Kadar air dan aktivitas air yang terkandung dalam formula A_1B_1, yaitu 1,87% dan 0,266 a_w. Rendahnya kadar air pada produk RUTF bertujuan untuk meminimalisir pertumbuhan bakteri agar aman dikonsumsi oleh anak malnutrisi akut yang rentan terhadap penyakit infeksi. Selain itu, densitas dan kandungan energi tinggi dapat dicapai pada pangan yang mengandung kadar air rendah.

Kadar abu diasumsikan sebagai jumlah mineral yang terkandung dalam bahan pangan, sehingga nilai kadar abu dapat menggambarkan penentuan kadar mineral total. Semakin tinggi kadar abu dalam suatu pangan, maka semakin banyak jumlah mineral yang terkandung dalam pangan tersebut (Andarwulan *et al*., 2011). Kadar abu yang terkandung pada formula A_1B_1 yaitu 2,80%.

Lemak merupakan sumber energi yang penting untuk bayi dan balita. Anak yang mengalami malnutrisi akut berat mengalami peningkatan kebutuhan energi untuk *catch-up growth*, sehingga memerlukan diet yang memiliki densitas energi tinggi (FAO, 2018). Tingginya densitas energi pada RUTF dapat dipenuhi oleh penggunaan pangan sumber lemak. Kandungan lemak pasta RUTF formula A_1B_1 yaitu 32,5%. Nilai tersebut telah memenuhi kandungan lemak

Tabel 4. Kandungan Gizi Formula Terpilih (A_1B_1)

Kandungan gizi	Satuan	Total (bb)	Rekomendasi WHO (2007)*, FAO (2019)**
Air	%	1,87±0,09	Maks. 2,5 (%)*
Water activity	a_w	0,266±0,74	0,2-0,45 a_w**
Abu	%	2,80±0,02	-
Protein	%	14,35±0,04	13-16,5%*
Lemak	%	32,50±0,38	26-37 %*
Karbohidrat	%	45,29±0,39	-
Energi	kkal/100 g	531±1,71	520-550 kkal/100 g*
Serat pangan	%	3,19±0,11	<5 g/100 g*
Zat besi (Fe)	mg/100 g	13,99±0,14	10-14 mg/100 g*
Kalsium (Ca)	mg/100 g	395,73±1,61	300-600 mg/100 g*
Daya cerna protein *in vitro*	%	95,47±0,16	-

Keterangan:
bb: basis basah

yang direkomendasikan oleh WHO (2007), yaitu berkisar 26–37%. Sumber lemak pada pasta RUTF berasal dari minyak kelapa. Pemilihan minyak kelapa sebagai sumber lemak memiliki beberapa kelebihan, diantaranya mengandung asam lemak jenuh yang tinggi sehingga tidak mudah teroksidasi dan dapat menjaga stabilitas mutu produk lebih lama, memiliki sifat terapeutik yaitu mudah dicerna dan diserap oleh tubuh, serta tidak memberatkan saluran pencernaan, sehingga cocok untuk anak yang mengalami malnutrisi (Mikołajczak, 2017).

Karbohidrat dalam produk RUTF menyeimbangkan kandungan protein dan lemak dalam mencapai kandungan energi yang tinggi (FAO, 2019). Karbohidrat yang terkandung dalam formula A_1B_1, sebesar 45,29%. Sumber karbohidrat pada formula ini berasal dari tepung beras, gula dan susu skim. Kandungan pati dalam karbohidrat mempengaruhi viskositas pasta untuk membentuk tekstur semisolid.

Formula A_1B_1 mengandung energi sebesar 531 kkal/100 g atau setara dengan densitas energi sebesar 5,3 kkal/g. Nilai tersebut telah memenuhi rekomendasi WHO (2007), yaitu sebesar 520-550 kkal/100 g. Pada anak yang mengalami malnutrisi akut berat, energi dalam jumlah besar dari makanan dibutuhkan untuk mengejar ketertinggalan pertumbuhan dan mencapai target pertambahan berat badan sebesar 10 g/kgBB/hari (FAO, 2018). Kandungan energi tinggi diperoleh dari penggunaan jumlah minyak yang cukup banyak, yaitu 32% dalam satu formula. Selain itu, rendahnya kadar air berkontribusi terhadap peningkatan densitas energi.

Balita yang mengalami malnutrisi akut berat dianjurkan untuk mengonsumsi serat dalam jumlah rendah. Serat hanya direkomendasikan <5 g dalam 100 g RUTF. Hasil analisis serat pangan pada formula A_1B_1 yaitu 3,19%, sehingga nilai tersebut telah memenuhi standar yang direkomendasikan. Menurut Michaelsen *et al*. (2009), serat pangan dapat menimbulkan efek *bulky* (rasa kenyang) dan mempersingkat waktu transit pada saluran pencernaan, sehingga tidak dianjurkan untuk dikonsumsi dalam jumlah banyak oleh balita yang mengalami malnutrisi akut berat khususnya pada usia dibawah 2 tahun yang rentan mengalami masalah pencernaan.

Anak yang mengalami malnutrisi akut berat perlu memenuhi asupan zat gizi mikro untuk menanggulangi defisit dan menunjang proses pertumbuhan. Zat besi dan kalsium merupakan mineral yang memiliki peranan penting selama masa pertumbuhan, termasuk pada anak yang mengalami malnutrisi akut berat. Zat besi berperan sebagai prekursor untuk sintesis hemoglobin yang memobilisasi oksigen dan zat gizi penting ke seluruh jaringan tubuh (Takele *et al*., 2021). Menurut EFSA (2006), defisiensi zat besi pada masa pertumbuhan, khususnya saat periode kritis dapat menyebabkan gangguan perkembangan kognitif dan psikomotorik serta menurunnya fungsi kekebalan tubuh. Hasil analisis zat besi pasta RUTF pada A_1B_1, yaitu 13,99 mg/100 g. Nilai tersebut telah memenuhi standar zat besi yang direkomendasikan oleh WHO (2007), yaitu berkisar 10–14 mg/100 g. Sumber zat besi berasal dari penambahan *premix* vitamin mineral.

Kalsium merupakan jenis zat gizi tipe satu yang dibutuhkan dalam mineralisasi tulang, meliputi pembentukan dan pemeliharaan kesehatan tulang. Asupan kalsium dari makanan harus tersedia dalam jumlah yang cukup agar simpanan kalsium dalam tubuh dapat memenuhi kebutuhan selama masa pertumbuhan (Golden, 2009). Hasil analisis kadar kalsium pada formula A_1B_1 sebesar 395,73 mg/100 g. Nilai tersebut telah memenuhi rentang kalsium RUTF yang direkomendasikan oleh WHO (2007), yaitu 300–600 mg/100g. Sebagian besar kandungan kalsium diperoleh dari susu skim. Susu merupakan pangan sumber kalsium paling baik karena mudah dicerna dan diserap oleh tubuh. Selain itu, penyerapan kalsium dari susu tidak terganggu oleh adanya oksalat yang biasanya terdapat pada pangan nabati (European Food Safety Authority, 2006). Anak yang mengalami malnutrisi akut membutuhkan kalsium untuk menunjang kepadatan tulang dan mencegah terjadinya deformasi tulang akibat defisiensi kalsium (Golden, 2009).

SIMPULAN DAN SARAN

Formula dengan perpaduan tepung beras dan tepung kedelai dipilih sebagai formula terbaik berdasarkan hasil uji hedonik, kandungan protein

dan daya cerna protein. Secara keseluruhan, hasil analisis zat gizi formula terpilih telah memenuhi persyaratan RUTF yang direkomendasikan oleh WHO. Sebagai formula terpilih, formula dengan perpaduan tepung beras dan tepung kedelai berpotensi untuk dimanfaatkan sebagai alternatif produk RUTF yang sejauh ini masih *import*. Pemberian produk pada sasaran perlu dilakukan untuk mengetahui daya terima produk terhadap balita. Pada penelitian selanjutnya juga perlu menganalisis lebih lengkap zat gizi mikro sesuai persyaratan RUTF yang direkomendasikan WHO. Selain itu, diperlukannya penelitian lebih lanjut terkait kualitas protein secara *in vivo*.

DAFTAR PUSTAKA

Agume, A. S. N., Njintang, N. Y., & Mbofung, C. M. F. (2017). Effect of soaking and roasting on the physicochemical and pasting properties of soybean flour. *Foods*, *6*(2), 1–10. https://doi.org/10.3390/foods6020012.

Andarwulan N, Kusnandar F, H. D. (2011). *Analisis Pangan*. Dian Rakyat.

Astawan, M., Wresdiyati, T., & Saragih, A. M. (2015). Evaluasi mutu protein tepung tempe dan tepung kedelai rebus pada tikus percobaan evaluation of protein nutritional quality of tempe and boiled soybean flours by rats. *Jurnal Mutu Pangan : Indonesian Journal of Food Quality*, *2*(1), 11–17. http://journal.ipb.ac.id/index.php/jmpi/article/view/27865.

Charrondiere, U. R., Chevassus-Agnes, S., Marroni, S., & Burlingame, B. (2004). Impact of different macronutrient definitions and energy conversion factors on energy supply estimations. *Journal of Food Composition and Analysis*, *17*(3–4), 339–360. Https://doi.org/10.1016/j.jfca.2004.03.011

Ciliberto, M. A., Sandige, H., Ndekha, M. J., Ashorn, P., Briend, A., Ciliberto, H. M., & Manary, M. J. (2005). Comparison of home-based therapy with ready-to-use therapeutic food with standard therapy in the treatment of malnourished Malawian children: A controlled, clinical effectiveness trial. *American Journal of Clinical Nutrition*, *81*(4), 864–870. https://doi.org/10.1093/ajcn/81.4.864.

European Food Safety Authority (EFSA). (2006). *Tolerable upper intake level on vitamins and minerals*. European Food Safety Authority.

FAO. (2018). *Protein quality assessment in follow-up formula for young children and ready to use therapeutic foods* (Issue November). FAO.

FAO/WHO/UNU. (2007). *Protein And Amino Acid Requirements In Human Nutrition. Report of a joint WHO/FAO/UNU Expert Consultation*. WHO.

Food Agriculture Organization (FAO). (2019). *Joint FAO/WHO Food Standards Programme Codex Committee on Nutrition and Foods for Special Dietary Uses*. FAO.

Golden, M. H. (2009). Proposed recommended nutrient densities for moderately malnourished children. *Food and Nutrition Bulletin*, *30*(3 SUPPL. 1), S268–S342. https://doi.org/10.1177/15648265090303s302.

Kementrian Kesehatan Republik Indonesia. (2017). *Tabel Komposisi Pangan Indonesia*. Kemenkes RI.

Kementrian Kesehatan Republik Indonesia. (2018). *Riset Kesehatan Dasar*. Kemenkes RI.

Kementrian Kesehatan Republik Indonesia. (2020). *Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2020 Tentang Standar Antropometri Anak*. Kemenkes RI.

Ketnawa, S., & Ogawa, Y. (2019). Evaluation of protein digestibility of fermented soybeans and changes in biochemical characteristics of digested fractions. *Journal of Functional Foods*, *52*(July 2018), 640–647. https://doi.org/10.1016/j.jff.2018.11.046

Kustyawati, M. E., Nawansih, O., & Nurdjanah, S. (2017). Profile of aroma compounds and acceptability of modified tempeh. *International Food Research Journal*, *24*(2), 734–740.

Lenters L, Wazny K, B. Z. (2016). *Management of Severe and Moderate Acute Malnutrition in Children*. The World Bank.

Linneman, Z., Matilsky, D., Ndekha, M., Manary, M. J., Maleta, K., & Manary, M. J. (2007). A large-scale operational study of home-based therapy with ready-to-use therapeutic food in childhood malnutrition in Malawi. *Maternal and Child Nutrition*, *3*(3), 206–215. https://doi.org/10.1111/j.1740-8709.2007.00095.x

Martorell, R., Horta, B. L., Adair, L. S., Stein, A. D., Richter, L., Fall, C. H. D., Bhargava, S. K., Biswas, S. K. D., Perez, L., Barros, F. C., Victora, C. G., & Group, C. on H. O. R. in T. S. (2010). Weight gain in the first two years of life is an important predictor of schooling outcomes in pooled analyses from five birth cohorts from

low- and middle-income countries. *The Journal of Nutrition*, *140*(2), 348–354. https://doi.org/10.3945/jn.109.112300.(SES)

Michaelsen KF, Hoppe C, Roos N, Kaestel P, S. M. (2009). Choice of foods and ingredients for moderately malnourished children 6 months to 5 years of age. *Food and Nutrition Bulletin*, *30*(3), 5343–5403.

Mikołajczak N. (2017). Coconut oil in human diet – nutrition value and potential health benefits. *Journal of Education, Health and Sport*, *7*(9), 307–319. https://doi.org/http://ojs.ukw.edu.pl/index.php/johs/article/view/4887.

Nielsen SS. (2009). Food Analysis. In *Angewandte Chemie International Edition* (Vol. 6, Issue 11). Springer.

Salazar-Villanea, S., Hendriks, W. H., Bruininx, E. M. A. M., Gruppen, H., & Van Der Poel, A. F. B. (2016). Protein structural changes during processing of vegetable feed ingredients used in swine diets: Implications for nutritional value. *Nutrition Research Reviews*, *29*(1), 126–141. https://doi.org/10.1017/S0954422416000056

Saunders, R. M., Connor, M. A., Booth, A. N., Bickoff, E. M., & Kohler, G. O. (1973). Measurement of digestibility of alfalfa protein concentrates by in vivo and in vitro methods. *The Journal of Nutrition*, *103*(4), 530–535. https://doi.org/10.1093/jn/103.4.530.

Sediaoetama AD. (1991). *Ilmu Gizi untuk Mahasiswa dan Profesi Jilid 1*. Dian Rakyat.

Setyaningsih D, Apriyanto A, S. M. (2010). *Analisis Sensori untuk Industri Pangan dan Agro*. IPB Press.

Suarni, & Yasin, M. (2011). Jagung sebagai Sumber Pangan Fungsional. *Iptek Tanaman Pangan*, *6*(1), 41–56.

Takele, W. W., Baraki, A. G., Wolde, H. F., Desyibelew, H. D., Derseh, B. T., Dadi, A. F., Mekonnen, E. G., & Akalu, T. Y. (2021). Anemia and contributing factors in severely malnourished infants and children aged between 0 and 59 months admitted to the treatment centers of the Amhara Region, Ethiopia: a multicenter chart review study. *Anemia*, *2021*, 1–8. https://doi.org/10.1155/2021/6636043

United Nations Children's Fund (UNICEF). (2013). *Improving child nutrition: the achievable imperative for global progress*. UNICEF.

Villanueva, N. D. M., Petenate, A. J., & Da Silva, M. A. A. P. (2005). Performance of the hybrid hedonic scale as compared to the traditional hedonic, self-adjusting and ranking scales. *Food Quality and Preference*, *16*(8), 691–703. https://doi.org/10.1016/j.foodqual.2005.03.013

World Health Organization (WHO). (2010). *Nutrition Landscape Information System (NLIS) Country Profile Indicators*. World Health Organization.

PENGEMBANGAN PRODUK *READY TO USE THERAPEUTIC FOOD (RUTF)* BERBENTUK BAR BERBAHAN KACANG HIJAU, SEREALIA, DAN MINYAK NABATI

Development of Ready to Use Therapeutic Food (RUTF) Bar Product Made from Mungbean, Cereal, and Vegetable Oils

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ABSTRAK

Pemberian produk *RUTF* (*Ready to Use Therapeutic Food*) merupakan salah satu solusi untuk mengatasi malnutrisi akut berat pada balita. Penelitian ini bertujuan untuk mengembangkan dan menganalisis produk *RUTF* berbentuk *bar* dari kacang hijau, serealia, dan minyak nabati untuk balita malnutrisi akut berat. Penelitian ini menggunakan Rancangan Acak Lengkap Faktorial dengan dua faktor dan dua ulangan. Faktor tersebut terdiri dari faktor A (kombinasi penggunaan tepung kacang hijau dengan jenis serealia yaitu tepung beras atau tepung jagung), dan faktor B (minyak nabati yaitu minyak kelapa atau minyak kelapa sawit). Penentuan formula terpilih didasarkan pada uji organoleptik (uji hedonik) dan kandungan gizi produk (energi dan protein). Hasil analisis uji hedonik menunjukkan bahwa atribut warna, aroma, rasa tekstur dan keseluruhan produk tidak berbeda nyata antar formula dan semua formula cenderung disukai panelis. Perlakuan kombinasi penggunaan tepung kacang hijau dengan serealia berpengaruh secara signifikan terhadap kandungan protein sedangkan perlakuan penggunaan minyak nabati berpengaruh secara signifikan terhadap kandungan energi produk. Hasil penelitian menunjukkan bahwa formula yang dipilih adalah formula A1B1 (kombinasi penggunaan tepung kacang hijau dengan tepung beras dan minyak kelapa) yang mengandung energi 522 kkal, 3,42% kadar air, 2,32% kadar abu, 13,57% protein, 28,89% lemak, 51,81% karbohidrat, serat pangan 4,66%, zat besi 13,82 mg /100g, kalsium 348,24 mg/100g, daya cerna protein 94,93%, dan aktivitas air 0,21. Formula A1B1 memenuhi persyaratan standar produk *RUTF* untuk semua kandungan gizi dan aktivitas air kecuali kandungan air berdasarkan WHO (2007).

Kata kunci: kacang hijau, malnutrisi akut berat, minyak nabati, *RUTF,* serealia

ABSTRACT

Providing RUTF (Ready to use therapeutic food) product is one of the solution to overcome severe acute malnutrition in children under five years. The study aimed was to develop and analyze RUTF products in the form of bar made from mung bean, cereal, and vegetable oils for severe acute malnutrition children under five years. This study used a completely randomized factorial design (RALF) with two factors and two replications. The factors consisted of factor A (the combination of mung bean flour with the type of cereal namely rice flour or, cornflour), and factor B (vegetable oil namely coconut oil or palm oil). The determination of selected formula was based on organoleptic test and nutrient content of product (energy and protein). The results of the hedonic test analysis showed that the attributes of color, aroma, taste, texture and overall product were not significantly different between formulas and all formulas tended to be favored by panelists. The combination treatment using mung bean flour with cereals had a significant effect on the protein content, while the use of vegetable oil had a significant effect on the energy content of the product. The result of this study showed that the selected formula was A1B1 formula (the combination mung bean flour with rice flour and coconut oil) which contained 522 kcal energy; 3.42% moisture content; 2.32% ash content; 13.57% protein; 28.89% fat; 51.81% carbohydrate; 4.66% dietary fiber, 13.82 mg/100g iron, 348.24 mg/100g calcium, 94.93% protein digestibility and 0.21 water activity. Formula A1B1 has fulfilled the requirements of the standard RUTF product for all nutritional content and water activity except for the moisture content base on WHO (2007).

Keywords: *mung bean, severe acute malnutrition, vegetable oil, RUTF, cereal*

 Received 31-07-2020, Accepted 11-09-2021, Published online 30-01-2022

PENDAHULUAN

Indonesia merupakan salah satu negara berkembang yang memiliki masalah *triple burden malnutrition* yaitu masalah kurang gizi, kelebihan gizi dan defisiensi mikronutrien (UNICEF, 2020). Malnutrisi merupakan masalah gizi yang terjadi karena adanya ketidakseimbangan antara asupan dan kebutuhan gizi. Malnutrisi yang terjadi karena penurunan asupan zat gizi atau kualitas gizi dalam waktu yang relatif singkat dan disertai dengan penyebab patologis disebut malnutrisi akut. Malnutrisi yang terjadi karena penurunan asupan zat gizi dalam waktu yang relatif lama dan menyebabkan gangguan pertumbuhan sering disebut malnutrisi kronis contohnya *stunting* pada balita (Lenters *et al.,* 2016).

Malnutrisi akut terbagi menjadi dua yaitu malnutrisi akut sedang dan malnutrisi akut berat. Malnutrisi akut sedang ditandai dengan nilai z *score* BB/TB berada diantara -3SD dan −2SD atau lingkar lengan atas antara 115 dan 125 mm. Sedangkan malnutrisi akut berat ditandai dengan nilai z *score* BB/TB kurang dari −3 SD, atau lingkar lengan atas kurang dari 115 mm, dan ada atau tidak adanya edema bilateral (Lenters *et al.,* 2016). Sebanyak 10,2% balita di Indonesia pada tahun 2018 mengalami malnutrisi akut (malnutrisi akut sedang 6,7% dan malnutrisi akut berat 3,5%) (Kemenkes, 2018). Berdasarkan batas ambang masalah kesehatan masyarakat, masalah malnutrisi akut di Indonesia masih termasuk kategori serius yaitu berada pada rentang prevalensi 10–14% (WHO, 2010).

Apabila masalah malnutrisi akut ini tidak dapat diatasi dengan baik maka akan dapat menyebabkan dampak negatif pada balita diantaranya dapat meningkatkan risiko kematian, morbiditas dan kecacatan, lebih mudah terkena penyakit infeksi, penurunan psikomotor, dan penurunan kemampuan kognitif anak (NDPC, 2016; UNICEF, 2013). Salah satu upaya mengatasi masalah ini adalah pemberian *RUTF (Ready to use therapeutic food)* (Hendrixson *et al.,* 2020). *RUTF* merupakan produk padat energi yang diperkaya dengan zat gizi mikro yang diberikan kepada balita malnutrisi akut berat tanpa komplikasi atau tanpa penyakit penyerta (Miele *et al.,* 2020). Beberapa penelitian telah membuktikan produk *RUTF* dapat meningkatkan pemulihan malnutrisi akut berat tanpa komplikasi dari 25–50% menjadi 80–90% (Ciliberto *et al.,* 2005; Linneman *et al.,* 2007).

Pengembangan produk *RUTF* di dianjurkan menggunakan bahan pangan tinggi zat gizi, terjangkau, dapat diterima dan dianjurkan menggunakan bahan pangan lokal. Beberapa bahan pangan lokal yang berpotensi digunakan dalam pengembangan produk *RUTF* yaitu kacang hijau, serealia (beras, jagung), minyak nabati (minyak kelapa dan kelapa sawit).

Kacang hijau mengandung protein yang tinggi dan mudah dicerna serta mengandung mineral yang relatif tinggi, dapat mengurangi kejadian perut kembung, bersifat *hypoallergic,* serta tidak menimbulkan efek samping seperti diare pada balita (Dahiya *et al.,* 2014; Hou *et al.,* 2019; Yi-Shen *et al.,* 2018). Kacang hijau dikombinasikan dengan pangan serealia (beras dan jagung) dengan tujuan agar saling melengkapi profil asam amino produk. Kacang hijau mengandung rendah asam amino sulfur (metionin dan sistein) tetapi tinggi asam amino lisin sedangkan pangan serealia (beras dan jagung) mengandung tinggi asam amino sulfur (metionin dan sistein) dan rendah asam amino lisin sehingga apabila kacang hijau dikombinasikan dengan pangan serealia (beras dan jagung) maka dapat saling melengkapi profil asam amino (Yi-Shen *et al.,* 2018).

Beras mengandung karbohidrat yang tinggi, serta tinggi asam amino metionin dan sistein, serta bersifat mudah dicerna (Rohman *et al.,* 2014; Wu *et al.,* 2019). Beras mengandung asam amino lisin yang rendah tetapi jika dibandingkan dengan jenis pangan serealia yang lain, asam amino lisin pada beras lebih tinggi dan hal ini dapat dikombinasikan dengan kacang hijau agar profil asam amino menjadi lebih lengkap (Michaelsen *et al.,* 2009).

Selain beras, pangan serealia yang dapat dikombinasikan dengan kacang hijau adalah jagung. Jagung yang digunakan yaitu jagung kuning, tidak hanya mengandung karbohidrat sebagai sumber zat gizi, namun juga mengandung beta karoten atau provitamin A, serta mengandung tinggi asam amino metionin dan sistein yang apabila dikombinasikan dengan kacang hijau profil asam amino dapat saling melengkapi (Budiarti *et al.,* 2017; Shah *et al.,* 2016).

Minyak nabati yang digunakan adalah jenis minyak nabati yang mengandung tinggi energi

yaitu minyak kelapa dan minyak kelapa sawit. Selain mengandung tinggi energi, minyak kelapa juga memiliki sifat antimikroba, antijamur, antivirus dan antibakteri, serta mengandung tinggi asam laurat yang mudah diserap dan dicerna oleh tubuh dan tidak membebani saluran gastointestinal (Mikołajczak, 2017; Vala & Kapadiya, 2014). Minyak kelapa sawit selain mengandung tinggi energi, juga mengandung vitamin E, perkursor vitamin A dan membantu pemeliharaan jaringan dan mendorong pertumbuhan pada membran sel (Boateng *et al.,* 2016).

Menurut Sigh *et al.* (2018), jenis-jenis produk *RUTF* yang dikembangkan di dunia adalah *RUTF* pasta/krim, biskuit/*compress bar*, dan wafer pasta. Pengembangan produk pasta dan krim sudah banyak dikembangkan dan sudah ada dikembangkan di Indonesia, sedangkan untuk pengembangan produk wafer dan *RUTF compress bar* masih sedikit dikembangkan di dunia dan belum ada dikembangkan di Indonesia. Oleh karena itu pada penelitian ini saya mengembangkan produk *RUTF* berbentuk *bar/compress bar.* Keunggulan pengembangan dalam bentuk *bar* yaitu dapat dikonsumsi langsung, praktis, mudah hancur saat ditekan, dan memiliki umur simpan yang cukup lama (FAO, 2015).

Produk *RUTF* berbentuk *bar* ini tidak melalui proses pemanggangan menggunakan oven seperti produk *food bar* yang biasa dikembangkan di Indonesia akan tetapi beberapa bahan tertentu disangrai dan campuran semua bahan dilakukan pengepresan agar berbentuk *bar*. Tujuan penelitian ini adalah untuk mengembangkan dan menganalisis produk *Ready-to-Use Therapeutic Food (RUTF)* berbentuk *bar* berbahan kacang hijau, serealia, dan minyak nabati untuk balita malnutrisi akut berat.

METODE

Desain penelitian ini yaitu *experimental* menggunakan Rancangan Acak Lengkap Faktorial (RALF) dengan 2 faktor perlakuan dan 2 ulangan. Faktor perlakuan yang diberikan yaitu faktor A (kombinasi penggunaan tepung kacang hijau dengan serealia (tepung beras atau tepung jagung) dan faktor B (penggunaan minyak nabati (minyak kelapa atau minyak kelapa sawit). Penelitian dilakukan bulan Desember 2020 - Mei 2021 di Laboratorium Pengolahan dan Percobaan Makanan, Laboratorium Organoleptik, Laboratorium Kimia dan Analisis Makanan Departemen Gizi Masyarakat Fakultas Ekologi Manusia IPB University, Laboratorium Ilmu Nutrisi dan Ternak Perah Departemen Ilmu Nutrisi dan Teknologi Pakan Fakultas Peternakan IPB University, SEAFAST Center IPB University dan Laboratorium Saraswati Indo Genetech (SIG), Bogor.

Bahan pangan yang digunakan adalah tepung kacang hijau, tepung beras, tepung jagung, minyak kelapa, minyak kelapa sawit, susu bubuk *full cream*, gula halus, maltodekstrin dan *vitamin mineral mix*.

Penelitian ini terdiri dari beberapa tahapan yaitu formulasi, pembuatan *RUTF* berbentuk *bar*, uji organoleptik, analisis kandungan protein dan perhitungan energi semua formula, penentuan formula terpilih, serta analisis kandungan zat gizi (kadar air, abu, lemak, protein, karbohidrat, serat pangan, zat besi, kalsium), daya cerna protein, perhitungan energi dan analisis aktivitas air (a_w) formula terpilih. Formulasi produk dilakukan berdasarkan hasil modifikasi produk HEBI yaitu produk *RUTF* berbentuk *bar* yang dikembangkan di negara Vietnam untuk mengatasi masalah malnutrisi akut pada balita (Wieringa *et al.,* 2013).

Proses modifikasi dilakukan dengan mempertimbangkan kandungan gizi sesuai persyaratan standar produk *RUTF.* Menurut FAO (2019) dalam pengembangan produk *RUTF* dianjurkan kandungan asam amino pembatas produk mendekati skor 100 dan memiliki nilai PDCAAS *(Protein digestibility Corrected Amino Acid Score*) ≥ 90 sehingga dalam proses formulasi diperlukan perhitungan estimasi asam amino dan nilai PDCAAS sebagai pertimbangan agar memenuhi anjuran FAO. Selain itu, pada saat penentuan formulasi juga mempertimbangkan aspek organoleptik produk.

Kombinasi tepung kacang hijau dan serealia (tepung beras dan jagung) menyesuaikan dengan estimasi terpenuhinya kandungan zat gizi berdasarkan standar produk *RUTF* dan mempertimbangkan kandungan asam amino pembatas mendekati nilai 100, serta estimasi nilai PDCAAS mencapai ≥ 90. Oleh karena itu,

perbandingan kombinasi tepung kacang hijau dengan tepung beras sebesar 22.00 : 13,25 g sedangkan kombinasi tepung kacang hijau dan tepung jagung sebesar 21.00 : 14,25 g. Jumlah penggunaan minyak nabati (minyak kelapa dan kelapa sawit) sebanyak 22,5 gram dengan pertimbangan hasil estimasi perhitungan agar memenuhi standar kandungan gizi produk *RUTF* terutama kandungan energi dan lemak.

Protein yang berkualitas tinggi dapat didapatkan dengan formulasi *RUTF* mengandung minimal 50% protein susu dan penggunaannya meningkatkan daya cerna protein dan nilai PDCAAS (≥ 90) (FAO, 2019). Penggunaan susu sebesar 25–35% (Owino *et al.,* 2012). Penggunaan sumber protein hewani yang lebih tinggi lebih efektif meningkatkan pemulihan malnutrisi akut berat. Pada penelitian intervensi pemberian *RUTF* 25% susu lebih efektif dan memiliki kenaikan berat badan dan tinggi badan lebih tinggi dibandingkan pemberian *RUTF* 10% susu (Oakley *et al.,* 2010). Oleh karena itu penggunaan susu *full cream* pada penelitian ini sebesar 35 g (33,5% total formula). Jumlah penggunaan susu, gula halus, maltodekstrin, dan vitamin mineral mix juga mempertimbangkan estimasi pemenuhan kandungan gizi standar *RUTF* dan hasil organoleptik. Formulasi RUTF berbentuk bar disajikan pada Tabel 1.

Proses pembuatan *RUTF* berbentuk *bar* diawali dengan persiapan bahan pangan dan penyangraian tepung kacang hijau, tepung beras serta tepung jagung. Tepung kacang hijau disangrai ± 15 menit hingga mencapai suhu 130°C sedangkan tepung beras dan tepung jagung disangrai ± 10 menit hingga mencapai suhu 115°C dan selanjutnya masing-masing tepung diayak. Proses berikutnya adalah penimbangan bahan sesuai dengan berat setiap formula. Bahan-bahan kering seperti tepung kacang hijau, tepung beras atau jagung, gula halus, maltodekstrin, susu bubuk *full cream* dan vitamin mineral mix dicampur hingga rata. Tahapan selanjutnya campuran bahan kering dicampur hingga rata dengan minyak kelapa atau minyak kelapa sawit kemudian campuran bahan ditimbang sesuai standar porsi lalu dicetak dan dipress (tekanan 1 ton/cm^2 selama 1 menit). Setelah pengepresan, proses pembuatan produk *RUTF* berbentuk *bar* sudah selesai dan sudah dapat untuk dikonsumsi (Nga *et al.,* 2013).

Tahapan berikutnya semua formula dilakukan uji organoleptik menggunakan metode 10 cm *hybrid hedonic scale* yaitu skala garis linier yang menyajikan garis sepanjang 10 cm di setiap atribut dan memberikan keterangan skala yang paling ekstrim di setiap ujung garis. Metode ini memiliki beberapa keunggulan yaitu tidak terbatas pada sejumlah kategori sehingga panelis bebas menilai produk, menghindari kesalahan psikologis pada saat penilaian serta menghasilkan data kontinius sehingga analisis dapat dilakukan secara parametrik maupun nonparametrik (Villanueva *et al.,* 2005). Kegiatan uji ini dilakukan pada 30 orang panelis semi terlatih yaitu mahasiswa/i IPB University yang sudah mendapatkan materi mengenai organoleptik dan sudah pernah melakukan uji organoleptik. Selanjutnya semua formula dianalisis

Tabel 1. Formulasi *RUTF* Berbentuk *Bar*

Bahan	A1B1	A1B2	A2B1	A2B2
Tepung kacang hijau (g)	22,00	22,00	21,00	21,00
Tepung beras (g)	13,25	13,25	0,00	0,00
Tepung jagung (g)	0,00	0,00	14,25	14,25
Minyak kelapa (g)	22,50	0,00	22,50	0,00
Minyak kelapa sawit (g)	0,00	22,50	0,00	22,50
Susu bubuk *full cream* (g)	35,00	35,00	35,00	35,00
Gula halus (g)	1,00	1,00	1,00	1,00
Maltodekstrin (g)	10,00	10,00	10,00	10,00
Vitamin mineral mix (g)	0,75	0,75	0,75	0,75
Total	104,5	104,5	104,5	104,5

Keterangan: A1B1 (kombinasi tepung kacang hijau dengan tepung beras, penggunaan minyak kelapa), A1B2 (kombinasi tepung kacang hijau dengan tepung beras, penggunaan minyak kelapa sawit), A2B1 (kombinasi tepung kacang hijau dengan tepung jagung, penggunaan minyak kelapa), A2B2 (kombinasi tepung kacang hijau dengan tepung jagung, penggunaan minyak kelapa sawit).

kandungan protein (SNI 01-2891-1992) dan dihitung kandungan energinya (Winarno, 2008).

Penentuan formula terpilih ditentukan berdasarkan hasil signifikansi analisis statistik uji organoleptik berupa uji hedonik (atribut keseluruhan) semua formula sebagai pertimbangan utama, apabila hasil uji organoleptik tidak berbeda nyata maka pertimbangan berikutnya adalah hasil analisis kandungan energi dan protein semua formula.

Formula terpilih selanjutnya dilakukan analisis kadar air metode oven, kadar abu total, kadar protein metode kjeldhal dan kadar lemak metode soxhlet (SNI 01-2891-1992), kadar karbohidrat metode *by difference* (Andarwulan *et al.,* 2011), serat pangan metode enzimatis gravimetri (AOAC *Official Method* 991,43), kadar mineral (Fe dan Ca) metode AAS (*Atomic Absorption Spectrophotometer)* (AOAC, 2005; Nielsen, 2010), daya cerna protein metode *in vitro* (Saunders *et al.,* 1973), energi (Winarno, 2008) dan analisis aktivitas air (a_w) menggunakan Aw meter (AOAC *Official Method* 978.18).

Data penelitian diolah menggunakan *Microsoft Excel* 2016 dan SPSS 25.0 *for Windows.* Data uji organoleptik, kandungan energi dan protein dianalisis dengan menggunakan uji *Twoway* ANOVA. Hasil analisis kadar air, abu, lemak, protein, karbohidrat, energi, serat pangan, zat besi, kalsium, daya cerna protein dan aktivitas air (a_w) produk *RUTF* berbentuk *bar* formula terpilih disajikan dalam bentuk rata-rata.

HASIL DAN PEMBAHASAN

Analisis Uji Organoleptik dan Kandungan Gizi untuk Menentukan Formula Terpilih

Penentuan formula terpilih produk *RUTF* berbentuk *bar* ditentukan berdasarkan hasil signifikansi analisis statistik uji organoleptik berupa uji hedonik (atribut keseluruhan) sebagai pertimbangan utama. Analisis uji organoleptik yang dilakukan yaitu uji hedonik atau tingkat kesukaan terhadap produk dan menilai karakteristik produk. Hasil uji statistik pada Tabel 2 menunjukkan bahwa faktor A (kombinasi penggunaan tepung kacang hijau dengan jenis serealia), faktor B (penggunaan jenis minyak nabati), serta interaksi antar kedua faktor tidak berpengaruh secara signifikan ($p>0,05$) terhadap tingkat kesukaan panelis terhadap atribut warna, aroma, rasa, tekstur dan keseluruhan produk. Berdasarkan analisis statistik juga diketahui bahwa atribut warna, aroma, rasa, tekstur dan keseluruhan produk tidak berbeda nyata antar formula dan cenderung disukai oleh panelis.

Hasil uji organoleptik menunjukkan karakteristik warna produk pada formula dengan kombinasi tepung kacang hijau dengan beras dan menggunakan minyak nabati cenderung berwarna kuning keputihan sedangkan formula dengan kombinasi tepung kacang hijau dengan jagung dan menggunakan minyak nabati cenderung berwarna kuning muda. Selain itu, produk *RUTF bar* cenderung terasa manis, *creamy,* memiliki tekstur yang kompak, tidak terlalu keras dan

Tabel 2. Data Hasil Uji Organoleptik (Uji Hedonik), Kandungan Energi dan Protein *RUTF* Berbentuk *Bar*

Uji Organoleptik (Uji Hedonik), Kandungan Energi dan Protein	Formula ($\bar{x} \pm SD$)			
	A1B1	A1B2	A2B1	A2B2
Uji Organoleptik (Uji Hedonik)				
Warna*	$7,38 \pm 1,18^{a}$	$7,36 \pm 1,17^{a}$	$7,12 \pm 1,40^{a}$	$7,19 \pm 1,42^{a}$
Aroma*	$7,32 \pm 1,40^{a}$	$6,78 \pm 1,54^{a}$	$7,41 \pm 1,48^{a}$	$6,88 \pm 1,95^{a}$
Rasa*	$6,97 \pm 1,69^{a}$	$7,21 \pm 1,54^{a}$	$7,33 \pm 1,63^{a}$	$6,96 \pm 1,66^{a}$
Tekstur*	$6,72 \pm 1,85^{a}$	$7,10 \pm 1,44^{a}$	$6,74 \pm 1,86^{a}$	$6,30 \pm 1,98^{a}$
Keseluruhan*	$7,32 \pm 1,11^{a}$	$7,30 \pm 1,35^{a}$	$7,40 \pm 1,40^{a}$	$6,97 \pm 1,59^{a}$
Kandungan Energi dan Protein				
Protein	$13,57 \pm 0,23^{Aa}$	$13,60 \pm 0,16^{Aa}$	$13,28 \pm 0,04^{Ba}$	$13,26 \pm 0,06^{Ba}$
Energi	$522 \pm 0,37^{Aa}$	$520 \pm 0,17^{Ab}$	$522 \pm 0,27^{Aa}$	$520 \pm 0,36^{Ab}$

Keterangan: Huruf berbeda pada baris yang sama menunjukan perbedaan yang signifikan ($p<0.05$), * Tidak terdapat pengaruh yang signifikan pada interaksi antar perlakuan dan masing-masing perlakuan terhadap hasil analisis kandungan protein atau energi, $^{A-B}$ Faktor perlakuan kombinasi penggunaan tepung kacang hijau dengan jenis serealia yaitu tepung beras dan jagung (selain yang diberi tanda*), $^{a-b}$ Faktor perlakuan penggunaan jenis minyak nabati yaitu minyak kelapa dan minyak kelapa sawit (selain yang diberi tanda *)

mudah hancur saat ditekan, mudah untuk ditelan, *mouthfeel* cenderung halus serta aroma langu, rasa pahit dan *aftertaste* pahit cenderung sangat lemah. Produk *RUTF* untuk balita malnutrisi akut berat dianjurkan memiliki tekstur yang tidak keras, mudah hancur saat ditekan, memiliki *mouthfeel* yang halus, mudah untuk ditelan, memiliki rasa yang cenderung manis, tidak memiliki aroma langu atau aroma yang tidak menyenangkan. Berdasarkan uji organoleptik produk *RUTF* berbentuk *bar* ini sudah memenuhi anjuran tersebut.

Selain penentuan formula terpilih berdasarkan uji organoleptik, penentuan formula terpilih juga mempertimbangkan hasil analisis statistik kandungan energi dan protein. Kandungan energi dan protein dimasukkan dalam pertimbangan penentuan formula terpilih dikarenakan kandungan energi dan protein sangat penting untuk balita karena berperan dalam membantu pertumbuhan dan perkembangan balita serta membantu dalam metabolisme sistem kekebalan tubuh. Kandungan energi juga dapat membantu peningkatan berat badan balita termasuk pada balita malnutrisi akut berat (Diniyyah & Nindya, 2017; Dipasquale *et al.,* 2020). Hasil analisis kandungan energi dan protein disajikan pada Tabel 2.

Kandungan energi dan protein pada produk semua formula memenuhi standar produk *RUTF* berdasarkan WHO (2007) dan UNICEF (2019). Hasil uji statistik *two-way ANOVA* menunjukkan bahwa faktor A (kombinasi penggunaan tepung kacang hijau dengan jenis serealia) dan interaksi antara faktor A dan B tidak berpengaruh secara signifikan ($p>0,05$) terhadap kandungan energi sedangkan faktor B (penggunaan jenis minyak nabati) berpengaruh secara signifikan ($p<0,05$) terhadap kandungan energi produk. Hasil analisis juga menunjukkan kandungan energi formula yang dibuat dari minyak kelapa lebih tinggi secara nyata dibandingkan dengan minyak kelapa sawit. Hal ini disebabkan karena kandungan energi minyak kelapa lebih tinggi dibandingkan dengan minyak kelapa sawit. Kandungan energi per 100 mL yaitu minyak kelapa sawit sebesar 810 kkal sedangkan minyak kelapa sebesar 836 kkal.

Hasil uji statistik *two-way ANOVA* juga menunjukkan bahwa faktor B (penggunaan jenis minyak nabati) dan interaksi antara faktor A dan B tidak berpengaruh secara signifikan ($p>0,05$) terhadap kandungan protein sedangkan faktor A (kombinasi penggunaan tepung kacang hijau dengan jenis serealia) berpengaruh secara signifikan ($p<0,05$) terhadap kandungan protein produk. Hasil analisis juga menunjukkan formula produk yang dibuat dari kombinasi tepung kacang hijau dengan tepung beras lebih tinggi secara nyata dibandingkan dengan kombinasi tepung kacang hijau dan tepung jagung.

Hal ini disebabkan karena jumlah penggunaan tepung kacang hijau yang dikombinasikan dengan tepung beras sebanyak 22 gram dan jumlah ini lebih tinggi dibandingkan dengan jumlah tepung kacang hijau yang dikombinasikan dengan tepung jagung yaitu sebanyak 21 gram. Selain itu kandungan protein tepung kacang hijau lebih tinggi dibandingkan dengan tepung beras dan jagung sehingga ketika jumlah tepung kacang hijau yang digunakan lebih tinggi maka akan berkontribusi dalam meningkatkan kandungan protein produk. Kandungan protein per 100 gram bahan tepung kacang hijau, tepung beras dan tepung jagung pada penelitian ini secara berurut adalah sebesar 24,40 gram, 6.,26 gram dan 6,84 gram.

Berdasarkan pertimbangan hasil analisis statistik terhadap data uji organoleptik berupa uji hedonik (atribut keseluruhan), kandungan energi dan protein dari semua formula *RUTF* berbentuk *bar* diketahui bahwa formula A1B1 merupakan formula terpilih. Hal ini karena hasil analisis uji hedonik (keseluruhan) tidak menunjukkan perbedaan yang nyata pada semua formula, sehingga setiap formula memiliki peluang yang sama untuk dipilih sebagai formula terpilih dengan tahapan pertimbangan selanjutnya berdasarkan kandungan energi dan protein.

Hasil analisis statistik menunjukkan kandungan energi formula A1B1 tidak berbeda nyata dengan formula A2B1 akan tetapi berbeda nyata lebih tinggi dibandingkan dengan formula A1B2 dan A2B2. Kandungan protein formula A1B2 lebih tinggi dan tidak berbeda nyata dengan formula A1B1, akan tetapi berbeda nyata lebih tinggi dari formula A2B1 dan A2B2. Berdasarkan hasil analisis tersebut formula A1B1 mengandung energi dan protein yang tinggi dan dapat ditetapkan sebagai formula terpilih.

Kandungan zat gizi formula terpilih disajikan pada Tabel 3. Hasil analisis menunjukkan

Tabel 3. Kandungan Zat Gizi, Energi, Daya Cerna Protein dan Aktivitas Air Produk *RUTF* Berbentuk *Bar* Formula Terpilih

Kandungan Gizi	Formula Terpilih	Standar Umum *RUTF*	Standar *RUTF biscuit/compress bar****
Kadar air (%)	3,42 ± 0,06	Maksimal 2,5*	Maksimal 4
Kadar abu (%)	2,32 ± 0,01	-	Maksimal 5
Protein (%)	13,57 ± 0,23	12,8–16,2*	12,3–15,5
Lemak (%)	28,89 ± 0,04	25,8–36,3*	24,8–33,0
Karbohidrat (%)	51,81 ± 0,21	-	44,5–59,9
Energi (kkal)	522 ± 0,37	520–550*	Minimal 500 kkal
Serat pangan (%)	4,66 ± 0,33	<5,00*	< 5,00
Zat besi (mg/100g)	13,82 ± 0,01	10–14*	10–14
Kalsium (mg/100g)	348,24 ± 4,48	300–600*	300–600
Daya cerna protein (%)	94,93 ± 0,15	-	-
Aktivitas air (a_w)	0,21 ± 0,02	Maks. 0,6**	Maksimal 0,6

Keterangan : *WHO (2007), ** FAO (2020), *** UNICEF (2019), - Tidak tersedia

kadar abu, protein, lemak, karbohidrat, energi, serat pangan, zat besi, kalsium dan aktivitas air *RUTF* formula terpilih memenuhi persyaratan standar produk *RUTF* bentuk *biscuit/compress bar* (UNICEF, 2019) dan juga memenuhi standar umum semua kandungan gizi kecuali kadar air produk RUTF (WHO, 2007).

Kadar air merupakan komponen penting dalam produk pangan karena mempengaruhi pertumbuhan mikroorganisme. Kadar air yang rendah akan menurunkan pertumbuhan mikroorganisme dan meningkatkan densitas energi sehingga baik untuk balita malnutrisi akut berat (Michaelsen *et al.,* 2009). Kadar air produk formula terpilih lebih tinggi dibandingkan dengan produk *RUTF bar* (HEBI) penelitian sebelumnya yang memiliki kadar air 2,5% (Nga *et al.,* 2013) dan 2,4% (Wieringa *et al.,* 2013). Menurut Winarno (2008), ketika suatu produk makanan mengandung kadar air antara 3–7% masih tergolong cukup rendah dan dapat mengurangi terjadinya pertumbuhan mikroorganisme serta reaksi kimia yang dapat merusak produk. Selain itu, kadar air dapat mempengaruhi uji organoleptik produk seperti tekstur produk (Nurhusna *et al.,* 2020). Kadar air produk masih tergolong cukup rendah karena adanya proses penyangraian tepung kacang hijau dan tepung beras yang menyebabkan kadar air tepung menjadi berkurang.

Hasil analisis kadar abu formula terpilih adalah sebesar 2,32%. Kadar abu dapat mengasumsikan kadar mineral dalam produk makanan yang menunjukkan semakin tinggi kadar abu semakin tinggi kadar mineral produk (Andarwulan *et al.,* 2011). Protein dibutuhkan tubuh untuk struktur, fungsi,dan regulasi jaringan tubuh dan organ (Khan *et al.,* 2017). Menurut Diniyyah dan Nidya (2017), asupan protein pada balita sangat penting diperhatikan dan harus terpenuhi agar membantu proses pertumbuhan, perkembangan, serta membantu metabolisme kekebalan tubuh balita. Hasil analisis kadar protein sebesar 13,57%. Kadar protein produk formula terpilih pada penelitian ini lebih tinggi dibandingkan dengan produk *RUTF* dalam bentuk wafer (*NumTrey Wafer*) yang mengandung kadar protein sebesar 12,27 g (Sigh *et al.,* 2018). Akan tetapi kandungan protein formula terpilih lebih rendah dibandingkan dengan produk *RUTF bar* (HEBI) yang mempunyai kadar protein sebesar 15,33 g (Nga *et al.,* 2013), 16,41 g (Wieringa *et al.,* 2013) serta juga lebih rendah dibandingkan dengan produk *RUTF* dalam bentuk biskuit *bar* (BP-100) yang memiliki kandungan protein sebesar 14,68 g (Sigh *et al.,* 2018). Bahan pangan yang berkontribusi terhadap kandungan protein pada produk formula terpilih adalah tepung kacang hijau, tepung beras, dan susu *full cream.*

Lemak merupakan salah satu nutrisi penting untuk dikonsumsi balita. Selain berfungsi sebagai sumber energi, lemak juga berfungsi sebagai pelarut vitamin A, D, E, K serta penambahannya pada makanan akan memengaruhi rasa dan tekstur makanan (Sharlin & Edelstein, 2014). Kandungan lemak yang tinggi dapat meningkatkan densitas energi karena lemak berkontribusi memberikan

energi yang lebih banyak dibandingkan protein dan karbohidrat (Michaelsen *et al.,* 2009).

Hasil analisis kadar lemak produk *RUTF* berbentuk *bar* formula terpilih adalah sebesar 28,89%. Kadar lemak produk formula terpilih lebih tinggi dibandingkan dengan produk *RUTF* dalam bentuk wafer (*NumTrey Wafer*) yang mengandung kadar lemak sebesar 27,89 g (Sigh *et al.,* 2018). Akan tetapi lebih rendah dibandingkan dengan produk *RUTF bar* (HEBI) yang memiliki kadar lemak 34,67 g (Nga *et al.,* 2013), 35,68 g (Wieringa *et al.,* 2013) serta juga lebih rendah dibandingkan dengan produk *RUTF* berbentuk biskuit *bar* (BP-100) yang memiliki kandungan lemak sebesar 30,33 g (Sigh *et al.,* 2018). Bahan pangan yang berkontribusi terhadap kandungan lemak formula terpilih adalah minyak kelapa (93 g/100 ml), susu *full cream* (28,57 g/100g), tepung kacang hijau (24,4 g/100g) dan tepung beras (0,64 g/100g).

Kadar karbohidrat dalam produk *RUTF* diperlukan oleh balita sebagai sumber energi, penyuplai dalam membantu proses pertumbuhan, fungsi tubuh dan pelaksanaan aktivitas (Sharlin & Edelstein, 2014). Selain itu, kadar karbohidrat juga mempengaruhi organoleptik produk seperti warna, rasa dan tekstur (Sihab *et al.,* 2017). Karbohidrat dapat mempengaruhi warna produk karena adanya reaksi *Maillard* yang menghasilkan warna cenderung lebih coklat atau lebih pekat, selain itu reaksi *Maillard* ini juga dapat mempengaruhi rasa pada produk (Nurhusna *et al.,* 2020). Kandungan karbohidrat juga dapat meningkatkan tekstur kekerasan pada suatu produk seperti maltodekstrin dan jenis karbohidrat yang tidak dapat dicerna oleh tubuh (Sihab *et al.,* 2017).

Hasil analisis kadar karbohidrat produk formula terpilih sebesar 51.81%. Kadar karbohidrat formula terpilih lebih tinggi dibandingkan dengan produk *RUTF* dalam bentuk wafer (*NumTrey Wafer*) dan *RUTF bar* (HEBI) yang masing-masing secara berurutan mengandung kadar karbohidrat sebesar 51,5 g dan 42,5 g (Nga *et al.,* 2013; Sigh *et al.,* 2018).

Kadar air, abu, protein dan lemak mempengaruhi kandungan karbohidrat formula terpilih. Semakin rendah kandungan air, abu, protein dan lemak maka kadar karbohidrat menjadi semakin meningkat (Sihab *et al.,* 2017). Bahan pangan yang berkontribusi terhadap kandungan karbohidrat formula terpilih adalah tepung kacang hijau, tepung beras, susu *full cream*, maltodekstrin dan gula halus.

Asupan energi sangat penting untuk balita yang mengalami masalah malnutrisi akut karena berperan dalam meningkatkan berat badan balita dan menunjang proses pertumbuhan, perkembangan dan metabolisme tubuh balita (Diniyyah & Nindya, 2017). Hasil analisis kandungan energi produk *RUTF* formula terpilih per 100 gram adalah sebesar 522 kkal. Kandungan energi formula terpilih lebih tinggi dibandingkan dengan produk *RUTF* dalam bentuk wafer (*NumTrey Wafer*) yang mempunyai kandungan energi sebesar 506 kkal (Sigh *et al.,* 2018). Akan tetapi kandungan energi produk formula terpilih pada penelitian ini lebih rendah dibandingkan dengan produk *RUTF bar* (HEBI) yang memiliki kandungan energi sebesar 544 kkal (Nga *et al.,* 2013) dan 547 kkal (Wieringa *et al.,* 2013). Selain itu, kandungan energi formula terpilih juga lebih rendah dibandingkan dengan produk *RUTF* dalam bentuk biskuit *bar* (BP-100) yang memiliki kandungan energi sebesar 529 kkal (Sigh *et al.,* 2018).

Kandungan lemak, protein, dan karbohidrat sangat mempengaruhi kandungan energi. Kandungan lemak produk *RUTF* formula terpilih merupakan penyumbang energi terbesar dan dilanjutkan dengan kandungan karbohidrat dan protein. Meskipun pada formula terpilih kandungan lemak menjadi penyumbang energi terbesar, hanya saja kandungan lemaknya lebih sedikit dibandingkan dengan penelitian sebelumnya (HEBI dan BP-100).

Konsumsi serat pangan pada balita harus dibatasi dan dalam jumlah yang rendah karena konsumsi serat yang tinggi dapat meningkatkan rasa kenyang, penurunan daya cerna energi dan zat gizi lain, serta mempersingkat waktu transit gastrointestinal. Sebuah penelitian menunjukkan pemberian makanan tinggi serat (13 g/hari) pada bayi dan anak-anak di Belanda menunjukkan penurunan penambahan berat badan dan pertumbuhan linear dibandingkan kelompok kontrol (Michaelsen *et al.,* 2009). Kandungan serat pangan produk formula terpilih sebesar 4,66% dan sudah memenuhi standar produk *RUTF*. Kandungan serat pangan produk formula

terpilih lebih tinggi dibandingkan dengan produk *RUTF* dalam bentuk wafer (*NumTrey Wafer*) yang mempunyai kadar serat pangan sebesar 1.1 g (Sigh *et al.,* 2018). Bahan pangan yang berkontribusi terhadap kandungan serat pangan produk formula terpilih adalah tepung kacang hijau (3,69 g/100 g) dan tepung beras (2,4 g/100 g) (Mubarak, 2005; USDA, 2018).

Menurut Michaelsen *et al.,* (2009), asupan zat besi sangat penting untuk balita yang mengalami malnutrisi akut berat, kekurangan asupan zat besi yang parah dapat menyebabkan keterbelakangan perkembangan mental. Zat besi memiliki peranan penting dalam transportasi oksigen, dan penting untuk fungsi imun, fungsi otak dan perkembangan otak. Kandungan zat besi pada formula terpilih sebesar 13,82 mg/100g. Kandungan zat besi produk formula terpilih pada penelitian ini lebih tinggi dibandingkan dengan produk *RUTF* dalam bentuk wafer (*NumTrey Wafer*), *RUTF bar* (HEBI) dan produk *RUTF* dalam bentuk biskuit *bar* / BP-100 (10 mg/100 g) dengan masing-masing produk secara berurutan mengandung zat besi per 100 g sebesar 5,8 mg, 8 mg dan 10 mg (Nga *et al.,* 2013; Sigh *et al.,* 2018).

Bahan pangan yang berkontribusi terhadap kandungan zat besi formula terpilih adalah paling banyak vitamin mineral mix dan tepung kacang hijau, selain itu tepung beras dan susu *full cream* juga berkontribusi terhadap kandungan zat besi. Kandungan zat besi per 100 g dari bahan-bahan tersebut adalah *vitamin mineral mix* sebesar 1656,4 mg, tepung kacang hijau sebesar 7,73 mg, tepung beras 0,35 mg dan susu bubuk *full cream* 0,47 mg (Mubarak, 2005; USDA, 2018).

Kalsium memiliki peran dalam pertumbuhan dan perkembangan tulang serta berperan dalam pengaktifan enzim yang terlibat pada pencernaan lemak, protein dan produksi energi (Sharlin & Edelstein, 2014). Selain itu, asupan kalsium juga diperlukan untuk mencegah terjadinya rakhitis pada balita (Witte & Fischer, 2020). Produk *RUTF* formula terpilih mengandung kalsium sebesar 348,24 mg/100g. Kandungan kalsium formula terpilih lebih tinggi dibandingkan dengan produk *RUTF* dalam bentuk wafer (*NumTrey Wafer*) yang mempunyai kadar kalsium sebesar 219 mg (Sigh *et al.,* 2018). Akan tetapi lebih rendah dibandingkan dengan produk *RUTF* dalam bentuk biskuit *bar* (BP-100) yang memiliki kandungan kalsium sebesar 470 mg/100 g (Sigh *et al.,* 2018). Bahan pangan *vitamin mineral mix* dan susu *full cream* memiliki kontribusi yang lebih besar terhadap kandungan kalsium jika dibandingkan dengan tepung kacang hijau dan tepung beras. Kandungan kalsium per 100 g dari bahan-bahan tersebut adalah *vitamin mineral mix* sebesar 9938,65 mg, susu bubuk *full cream* 912 mg, tepung kacang hijau sebesar 71,92 mg, dan tepung beras 10,00 mg.

Kualitas protein yang tinggi dalam suatu produk sangat dianjurkan dikonsumsi oleh balita yang mengalami malnutrisi akut berat dan kualitas protein dapat diukur melalui daya cerna protein produk. Berdasarkan hasil analisis, daya cerna protein produk *RUTF* formula terpilih yaitu sebesar 94,93%. Nilai daya cerna protein produk *RUTF* berbentuk *bar* formula terpilih lebih dari 80% dan tergolong memiliki daya cerna protein yang tinggi (Kaspchak *et al.,* 2018). Penggunaan pangan sumber protein hewani pada produk (susu *full cream*) yang tinggi menjadi salah satu faktor yang menyebabkan daya cerna protein produk tinggi. Serat pangan dan proses pengolahan dalam bentuk pemanasan dapat menyebabkan penurunan daya cerna protein. Akan tetapi, pada penelitian ini tidak menyebabkan penurunan yang cukup banyak dikarenakan kandungan serat pangan tidak tinggi dan proses pemanasan yang tidak terlalu lama.

Aktivitas air (a_w) merupakan air yang bebas dalam suatu produk dan nilainya mempengaruhi pertumbuhan atau metabolisme mikroba pada produk tersebut (Asiah *et al.,* 2018; Vesterlund *et al.,* 2012). Aktivitas air dapat memprediksi keamanan dan stabilitas yang berhubungan dengan pertumbuhan mikroba, laju reaksi kimia dan biokimia, serta sifat fisik produk (Panja *et al.,* 2019). Produk *RUTF* secara umum memiliki aktivitas air yang rendah yaitu berkisar antara 0,2–0,6 (FAO, 2015). Berdasarkan hasil analisis aktivitas air (a_w) formula terpilih diperoleh nilai aktivitas air yang rendah yaitu 0,21. Produk *RUTF* dengan nilai aktivitas air 0,20 – 0,45 menunjukkan hasil yang baik terhadap stabilitas vitamin larut lemak dan lemak (FAO, 2019). Aktivitas air produk formula terpilih lebih rendah dibandingkan dengan beberapa produk *RUTF* lainnya seperti *RUTF* berbentuk pasta yaitu berkisar 0,24–0,29 (Santini *et al.,* 2013). Hal ini disebabkan karena

pengunaan bahan seperti maltodekstrin dan proses pengolahan produk seperti penyangraian yang dapat mengurangi nilai aktivitas air produk (Badola *et al.,* 2017).

KESIMPULAN DAN SARAN

Pengembangan produk *RUTF* berbahan kacang hijau, serealia, dan minyak nabati diperoleh formula A1B1 (kombinasi kacang hijau dengan beras dan minyak kelapa) sebagai formula terpilih. Hasil analisis produk formula A1B1 berpotensi dijadikan sebagai produk *RUTF* alternatif untuk balita malnutrisi akut berat. Hal ini dapat dilihat dari kadar abu, protein, lemak, karbohidrat, energi, serat pangan, zat besi, kalsium, daya cerna protein dan aktivitas air sudah memenuhi standar yang dianjurkan untuk produk *RUTF* kecuali kadar air berdasarkan standar umum produk *RUTF* (WHO 2007).

Perlu adanya proses pengolahan bahan pangan dengan cara ekstruksi untuk membantu kadar air lebih rendah dan memenuhi standar umum produk *RUTF* berdasarkan WHO (2007) serta diperlukan penelitian lanjut terkait dengan uji daya terima produk penelitian kepada kelompok sasaran yaitu balita malnutrisi akut berat.

DAFTAR PUSTAKA

AOAC. (2005). *Official Methods of Analysis of AOAC International* (18th ed.). Washington : Asociation of Official of Analytical Chemist International.

Andarwulan, N., Kusnandar, F., & Herawati, D. (2011). *Analisis Pangan*. Jakarta : Dian Rakyat.

Asiah, N., Cempaka, L., & David, W. (2018). *Pendugaan Umur Simpan Produk Pangan*. Jakarta : UB Press.

Badola, R., Singh, R. R. B., Panjagari, N. R., Singh, A. K., & Hussain, S. A. (2017). Effect of selected humectants as water activity modifiers on the quality of model khoa system. *Indian J Dairy Sci*, *70*(2), 145–154.

Boateng, L., Ansong, R., Owusu, W. B., & Steiner-Asiedu, M. (2016). Coconut oil and palm oil's role in nutrition, health and national development: A review. *Ghana Medical Journal*, *50*(3), 189–196. doi: 10.4314/gmj.v50i3.11

Budiarti, A. E., Ansharullah, & Karimuna, L. (2017). Pengaruh substitusi tepung jagung (Zea mays. L) terfermentasi terhadap karakteristik organoleptik dan nilai gizi cake tulban. *J Sains Dan Teknologi Pangan*, *2*(3), 508–519.

Ciliberto, M. A., Sandige, H., Ndekha, M. J., Ashorn, P., Briend, A., Ciliberto, H. M., & Manary, M. J. (2005). Comparison of home-based therapy with ready-to-use therapeutic food with standard therapy in the treatment of malnourished Malawian children: a controlled, clinical effectiveness trial. *American Journal of Clinical NUtrition*, *81*(4), 864–870. doi: 10.1093/ajcn/81.4.864

Dahiya, P. K., Nout, M. J. R., van Boekel, M. A., Khetarpaul, N., Grewal, R. B., & Linnemann, A. (2014). Nutritional characteristics of mung bean foods. *British Food Journal*, *116*(6), 1031–1046. doi: 10.1108/BFJ-11-2012-0280

Diniyyah, S. R., & Nindya, T. S. (2017). Asupan Energi, Protein dan Lemak dengan Kejadian Gizi Kurang pada Balita Usia 24-59 Bulan di Desa Suci, Gresik. *Amerta Nutr*, 341–350. doi: 10.2473/amnt.v1i4.2017.341-350

Dipasquale, V., Cucinotta, U., & Romano, C. (2020). Acute malnutrition in children: Pathophysiology, clinical effects and treatment. *Nutrients*, *12*(8), 2413–2421. doi: 10.3390/nu12082413

FAO. (2015). *Codex alimentarius comission, joint FAO/WHO food standards programme codex committee on nutrition and foods for special dietary uses : Discussion paper on a standard for ready to-use foods*. Germany : Food and Agriculture Organization.

FAO. (2019). *Codex alimentarius comission, joint FAO/WHO food standards programme codex committee on nutrition and foods for special dietary uses : proposed Draft Guideline for Ready to Use Therapeutic Foods Section 5.2.2 (Food Additive) and Section 6.2 (Protein)*. Italy : Food and Agriculture Organization.

Hendrixson, D. T., Godbout, C., Los, A., Callaghan-Gillespie, M., Mui, M., Wegner, D., Bryant, T., Koroma, A., & Manary, M. J. (2020). Treatment of severe acute malnutrition with oat or standard ready-to-use therapeutic food: A triple-blind, randomised controlled clinical trial. *Gut*, *69*(12), 2143–2149. doi: 10.1136/gutjnl-2020-320769

Hou, D., Yousaf, L., Xue, Y., Hu, J., Wu, J., Hu, X., Feng, N., & Shen, Q. (2019). Mung bean (Vigna radiata L.): Bioactive polyphenols, polysaccharides, peptides, and health

benefits. *Nutrients*, *11*(6), 1–28. doi:10.3390/nu11061238

Kaspchak, E., Mafra, L. I., & Mafra, M. R. (2018). Effect of heating and ionic strength on the interaction of bovine serum albumin and the antinutrients tannic and phytic acids, and its influence on in vitro protein digestibility. *Food Chemistry*, *252*, 1–31. doi:10.1016/j.foodchem.2018.01.089

Kemenkes. (2018). *Hasil utama Riskesdas 2018*. Jakarta : Kementrian Kesehatan Republik Indonesia.

Khan, R. H., Shiddiqi, M. K., & Salahuddin, P. (2017). *Protein structure and function*. Https://Www.Researchgate.Net/Publication/316139245_Protein_Structure_and_Function. Retrieved from https://www.researchgate.net/publication/316139245_Protein_Structure_and_Function

Lenters, L., Wazny, K., & Bhutta, Z. A. (2016). *Management of Severe and Moderate Acute Malnutrition in Children*. Washington : The World Bank.

Linneman, Z., Matilsky, D., Ndekha, M., Manary, M. J., Maleta, K., & Manary, M. J. (2007). A large-scale operational study of home-based therapy with ready-to-use therapeutic food in childhood malnutrition in Malawi. *Maternal and Child Nutrition*, *3*, 206–215.

Michaelsen, K. F., Hoppe, C., Roos, N., Kaestel, P., Stougaard, M., Lauritzen, L., Molgaard, C., Girma, T., & Friis, H. (2009). Choice of foods and ingredients for moderately malnourished children 6 months to 5 years of age. *Food and Nutrition Bulletin*, *30*(3), 343–404. doi: 10.1177/15648265090303s303

Miele, N. A., Armini, V., Troccoli, A. M., Puleo, S., Paduano, A., Sacchi, R., & Cavella, S. (2020). Sensory evaluation and volatile compounds of an alternative ready-to-use therapeutic food for malnourished children. *Journal of Food Science*, *85*(4), 1265–1273. doi: 10.1111/1750-3841.15110

Mikołajczak, N. (2017). Coconut oil in human diet-nutrition value and potential health benefits. *Journal of Education*, *7*(9), 307–319. https://doi.org/10.5281/zenodo.997464

Mubarak, A. E. (2005). Nutritional composition and antinutritional factors of mung bean seeds (Phaseolus aureus) as affected by some home traditional processes. *Food Chemistry*, *89*(4), 489–495. doi: 10.1016/j.foodchem.2004.01.007

NDPC. (2016). *Social and Economic Impact of Child Undernutrition on Ghana's Long-Term Development*. Retrieved from. https://reliefweb.int/sites/reliefweb.int/files/resources/GHANA.pdf

Nga, T. T., Nguyen, M., Mathisen, R., Hoa, D. T. B., Minh, N. H., Berger, J., & Wieringa, F. T. (2013). Acceptability and impact on anthropometry of a locally developed Ready-to-use therapeutic food in pre-school children in Vietnam. *Nutrition Journal*, *12*(120), 1–8. doi: 10.1186/1475-2891-12-120

Nielsen, S. S. (2010). *Food Analysis* (Fourth). West Lafayette : Springer. Retrieved from www.springer.com/series/5999

Nurhusna, A., Marliyati, A., & Palupi, E. (2020). Snack bar made from sorghum and beans wuth addtion of red palm oil as suplementary food for pregnant women with chronic energy deficiency. *Media Gizi Indonesia*, *15*(3), 173–183. doi: 10.204736/mgi.v15i3

Oakley, E., Reinking, J., Sandige, H., Trehan, I., Kennedy, G., Maleta, K., & Manary, M. (2010). A ready-to-use therapeutic food containing 10% milk is less effective than one with 25% milk in the treatment of severely malnourished children. *Journal of Nutrition*, *140*(12), 2248–2252. doi: 10.3945/jn.110.123828

Owino, V. O., Irena, A. H., Dibari, F., & Collins, S. (2012). Development and acceptability of a novel milk-free soybean-maize-sorghum ready-to-use therapeutic food (SMS-RUTF) based on industrial extrusion cooking process. *Maternal and Child Nutrition*, *10*(1), 126–134. doi: 10.1111/j.1740-8709.2012.00400.x

Panja, P., Deepika, & Bhattacharjee, D. (2019). An overview of the principles and effects of intermediate moisture fruits and vegetables. *International Journal of Chemical Studies*, *3*(6), 848–855. Retrived from http://www.chemijournal.com

Rohman, A., Helmiyati, S., Hapsari, M., & Setyaningrum, D. L. (2014). Rice in health and nutrition. *International Food Research Journal*, *21*(1), 13–24.

Santini, A., Novellino, E., Armini, V., & Ritieni, A. (2013). State of the art of ready-to-use therapeutic food: A tool for nutraceuticals addition to foodstuff. *Food Chemistry*, *140*(4), 843–849. doi: 10.1016/j.foodchem.2012.10.098

Saunders, R. M., Connor, M. A., Booth, A. N., Bickoff, E. M., & Kohler, G. O. (1973). Measurement of digestibility of alfafa protein

concentrates by in vivo and in vitro methods. *J. Nutr*, *103*(4), 530–535. doi: 10.1093/jn/103.4.530

Shah, T. R., Prasad, K., & Kumar, P. (2016). Maize-a potential source of human nutrition and health: a review. *Cogent Food & Agriculture*, *2*(1), 1–9. doi: 10.1080/23311932.2016.1166995.

Sharlin, J., & Edelstein, S. (2014). *Buku Ajar Gizi dalam Daur Kehidupan* (C. A. Agustin, E. Rezkina, & Q. Rahmah (eds.)). Jakarta : EGC.

Sigh, S., Roos, N., Chamnan, C., Laillou, A., Prak, S., & Wieringa, F. T. (2018). Effectiveness of a locally produced, fish-based food product on weight gain among cambodian children in the treatment of acute malnutrition: A randomized controlled trial. *Nutrients*, *10*(7), 1–17. doi 10.3390/nu10070909

Sihab, Karimuna, L., & Tamrin. (2017). Pengaruh formulasi tepung beras dan tepung ubi kayu fermentasi dengan penambahan maltodekstrin terhadap penilaian organoleptik dan kandungan gizi keripik bayam (Amaranthus spp). *J Sains Dan Teknologi Pangan*, *2*(3), 575–589.

UNICEF. (2013). *Improving Child Nutrition : The achievable imperative for global progress*. New York : United Nations Children's Fund.

UNICEF. (2019). *Product spesification sheet RUTF biscuit (BP-100)*. New York : United Nations Children's Fund.

UNICEF. (2020). *COVID-19 and Children in Indonesia*. Jakarta : United Nations Children's Fund. Retrieved from https://www.unicef.org/indonesia/sites/unicef.org.indonesia/files/2020-05/COVID-19-and-Children-in-Indonesia-2020_0.pdf

USDA. (2018). *Rice flour, white*. National Nutrient Database for Standar Reference. Retrieved from https://fdc.nal.usda.gov/fdc-app.html#/food-details/169714/nutrients

Vala, G. S., & Kapadiya, P. K. (2014). Medicinal benefits of coconut oil (a review paper). *International Journal of Life Sciences Research*, *2*(4), 124–126. Retrieved from https://www.researchgate.net/publication/268805677

Vesterlund, S., Salminen, K., & Salminen, S. (2012). Water activity in dry foods containing live probiotic bacteria should be carefully considered: A case study with Lactobacillus rhamnosus GG in flaxseed. *International Journal of Food Microbiology*, *157*(2), 319–321. doi: 10.1016/j.ijfoodmicro.2012.05.016.

Villanueva, N. D. M., Petenate, A. J., & Da Silva, M. A. A. P. (2005). Performance of the hybrid hedonic scale as compared to the traditional hedonic, self-adjusting and ranking scales. *Food Quality and Preference*, *16*(8), 691–703. doi: 10.1016/j.foodqual.2005.03.013.

WHO. (2007). *Community-based management of severe acute malnutrition*. Geneva : World Health Organization.

WHO. (2010). *Nutrition Landscape Information System (NLIS) Country Profile indicators*. Geneva : World Health Organization.

Wieringa, F. T., Tran, N. T., Hoang, M.-A., Brown, M., Maalouf-Manasseh, Z., Lu'u, T. T. M., Nguyen, M. T. H., Hop, L. T., & Berger, J. (2013). *Acceptability of Two Ready-to-Use Therapeutic Foods among HIV Positive Patients in Vietnam*. Washington : FHI 360. Retrieved from https://www.researchgate.net/publication/321758805.

Winarno, F. (2008). *Kimia Pangan dan Gizi*. Jakarta : M-Brio Press.

Witte, M. A., & Fischer, P. R. (2020). Severe acute malnutrition, calcium and vitamin D: Important interactions. *Public Health Nutrition*, *23*(17), 3187–3189. Doi: 10.1017/S1368980020002499.

Wu, T., Wang, L., Li, Y., Qian, H., Liu, L., Tong, L., Zhou, X., Wang, L., & Zhou, S. (2019). Effect of milling methods on the properties of rice flour and gluten-free rice bread. *LWT-Food Science and Technology*, *108*, 137–144. doi: 10.1016/j.lwt.2019.03.050.

Yi-Shen, Z., Shuai, S., & Fitzgerald, R. (2018). Mung bean proteins and peptides: Nutritional, functional and bioactive properties. *Food and Nutrition Research*, *62*, 1–11. doi:10.29219/fnr.v62.1290.

PENGARUH PEMANFAATAN TEPUNG BUAH KERSEN (*MUNTINGIA CALABURA* L.) DAN SUBSTITUSI GULA TERHADAP KANDUNGAN GIZI, ANTIOKSIDAN DAN ORGANOLEPTIK BISKUIT

The Effect of Calabura Fruit (Muntingia calabura L.*) Flour Utilization and Sugar Substitution on Nutritional, Antioxidants and Organoleptics of Biscuit*

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ABSTRAK

Perubahan pola konsumsi ke pola yang kurang sehat seperti peningkatan konsumsi gula dan rendahnya konsumsi sayur dan buah, berkontribusi terhadap peningkatan prevalensi *overweight* dan obesitas di Indonesia. *Overweight* dan obesitas merupakan faktor risiko penyakit tidak menular. Pada penderita obesitas terjadi peningkatan stres metabolik, yang lebih lanjut dapat memicu penyakit tidak menular. Buah kersen (*Muntingia calabura* L.) memiliki potensi gizi dan antioksidan yang dapat dimanfaatkan pada pengembangan produk pangan. Pemanfaatan buah kersen dan substitusi gula pada biskuit dapat dilakukan sebagai upaya untuk membuat produk biskuit menjadi lebih bergizi, mengandung antioksidan dan lebih rendah gula yang dapat berkontribusi pada pencegahan faktor risiko *overweight* dan obesitas. Penelitian ini bertujuan untuk menganalisis pengaruh pemanfaatan tepung buah kersen dan substitusi gula terhadap kandungan gizi, kandungan antioksidan, aktivitas antioksidan, karakteristik organoleptik serta karakteristik fisik biskuit. Rancangan Percobaan yang digunakan adalah Rancangan Acak Lengkap Faktorial dengan dua faktor, yaitu substitusi tepung buah kersen dan substitusi gula. Analisis yang dilakukan meliputi analisis kandungan gizi, kadar dan aktivitas antioksidan, dan kekerasan. Pengaruh perlakuan terhadap kandungan zat gizi dianalisis menggunakan sidik ragam (ANOVA), sedangkan terhadap sifat organoleptik menggunakan *Kruskal Wallis*. Hasil penelitian menunjukkan bahwa substitusi tepung buah kersen dan gula memberikan pengaruh terhadap kadar abu serta kandungan dan aktivitas antioksidan biskuit ($p<0,05$), namun tidak berpengaruh pada karakteristik organoleptik biskuit. Peningkatan taraf substitusi tepung buah kersen meningkatkan aktivitas dan kadar antioksidan biskuit.

Kata kunci: antioksidan, gula pengganti, *Muntingia calabura* L., obesitas, penyakit tidak menular

ABSTRACT

Changes in dietary pattern to unhealthy, such as increased in sugar and low of fruits and vegetables consumption, are among factors contribute to the increase of overweight and obesity prevalence in Indonesia. Overweight and obesity are risk factors of non-communicable diseases. Obese people had increased of metabolic stress, further lead to non-communicable diseases. Calabura fruit (Muntingia calabura L.*) has nutritional and antioxidant potential, which can be utilized in the development of food products. The utilization of Calabura fruit and sugar substitution in biscuits could be done as an effort to make healthy biscuits, contain antioxidants and lower sugar, which may contribute to the prevention of overweight and obesity. This research aims to analyze the effect of utilization of Calabura fruit flour and sugar substitution on the nutritional, antioxidant, antioxidant activity, organoleptic and physical characteristics of biscuits. An experimental study was conducted by using completely randomized factorial design with two factors: the substitution of Calabura fruit flour and sugar substitution. The analysis included nutrients and antioxidants content, antioxidant activity, and hardness of biscuits. The effect of treatment on nutritional content was analyzed using ANOVA and the Kruskal Wallis test for organoleptic. The results show that Calabura fruit flour and sugar substitution significantly affect ash, antioxidants content, and antioxidant activity of biscuit ($p<0,05$), but has no effect on organoleptic characteristics. The increased level of Calabura flour substitution improves antioxidant content and antioxidant activity in biscuits..*

Keywords*— antioxidants, sugar replacer, Muntingia calabura* L.*, obesity, non-communicable diseases*

 Received 14-07-2020, Accepted 11-09-2021, Published online 30-01-2022

PENDAHULUAN

Kondisi *overweight* dan obesitas di Indonesia saat ini semakin mengalami peningkatan dari tahun ke tahun. Prevalensi obesitas pada dewasa usia 18 tahun ke atas meningkat dari 14,8% pada 2013 menjadi 21,8% pada 2018 (Kemenkes, 2018). Kondisi ini erat kaitannya dengan kejadian berbagai penyakit termasuk penyakit tidak menular seperti penyakit jantung, stroke, diabetes mellitus dan sebagainya. Tingkat morbiditas dan mortalitas pada penderita obesitas meningkat dengan umur harapan hidup yang lebih pendek (Syafiq *et al.*, 2014). Pada kondisi obesitas terjadi pembentukan lemak tubuh yang berlebihan, penghambatan pemecahan lemak dan inflamasi (Susantiningsih, 2015). Inflamasi yang disebabkan obesitas secara lebih lanjut menyebabkan perubahan kondisi metabolik seperti stres metabolik. Stres metabolik juga berkaitan dengan stres oksidatif dalam tubuh yaitu ketidakseimbangan antara radikal bebas dan antioksidan. Stres oksidatif dalam tubuh menyebabkan kerusakan sel, jaringan atau organ, yang lebih lanjut memicu patogenesis penyakit-penyakit tidak menular. Protein penanda inflamasi (*C-Reactive Protein*; CRP) pada obesitas 10 kali lebih tinggi dibandingkan normal (Cave, Hurt, & Frazier, 2008).

Perubahan pola konsumsi kepada makanan tinggi lemak, tinggi gula, rendah serat dan antioksidan, serta rendahnya aktivitas fisik merupakan beberapa penyebab *overweight* dan obesitas. Siervo *et al.* (2013) menunjukkan bahwa konsumsi makanan dan minuman tinggi gula berhubungan dengan peningkatan prevalensi berat badan lebih ($\rho = 0,37$, $P<0,001$) dan obesitas ($\rho = 0,31$, $P<0,001$), di mana faktor konsumsi energi dari gula merupakan prediktor obesitas ($B=0,04$, $SE=0,01$, $p=0,009$). Selain itu, rendahnya konsumsi serat dan makanan sumber antioksidan menjadi faktor pencetus kegemukan yang tidak kalah penting. Hal ini ditunjukkan dari rendahnya konsumsi sayur dan buah pada masyarakat Indonesia. Sebagian besar (95,5%) masyarakat usia ≥ 5 tahun mengonsumsi sayur dan buah di bawah anjuran pedoman gizi seimbang 5 porsi sehari (Kemenkes, 2018).

Organisasi Kesehatan Dunia (WHO) menyebutkan bahwa senyawa bioaktif penting untuk pencegahan penyakit diabetes, kanker dan obesitas terutama dari buah-buahan kecil berwarna (Stapleton *et al.*, 2008). Buah kersen (*Muntingia calabura L.*) merupakan buah yang memiliki potensi gizi dan bioaktif antioksidan. Buah ini tumbuh luas di beberapa negara termasuk Indonesia. Kandungan gizi buah kersen meliputi air (77,36%), abu (5,65%), karbohidrat (72,15%), protein (8,29%), lemak (7,79%), serat kasar (5,93%), dan vitamin C (3,30 mg per 100 g), dengan nilai energi total yang rendah (Pereira *et al.*, 2016). Selain itu, buah kersen berkontribusi pada senyawa bioaktif antioksidan seperti asam fenolik, antosianin dan flavonoid yang menunjukkan bioaktivitas antimikroba, antioksidan dan antiinflamasi. Aktivitas antiinflamasi flavons, flavonols (rutin, quercetin, kaempferol, mirisetin) dan beberapa terpenoid pada buah kersen dapat menghambat ekspresi COX dan lipopolisakarida yang bertanggung jawab pada kejadian inflamasi (Gomathi, Anusuya, & Manian, 2013). Buah kersen mengandung senyawa fenolik sebesar 526,55 mg asam tanin ekuivalen (TAE) per 100 g, antosianin 4,08 mg sianidin-3-glukosida ekuivalen (CGE) per 100 g dan aktivitas antioksidan DPPH IC50 (82,25 µg/mL) (Pereira *et al.*, 2016). Namun, potensi dari buah kersen masih belum dimanfaatkan secara optimal. Buah kersen hanya dikonsumsi sesekali dan pohonnya secara umum hanya dimanfaatkan sebagai pohon peneduh pinggir jalan.

Buah kersen berpeluang untuk digunakan dalam menghasilkan produk pangan dengan kandungan gizi dan manfaat bioaktif antioksidan. Produk pangan seperti biskuit memiliki peluang untuk dikembangkan disebabkan tingginya konsumsi, disukai, praktis dan memiliki keawetan yang baik. Biskuit yang beredar di masyarakat umumnya memiliki kandungan karbohidrat dan gula yang tinggi serta rendah serat dan antioksidan. Saat ini, mulai bermunculan produsen makanan yang berupaya menghasilkan produk pangan yang lebih sehat. Selain itu, beberapa penelitian pada produk biskuit dilakukan untuk menghasilkan biskuit yang memiliki kandungan gizi dan memiliki manfaat kesehatan dengan cara mengombinasikan dan memanfaatkan bahan-bahan berpotensi gizi serta meminimalkan penggunaan gula. Oleh karena itu, pemanfaatan buah kersen dalam menghasilkan biskuit yang bergizi dan mengandung antioksidan menarik untuk dilakukan

sebagai upaya menghasilkan produk pangan yang berkontribusi pada pencegahan penyakit tidak menular terutama dari faktor risiko *overweight* dan obesitas. Penelitian ini bertujuan untuk melihat pengaruh pemanfaatan buah kersen dan substitusi gula pada kandungan gizi, antioksidan dan organoleptik biskuit.

METODE

Desain penelitian ini adalah eksperimental menggunakan rancangan acak lengkap faktorial berupa faktor substitusi tepung buah kersen dan substitusi gula pada biskuit berbasis parsial mocaf. Buah kersen diolah menjadi tepung buah kersen sebelum digunakan dalam pembuatan biskuit. Tepung buah kersen dibuat dengan cara pengeringan menggunakan alat vakum evaporator, kemudian penggilingan dan pengayakan 40 mesh. Taraf tepung buah kersen untuk substitusi parsial terigu mocaf yaitu 11%, 17% dan 22% terhadap total tepung terigu dan mocaf, dan taraf substitusi gula yaitu 40% dan 50% dari total gula, menggunakan campuran 2 jenis pemanis yang dihitung setara dengan kemanisan sukrosa. Pemanis yang digunakan adalah sorbitol dan Diabetasol sukralosa. Formulasi biskuit disajikan pada Tabel 1.

Proses pembuatan biskuit dengan metode *creaming*, diawali dengan pencampuran bahan basah kemudian pencampuran bahan kering tepung-tepungan hingga adonan tercampur rata. Selanjutnya, pencetakan adonan setebal 4 mm dan pemanggangan pada suhu 160°C selama 15 menit. Uji organoleptik terhadap biskuit dilakukan menggunakan uji hedonik pada atribut rasa, aroma, warna, tekstur (*mouthfeel*) dan keseluruhan. Skala penilaian dari 1 hingga 7, yaitu 1 (Sangat tidak suka), 2 (Tidak suka), 3 (Agak tidak suka), 4 (Biasa), 5 (Agak suka), 6 (Suka), dan 7 (Sangat suka) oleh 31 orang panelis semi terlatih. Analisis kandungan gizi, sifat fisik kekerasan, aktivitas antioksidan dan kadar antioksidan dilakukan terhadap seluruh formula biskuit. Analisis kandungan gizi meliputi kadar air menggunakan metode oven, kadar abu menggunakan metode gravimetri, kadar protein metode Kjeldahl menggunakan Foss Tecator Kjeltec KT 200, kadar lemak metode Soxhlet menggunakan Foss Soxtec ST 243 dan kadar karbohidrat *by difference* (AOAC, 2005). Aktivitas antioksidan metode DPPH mengacu Molyneux (2004) dan Preethi, Vijayalakshmi, Shamna, & Sasikumar (2010) dengan modifikasi. Analisis kadar antioksidan kuantitatif meliputi total fenol menggunakan metode Folin-Ciocalteau (Vongsak, Sithisarn, & Mangmool, 2013), total flavonoid metode kolorimetri $AlCl_3$ (Recuenco, Lacsamana, & Sabularse, 2016), dan antosianin total (Lao

Tabel 1. Formulasi Biskuit

Formula (g)	Berat bahan (g)						
	kontrol	F1	F2	F3	F4	F5	F6
Tepung terigu	45	40	37,5	35	40	37,5	35
Tepung mocaf	45	40	37,5	35	40	37,5	35
Pati jagung	10	10	10	10	10	10	10
Tepung kersen*	-	10	15	20	10	15	20
Susu bubuk skim	2	2	2	2	2	2	2
Kuning telur	10	10	10	10	10	10	10
Garam	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Gula aren*	25	15	15	15	12,5	12,5	12,5
Sorbitol*	-	13,5	13,5	13,5	16,5	16,5	16,5
Gula sukralosa*	-	0,2	0,2	0,2	0,25	0,25	0,25
Mentega	16	16	16	16	16	16	16
Margarin	16	16	16	16	16	16	16
Vanili esens	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Baking powder	0,25	0,25	0,25	0,25	0,25	0,25	0,25
Total adonan	170	175	175	175	175	175	175

Keterangan: *variabel perlakuan

& Giusti, 2015). Analisis fisik kekerasan diukur menggunakan Stevens-LFRA *Texture Analyzer*.

Data yang terkumpul ditabulasi dan dianalisis menggunakan Excel dan SPSS 16.0 *for Windows*. Semua data diuji normalitas sebelum diuji statistik. Data hasil uji organoleptik dianalisis menggunakan *Kruskal Wallis* yang disajikan dalam nilai modus dan persentase panelis. Hasil analisis kimia dianalisis secara statistik menggunakan *two-way* ANOVA (α=0,05), diikuti dengan uji lanjut Duncan bila terdapat pengaruh signifikan. *Sifat* fisik kekerasan biskuit dianalisis secara deskriptif.

HASIL DAN PEMBAHASAN

Uji Organoleptik Biskuit

Hasil uji organoleptik disajikan pada Tabel 2. Berdasarkan uji statistik *Kruskal Wallis*, seluruh perlakuan tidak berpengaruh signifikan (p>0,05) terhadap tingkat kesukaan panelis pada atribut warna, rasa, aroma, tekstur (*mouthfeel*) dan keseluruhan. Namun, berdasarkan kecenderungan data, F5 paling disukai (modus 6) dengan persentase jumlah panelis tertinggi pada atribut warna. Warna biskuit relatif cokelat. Kombinasi penggunaan tepung buah kersen dengan warna °Hue kuning merah dan gula aren memberikan warna coklat pada biskuit, selain efek reaksi *Maillard* yang terjadi selama pemanggangan. Warna coklat juga berasal dari interaksi antioksidan fenol dengan bahan biskuit. Oksidasi fenol oleh pengaruh enzim, pemanasan dan pH tinggi menghasilkan quinon yang menghasilkan pigmen warna coklat (Bittner, 2006). Hal ini sebagaimana (Ou & Wang, 2019) dimana senyawa fenolik, taraf penambahan bahan mengandung fenolik dan suhu pemanggangan dapat mempengaruhi warna Berdasarkan rasa, F1 disukai dengan persen modus tertinggi (40%). F1 juga paling disukai dari segi aroma dengan nilai modus 6 (suka) dan persentase panelis tertinggi (40%).

Atribut sensori produk panggang dapat dipengaruhi oleh penggunaan *by-product* yang mengandung antioksidan fenolik. Penambahan 20% pomace buah campuran blackcurrant, rowan, rosehip dan elderberry pada *cookies* menurunkan penilaian terhadap aroma dengan aroma panggang yang rendah (Tańska, Roszkowska, & Czaplicki, 2016). Keberadaan polifenol menghambat pembentukan senyawa aroma dan *flavor* yang dihasilkan dari reaksi mekanisme penangkapan senyawa karbonil dari fragmentasi gula selama pemanggangan pada produk panggang (Ou & Wang, 2019).

Peningkatan taraf substitusi gula menurunkan jumlah gula yang terlibat pada reaksi *Maillard* sehingga senyawa karbonil yang terbentuk lebih sedikit. Kandungan fenolik dalam tepung buah dan interaksinya dengan gula dapat menurunkan pembentukan senyawa flavor dan aroma biskuit. Pengaruh taraf substitusi tepung buah kersen dan gula terhadap atribut sensori pada penelitian ini tidak berbeda signifikan, namun dilaporkan menghasilkan aroma dan rasa buah kersen yang lemah yang masih disukai panelis.

Atribut tekstur disukai oleh panelis (modus 6) pada formula F2 dan F4. Formula F6 memiliki modus tekstur terendah yaitu 4 (biasa) di antara formula lainnya. Penggunaan tepung buah kersen pada tingkat substitusi tertinggi pada

Tabel 2. Hasil Uji Kesukaan (Hedonik)

Formula	Atribut				
	Warna	Rasa	Aroma	Tekstur	Keseluruhan
F1	5 (33,3)[a]	6 (40,0)[a]	6 (40,0)[a]	5 (33,3)[a]	6 (36,7)[a]
F2	6 (46,7)[a]	6 (30,0)[a]	4 (33,3)[a]	6 (40,0)[a]	6 (30,0)[a]
F3	6 (40,0)[a]	5 (30,0)[a]	4 (26,7)[a]	5 (33,3)[a]	5 (26,7)[a]
F4	6 (33,3)[a]	5 (26,7)[a]	6 (30,0)[a]	6 (30,0)[a]	5 (36,7)[a]
F5	6 (50,0)[a]	6 (26,7)[a]	6 (26,7)[a]	5 (33,3)[a]	5 (36,7)[a]
F6	5 (33,3)[a]	5 (43,3)[a]	6 (33,3)[a]	4 (30,0)[a]	6 (30,0)[a]
Nilai p	0,202	0,360	0,833	0,305	0,580

Keterangan: Skala 1= sangat tidak suka, 2= tidak suka, 3= agak tidak suka, 4= biasa, 5= agak suka, 6= suka, 7= sangat suka. Tepung kersen (TK), Substitusi gula (SG). Formula=TK:SG. F1= 11%:40% , F2 = 17%:40%, F3 = 22%:40%, F4 = 11:50% , F5= 17%:50% dan F6= 22%:50%. Huruf yang sama pada kolom yang sama menunjukkan tidak berbeda signifikan (p>0,05).

F6 menyebabkan tekstur yang kurang disukai. Beberapa panelis melaporkan tekstur biskuit yang kurang rapuh beremah dan *crunchy* renyah. Atribut keseluruhan menunjukkan bahwa formula yang disukai panelis (modus 6) yaitu F1, F2 dan F6. Nilai persentase panelis tertinggi terhadap kesukaan atribut keseluruhan biskuit kersen diperoleh oleh F1.

Kandungan Zat Gizi Biskuit

Kadar air biskuit kersen berkisar 2,99–4,58% (Tabel 3). Kadar air biskuit tidak berbeda signifikan (p>0,05) antar taraf dan interaksi substitusi tepung buah kersen dan gula. Namun, kadar air biskuit memperlihatkan kecenderungan peningkatan seiring peningkatan substitusi tepung buah kersen. Tepung buah kersen mengandung air yang akan meningkatkan kadar air biskuit seiring peningkatan substitusi tepung. Selain itu, peningkatan taraf substitusi gula menunjukkan kecenderungan penurunan kadar air biskuit. Hal ini disebabkan terbentuknya air terikat dalam biskuit oleh perlakuan substitusi gula. Air terikat adalah air yang berikatan suatu senyawa. Penggunaan gula sorbitol dan keberadaan gum arab dalam tepung buah kersen bersifat mengikat air (higroskopis). Air terikat ini akan sulit dan sedikit diuapkan ketika proses pemanggangan sehingga kadar air dalam biskuit tertahan (Barbosa-Cánovas *et al*., 2003). Kadar air yang sedikit teruapkan menyebabkan penilaian kadar air menjadi lebih rendah.

Kadar abu biskuit berkisar 1,51–1,97%. Interaksi perlakuan substitusi tepung buah kersen dan substitusi gula tidak memberikan perbedaan kadar abu yang signifikan. Kadar abu menunjukkan perbedaan signifikan dari perbedaan taraf substitusi tepung buah kersen berdasarkan uji *two-way* ANOVA (p<0,05). Semakin tinggi substitusi tepung buah kersen meningkatkan kadar abu biskuit. Kadar abu total menunjukkan kandungan mineral total dalam makanan (Nielsen, 2010). Buah kersen mengandung mineral yang berkontribusi pada peningkatan kadar abu biskuit. Buah kersen mengandung kadar abu dengan kandungan 16 jenis mineral di mana zat besi (Fe) sebagai mineral mikro tertinggi dan kalium sebagai mineral makro tertinggi (Muslimin *et al*., 2019).

Kadar protein, lemak dan karbohidrat biskuit tidak berbeda signifikan oleh perbedaan taraf dan interaksi substitusi tepung buah kersen dan substitusi gula. Kadar protein, lemak dan karbohidrat biskuit berkisar 4,58–4,96 %, 19,62–19,90 % dan 73,43–74,02%, secara berturut-turut. Kandungan protein, lemak, karbohidrat pada buah kersen kurang memberi kontribusi signifikan pada biskuit. Peningkatan taraf substitusi gula juga tidak memberikan pengaruh signifikan terutama pada karbohidrat diduga disebabkan perbedaan antar perlakuan taraf substitusi gula yang kecil.

Aktivitas dan kadar antioksidan biskuit Interaksi taraf substitusi tepung buah kersen dan gula menunjukkan pengaruh signifikan (p<0,05) terhadap persen penghambatan, total fenol, antosianin dan aktivitas antioksidan. Aktivitas antioksidan biskuit dinyatakan dalam persen penghambatan dan kesetaraan dengan asam

Tabel 3. Kandungan Gizi Biskuit per 100 g

Formula	Kandungan gizi (x ± SD)				
	Air	Abu	Protein	Lemak	Karbohidrat
F1	3,49^{a} ± 0,13	1,62^{ab} ± 0,07	4,96^{a} ± 0,32	19,90^{a} ± 0,36	73,52^{a} ± 0,76
F2	4,17^{a} ± 0,92	1,69^{ab} ± 0,05	4,63^{a} ± 0,09	19,64^{a} ± 0,38	74,02^{a} ± 0,53
F3	4,58^{a} ± 0,67	1,97^{c} ± 0,17	4,91^{a} ± 0,32	19,69^{a} ± 0,58	73,43^{a} ± 1,08
F4	2,99^{a} ± 0,79	1,51^{a} ± 0,07	4,84^{a} ± 0,11	19,62^{a} ± 0,80	74,02^{a} ± 0,83
F5	3,62^{a} ± 1,59	1,72^{ab} ± 0,09	4,58^{a} ± 0,01	19,85^{a} ± 0,73	73,84^{a} ± 0,81
F6	3,92^{a} ± 0,16	1,79^{bc} ± 0,01	4,83^{a} ± 0,0007	19,68^{a} ± 0,57	73,68^{a} ± 0,56
Nilai p					
Faktor A	0,316	0,010	0,143	0,982	0,803
Faktor B	0,299	0,160	0,502	0,948	0,689
Interaksi	0,991	0,356	0,969	0,850	0,825

Keterangan: Faktor A=Tepung kersen (TK), Faktor B= substitusi gula (SG). Formula=TK:SG. F1= 11%:40% , F2 = 17%:40%, F3 = 22%:40%, F4 = 11:50% , F5= 17%:50% dan F6= 22%:50%. Huruf yang sama pada kolom yang sama menunjukkan tidak berbeda signifikan (p>0,05).

askorbat (*Ascorbic acid Equivalent Antioxidant Capacity*; AEAC).

Persen penghambatan biskuit kersen berkisar 48,78% hingga tertinggi sebesar 93,84% (Tabel 4). Taraf minimal substitusi tepung buah kersen ke dalam biskuit sebesar 11% memiliki persen penghambatan sebesar 48,78% (F1) dan 65,56% (F4). Persen penghambatan ini tidak berbeda jauh dengan hasil penelitian Srivastava, Indrani, & Singh (2014) menggunakan tepung kulit delima, di mana biskuit dengan substitusi 7,5% tepung kulit delima menunjukkan persen penghambatan sebesar 52,71%. Penggunaan substitusi tepung buah pada biskuit memiliki kemampuan meredam radikal bebas DPPH setara dengan 82,16 mg hingga 159,33 mg asam askorbat per 100 g biskuit. Aktivitas antioksidan biskuit ini tidak berbeda dengan *cookies* sagu 7,5% pegagan (Saputri & Damayanthi, 2015) dengan aktivitas antioksidan 140 mg asam askorbat per 100 g. Peningkatan substitusi tepung buah kersen meningkatkan aktivitas antioksidan biskuit. Hasil ini sejalan dengan beberapa penelitian. Penggunaan tepung buah mangga pada biskuit meningkatkan antioksidan dan

polifenol (Ajila, Leelavathi, & Rao, 2008). Srivastava *et al.* (2014) menunjukkan adanya peningkatan persen aktivitas antioksidan biskuit dengan peningkatan tepung kulit buah delima dibandingkan kontrol. Aktivitas antioksidan biskuit disebabkan masih ada senyawa antioksidan alami yang tertahan selama pemanggangan dari tepung buah kersen. Buah kersen mengandung kadar fenolik tinggi terutama asam fenolik dan flavonoid dengan aktivitas antioksidan tinggi DPPH IC50 82,25 µg/mL (Pereira *et al.*, 2016). Besar aktivitas antioksidan biskuit mungkin juga disumbang oleh senyawa melanoidin yang dihasilkan dari reaksi *Maillard* selama pemanggangan. Melanoidin memiliki aktivitas antioksidan tinggi (Manzocco, *et al.*, 2001).

Fenol adalah antioksidan kuat yang memiliki peran penting pada kesehatan. Kadar total fenol biskuit berkisar 81,68–140,77 mg GAE/100 g. Peningkatan substitusi tepung buah kersen dan gula cenderung menghasilkan biskuit dengan kadar fenol yang berbeda signifikan ($p<0,05$). Kadar fenol biskuit meningkat seiring peningkatan substitusi tepung buah kersen. Hal ini juga ditunjukkan oleh Aksoylu & Çag (2015) di mana terdapat peningkatan aktivitas antioksidan dan total fenol dengan penggunaan *blueberry* atau tepung biji anggur pada biskuit.

Kadar total flavonoid biskuit berkisar 17,96–29,43 mg quercetin/100 g. Total flavonoid biskuit tidak berbeda signifikan ($p>0,05$) oleh pengaruh interaksi taraf substitusi tepung buah kersen dan gula. Namun, perbedaan taraf substitusi tepung buah kersen menunjukkan perbedaan yang signifikan ($p<0,05$). Hasil ini sejalan dengan Pasqualone *et al.* (2014) di mana terdapat peningkatan kadar flavonoid dengan penggunaan semolina dan ekstrak ampas anggur yang berkontribusi pada senyawa volatil.

Kadar total antosianin biskuit berada pada kisaran 1,47–2,33 mg/100 g. Antosianin merupakan

Tabel 4. Aktivitas dan Kadar Antioksidan Biskuit

Formula	Aktivitas antioksidan		Fenol (mg GAE/100 g)	Flavonoid (mg quercetin/100 g)	Antosianin (mg/100 g)
	% penghambatan	AEAC (mg/100 g)			
F1	$48,78^{a} \pm 3,92$	$82,16^{a} \pm 6,55$	$81,68^{a} \pm 5,07$	$17,96^{a} \pm 4,06$	$1,51^{a} \pm 0,014$
F2	$84,49^{b} \pm 1,76$	$142,88^{b} \pm 2,96$	$127,21^{b} \pm 0,44$	$24,96^{bc} \pm 2,55$	$1,68^{b} \pm 0,00$
F3	$93,84^{c} \pm 0,06$	$159,33^{c} \pm 0,11$	$127,67^{b} \pm 0,29$	$29,43^{c} \pm 2,57$	$2,33^{c} \pm 0,01$
F4	$65,56^{d} \pm 0,50$	$109,65^{d} \pm 0,83$	$106,47^{c} \pm 2,81$	$19,30^{ab} \pm 2,02$	$1,47^{d} \pm 0,00$
F5	$86,33^{b} \pm 5,48$	$145,15^{b} \pm 9,18$	$119,52^{b} \pm 0,72$	$19,79^{ab} \pm 1,53$	$1,62^{e} \pm 0,00$
F6	$91,27^{bc} \pm 0,00$	$153,91^{bc} \pm 0,09$	$140,77^{d} \pm 8,43$	$23,81^{abc} \pm 0,00$	$2,12^{f} \pm 0,01$
Nilai p					
Faktor A	0,000	0,000	0,000	0,011	0,000
Faktor B	0,017	0,026	0,006	0,068	0,000
Interaksi	0,007	0,007	0,004	0,160	0,000

Keterangan: Faktor A=Tepung kersen (TK), Faktor B= substitusi gula (SG). Formula=TK:SG. F1= 10%:40% , F2 = 15%:40%, F3 = 20%:40%, F4 = 10:50% , F5= 15%:50% dan F6= 20%:50%. Huruf yang sama pada kolom yang sama menunjukkan tidak berbeda signifikan ($p>0.05$).

antioksidan yang tidak stabil selama pengolahan terutama rusak akibat perlakuan panas dan pH. Kadar antosianin biskuit kersen tidak berbeda jauh dengan antosianin biskuit dari tepung gandum ungu (Pasqualone *et al.*, 2015) sebesar 1,38 mg/100 g.

Aktivitas antioksidan, fenol, flavonoid dan antosianin menunjukkan peningkatan dengan penggunaan tepung buah kersen pada biskuit, namun pengaruh gula belum terlihat jelas meski hasil statistik menunjukkan perbedaan signifikan. Meskipun demikian, diduga antioksidan fenolik memiliki interaksi dengan gula. Beberapa polifenol menangkap senyawa karbonil dan aldehid hasil dari pemecahan gula dan oksidasi lemak, serta bereaksi dengan senyawa flavor pada produk panggang (Ou & Wang, 2019). Antioksidan polifenol termasuk flavonoid dan antosianin dapat memberikan manfaat kesehatan dengan menurunkan inflamasi dan disfungsi metabolik terkait stres oksidatif, salah satunya melalui perbaikan biomarker status antioksidan (Bindels *et al.*, 2013; Farrell *et al.*, 2015; Gentile *et al.*, 2018).

Korelasi Fenol dengan Aktivitas Antioksidan dan Antioksidan

Kadar fenol yang meningkat seiring peningkatan tepung buah kersen berhubungan positif yang sangat kuat dengan peningkatan aktivitas antioksidan pada biskuit (r=0,886) (Tabel 5). Hasil ini sejalan dengan penelitian Kumar, Sandhir, & Ojha (2014) yang menunjukkan hubungan positif antara aktivitas antioksidan dan kadar fenol pada ekstrak daun lantana camara (r = 0,994). Hubungan yang sangat kuat menunjukkan senyawa fenol berkontribusi utama pada aktivitas antioksidan biskuit kersen. Nilai aktivitas antioksidan total mengikuti tren yang sama dengan kandungan fenol dalam ekstrak (Kumar *et al.*, 2014).

Fenol merupakan kelompok besar antioksidan yang meliputi flavonoid dan antosianin. Aktivitas antioksidan menggambarkan gabungan pengaruh dari senyawa fenolik, flavonoid dan senyawa lainnya dalam ekstrak tanaman. Sun *et al*. (2002) menyatakan bahwa keberadaan fenol, flavonoid dan antosianin pada makanan berhubungan dengan aktivitas antioksidan. Hal ini didukung oleh Pereira *et al*. (2018) bahwa buah kersen menunjukkan aktivitas antioksidan yang tinggi karena keberadaan antosianin, asam fenolik dan flavonoid.

Tabel 5. Korelasi Fenol dengan Aktivitas Antioksidan, Flavonoid dan Antosianin

Variabel korelasi	p	r
Fenol – % penghambatan	0,000	0,886**
Fenol – flavonoid	0,021	0,656*
Fenol – antosianin	0,001	0,837**

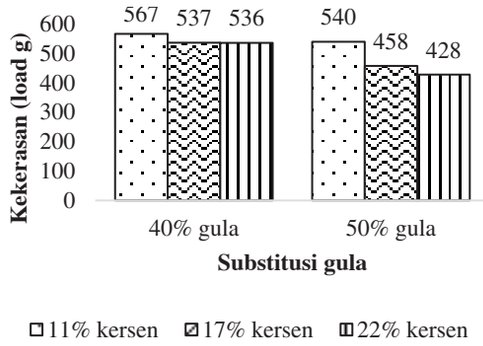
Keterangan:*korelasi kuat, **korelasi sangat kuat

Flavonoid dan antosianin berkontribusi signifikan terhadap total fenol pada biskuit ditunjukkan dengan korelasi yang kuat antara fenol dan flavonoid serta korelasi sangat kuat antara fenol dan antosianin. Flavonoid diperkirakan menyusun 2/3 dari fenol. Flavonoid pada buah kersen berupa rutin, quercetin, mirisetin. Penelitian *in vitro* oksidasi menunjukkan quercetin, mirisetin dan rutin bertindak sebagai antioksidan yang lebih kuat daripada vitamin (Miean & Mohamed, 2001). Pereira et al. (2018) menyebutkan bahwa antiosianin utama pada buah kersen adalah cyanidin-3-O-glukosida (97% dari fraksi antosianin). Cyanidin-3-O-glukosida memiliki aktivitas antioksidan yang lebih kuat dibanding peonidin atau malvidin glikosida (Wang, Cao, & Prior, 1997). Antosianin terutama terdapat pada kulit buah kersen. Penelitian ini menggunakan semua bagian buah kersen dalam pembuatan tepung buah kersen sebagai bahan substitusi biskuit.

Kekerasan Biskuit

Uji kekerasan biskuit dilakukan menggunakan uji penetrasi. Kekerasan menunjukkan ketahanan suatu bahan untuk pecah akibat pemberian gaya tekan. Selama proses pemanggangan biskuit, kepadatan adonan mengalami penurunan dan terbentuk struktur berongga. Pada saat yang sama tekstur yang penting dari biskuit terbentuk berupa kerenyahan disebabkan rendahnya kandungan gluten dan kelembaban.

Kekerasan biskuit kersen cenderung menurun dengan semakin meningkatnya substitusi buah kersen dan substitusi gula. Tepung buah kersen mengandung gum arab sebagai bahan pengisi atau enkapsulat. Hasil ini sejalan dengan penelitian Mudgil, Barak, & Khatkar (2017) yang



Gambar 1. Kekerasan Biskuit

menggunakan guar gum pada *cookies*. Guar gum menurunkan kekerasan *cookies* secara signifikan. Peningkatan substitusi gula dengan campuran gula sorbitol dan sukralosa juga turut berkontribusi pada penurunan kekerasan biskuit. Peningkatan sorbitol dalam biskuit bebas gluten menghasilkan tekstur yang kurang renyah (Aini, Affandi, & Basito, 2016). Sorbitol bersifat mengikat air atau higroskopis. Penggunaan sorbitol pada produk panggang berbasis terigu menghasilkan penurunan kekerasan dibandingkan sukrosa (Srikaeo & Thongta, 2015).

KESIMPULAN DAN SARAN

Pemanfaatan buah kersen dan substitusi gula dapat menghasilkan biskuit, mengandung gizi, antioksidan, dan lebih rendah kandungan gulanya. Buah kersen dapat meningkatkan aktivitas dan kadar antioksidan biskuit. Peningkatan subsitusi tepung buah kersen dan gula menurunkan kekerasan biskuit. Biskuit kersen memiliki peluang dikembangkan sebagai biskuit yang mengandung gizi dan antioksidan yang berguna untuk pencegahan faktor risiko penyakit tidak menular, *overweight* dan obesitas. Pengembangan lebih lanjut diperlukan pada penggunaan substitusi gula sorbitol yang lebih rendah atau kombinasi gula lainnya untuk meningkatkan karakteristik organoleptik dan fisik biskuit yang lebih disukai.

ACKNOWLEDGEMENT

Penelitian ini merupakan bagian dari tesis dengan judul Pemanfaatan Buah Kersen (*Muntingia calabura* L.) pada Biskuit sebagai Pangan Sumber Serat dan Antioksidan. Ucapan terima kasih peneliti sampaikan kepada Lembaga Penelitian dan Pengabdian Masyarakat (LPPM) IPB University melalui hibah Penelitian Dasar Unggulan Perguruan Tinggi (PDUPT) yang telah mendanai sebagian penelitian ini. Ucapan terima kasih juga kepada komisi pembimbing yang telah memberikan saran dan masukan dalam pelaksanaan penelitian.

DAFTAR PUSTAKA

Aini, F. Y., Affandi, D. R., & Basito. (2016). Kajian penggunaan pemanis sorbitol sebagai pengganti sukrosa terhadap karakteristik fisik dan kimia biskuit berbasis tepung jagung (*Zea mays*) dan tepung kacang merah (*Phaseoulus vulgaris* L.). *Jurnal Teknologi Hasil Pertanian*, *IX*(2).

Ajila, C. M., Leelavathi, K., & Prasada Rao, U. J. S. (2008). Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder. *Journal of Cereal Science*, *48*(2), 319–326. doi: 10.1016/j.jcs.2007.10.001

Aksoylu, Z., & Çag, Ö. (2015). Effects of blueberry , grape seed powder and poppy seed incorporation on physicochemical and sensory. *Journal of Food Quality*, *38*, 164–174.

AOAC. (2005). *Official Methods of Analysis of international*. Gaithersburg, MD, USA: AOAC

Barbosa-Cánovas, G., Fernández-Molina, J., Alzamora, S., Tapia, M., López Malo, A., & Chanes, J. (2003). *Handling and preservation of fruits and vegetables by combined methods for rural areas: technical manual FAO agricultural services*. Roma: Food and Agriculture Organization of the United Nations.

Bindels, L. B., Backer, F. De, Cani, P. D., Neyrinck, A. M., He, V. F. Van, & Delzenne, N. M. (2013). Polyphenol-rich extract of pomegranate peel alleviates tissue inflammation and hypercholesterolaemia in high-fat diet-induced obese mice : potential implication of the gut microbiota. *British Journal of Nutrition*, (109), 802–809. doi: 10.1017/S0007114512002206

Bittner, S. (2006). When quinones meet amino acids: chemical, physical and biological consequences. *Amino Acids*, *30*, 205–224.

Cave, M., Hurt, R., & Frazier, T. (2008). Obesity, inflammation, and the potential application of pharmaconutrition. *Nutr Clin Prac*, *23*, 16–34.

Farrell, N. J., Norris, G. H., Ryan, J., Porter, C. M., Jiang, C., & Blesso, C. N. (2015). Black

elderberry extract attenuates inflammation and metabolic dysfunction in diet-induced obese mice. *British Journal of Nutrition*, (114), 1123–1131. doi: 10.1017/S0007114515002962

Gentile, D., Fornai, M., Pellegrini, C., Colucci, R., Blandizzi, C., & Antonioli, L. (2018). Dietary flavonoids as a potential intervention to improve redox balance in obesity and related co-morbidities : a review. *Nutrition Research Reviews*, 1–9. doi: 10.1017/S0954422418000082

Gomathi, R., Anusuya, N., & Manian, S. (2013). A dietary antioxidant supplementation of Jamaican cherries (*Muntingia calabura* L.) attenuates inflammatory related disorders. *Food Science and Biotechnology*, *22*(3), 787–794. https://doi.org/10.1007/s10068-013-0146-1

Kemenkes. (2018). *Laporan Nasional Riskesdas 2018*. Retrieved from www.litbang.kemkes.go.id

Kumar, S., Sandhir, R., & Ojha, S. (2014). Evaluation of antioxidant activity and total phenol in different varieties of *Lantana camara* leaves. *BMC Research Notes*, *7*, 560. doi: 10.1186/1756-0500-7-560

Lao, F., & Giusti, M. M. (2015). Quantification of purple corn (*Zea mays* L.) anthocyanins using spectrophotometric and HPLC approaches : method comparison and correlation. *Food Anal. Methods*. doi: 10.1007/s12161-015-0318-0

Manzocco, L., Calligaris, S., Mastrocola, D., Nicoli, M., & Lerici, C. (2001). Review of non-enzymatic browning and antioxidant capacity in processed foods. *Trends Food Sci. Tech*, *11*, 340–346.

Miean, K. H., & Mohamed, S. (2001). Flavonoid (myricetin, quercetin, kaempferol, luteolin, and apigenin) content of edible tropical plants. *J. Agric. Food Chem*, *49*, 3106–3112.

Molyneux, P. (2004). The use of the stable free radical diphenylpicryl-hydrazyl (DPPH) for estimating antioxidant activity. *Songklanakarin J. Sci. Technol*, *26*(2), 211–219.

Mudgil, D., Barak, S., & Khatkar, B. S. (2017). Acceptability of cookies as a function of soluble dietary fiber, baking time and different water levels. *LWT - Food Science and Technology*, *80*, 537–539.

Muslimin, L., Hasyim, I., Yusuf, N. F., Mubarak, F., & Yulianty, R. (2019). Nutrient content, mineral content and antioxidant activity of *Muntingia calabura* Linn. *Pakistan Journal of Nutrition*, *18*, 726–732. doi: 10.3923/pjn.2019.726.732

Nielsen, S. S. (Ed.). (2010). *Food Analysis* (4th ed.). New York, USA: Springer. doi: 10.1007/978-1-4419-1478-1

Ou, J., & Wang, M. (2019). Positive and negative effects of polyphenol incorporation in baked foods. *Food Chemistry*, *284*, 90–99. doi: 10.1016/j.foodchem.2019.01.096

Pasqualone, A., Bianco, A. M., Paradiso, V. M., Summo, C., Gambacorta, G., & Caponio, F. (2014). Physico-chemical, sensory and volatile profiles of biscuits enriched with grape marc extract. *FRIN*, *65*, 385–393. doi: 10.1016/j.foodres.2014.07.014

Pasqualone, A., Maria, A., Michele, V., Summo, C., Gambacorta, G., Caponio, F., & Blanco, A. (2015). Production and characterization of functional biscuits obtained from purple wheat. *Food Chemistry*, *180*, 64–70. doi: 10.1016/j.foodchem.2015.02.025

Pereira, G. A., Arruda, H. S., de Morais, D. R., Eberlin, M. N., & Pastore, G. M. (2018). Carbohydrates, volatile and phenolic compounds composition, and antioxidant activity of calabura (*Muntingia calabura* L.) fruit. *Food Research International*, *108*, 264–273. doi: 10.1016/j.foodres.2018.03.046

Pereira, G. A., Tomé, P. H. F., Arruda, H. S., Fragiorge, E. J., & Ribeiro, P. R. (2016). Physicochemical characterization and antioxidant activity of Calabura fruit (*Muntingia calabura* L.). *Brazilian Journal of Food Research*, *7*(2), 67. doi: 10.3895/rebrapa.v7n2.3526

Preethi, K., Vijayalakshmi, N., Shamna, R., & Sasikumar, J. M. (2010). In vitro antioxidant activity of extracts from fruits of *Muntingia calabura linn*. from India. *Pharmacognosy Journal*, *2*(14), 11–18. doi: 10.1016/S0975-3575(10)80065-3

Recuenco, M., Lacsamana, M. S., & Sabularse, V. (2016). Total phenolic and total flavonoid contents of selected fruits in the Philippines. *Philippine Journal of Science*, *145 (3)*(January), 275–281.

Saputri, I., & Damayanthi, E. (2015). Penambahan pegagan (*Centella asiatica*) dengan berbagai konsentrasi dan pengaruhnya terhadap sifat fisiko-kimia cookies sagu. *Jurnal Gizi Dan Pangan*, *10*(2), 149–156. https://doi.org/10.25182/jgp.2015.10.2.%p

Siervo, M., Montagnese, C., Mathers, J. C., Soroka, K. R., Stephan, B. C. M., & Wells, J. C. K. (2013). Sugar consumption and global prevalence of obesity and hypertension : an ecological

analysis. *Public Health Nutrition*, *17*(3), 587–596. doi: 10.1017/S1368980013000141

Srikaeo, K., & Thongta, R. (2015). Effects of sugarcane, palm sugar, coconut sugar and sorbitol on starch digestibility and physicochemical properties of wheat based foods. *International Food Research Journal*, *22*, 923–929.

Srivastava, P., Indrani, D., & Singh, R. P. (2014). Effect of dried pomegranate (*Punica granatum*) peel powder (DPPP) on textural, organoleptic and nutritional characteristics of biscuits. *Food Science and Nutrition*, *65*(7), 827–833. doi: 10.3109/09637486.2014.937797

Stapleton, A. P., James, E. M., Goodwill, G. A., & Frisbee, J. C. (2008). Obesity and vascular dysfunction. *Pathophysiology*, *15*, 79–89.

Sun, J., Chu, Y., Wu, X., Hai, R., & Liu. (2002). Antioxidant and antiproliferative activities of common fruits. *Journal of Agricultural and Food Chemistry*, *50*, 7449–7454.

Susantiningsih, T. (2015). Obesitas dan Stres Oksidatif. *Jurnal Kesehatan Unila*, *5*.

Syafiq, A., Setiarini, A., Utari, D.M., Achadi, e.l., Fatmah, Kusharisupeni, ...Indrawani, Y.M. (2014). *Gizi dan Kesehatan Masyarakat*. Jakarta: Rajawali Pers.

Tańska, M., Roszkowska, B., & Czaplicki, S. (2016). Effect of fruit pomace addition on shortbread cookies to improve their physical and nutritional values. *Plant Foods Hum Nutr*, *71*, 307–313. doi: 10.1007/s11130-016-0561-6

Vongsak, B., Sithisarn, P., & Mangmool, S. (2013). Maximizing total phenolics, total flavonoids contents and antioxidant activity of *Moringa oleifera* leaf extract by the appropriate extraction method. *Industrial Crops & Products*, *44*(November 2017), 566–571. doi: 10.1016/j.indcrop.2012.09.021

Wang, H., Cao, G. H., & Prior, R. L. (1997). Oxygen radical absorbing capacity of anthocyanins. *J. Agric. Food Chem*, *45*, 304–309.

PENGARUH PEMANFAATAN TEPUNG BUAH KERSEN (*MUNTINGIA CALABURA* L.) DAN SUBSTITUSI GULA TERHADAP KANDUNGAN GIZI, ANTIOKSIDAN DAN ORGANOLEPTIK BISKUIT

The Effect of Calabura Fruit (Muntingia calabura L.*) Flour Utilization and Sugar Substitution on Nutritional, Antioxidants and Organoleptics of Biscuit*

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ABSTRAK

Perubahan pola konsumsi ke pola yang kurang sehat seperti peningkatan konsumsi gula dan rendahnya konsumsi sayur dan buah, berkontribusi terhadap peningkatan prevalensi *overweight* dan obesitas di Indonesia. *Overweight* dan obesitas merupakan faktor risiko penyakit tidak menular. Pada penderita obesitas terjadi peningkatan stres metabolik, yang lebih lanjut dapat memicu penyakit tidak menular. Buah kersen (*Muntingia calabura* L.) memiliki potensi gizi dan antioksidan yang dapat dimanfaatkan pada pengembangan produk pangan. Pemanfaatan buah kersen dan substitusi gula pada biskuit dapat dilakukan sebagai upaya untuk membuat produk biskuit menjadi lebih bergizi, mengandung antioksidan dan lebih rendah gula yang dapat berkontribusi pada pencegahan faktor risiko *overweight* dan obesitas. Penelitian ini bertujuan untuk menganalisis pengaruh pemanfaatan tepung buah kersen dan substitusi gula terhadap kandungan gizi, kandungan antioksidan, aktivitas antioksidan, karakteristik organoleptik serta karakteristik fisik biskuit. Rancangan Percobaan yang digunakan adalah Rancangan Acak Lengkap Faktorial dengan dua faktor, yaitu substitusi tepung buah kersen dan substitusi gula. Analisis yang dilakukan meliputi analisis kandungan gizi, kadar dan aktivitas antioksidan, dan kekerasan. Pengaruh perlakuan terhadap kandungan zat gizi dianalisis menggunakan sidik ragam (ANOVA), sedangkan terhadap sifat organoleptik menggunakan *Kruskal Wallis*. Hasil penelitian menunjukkan bahwa substitusi tepung buah kersen dan gula memberikan pengaruh terhadap kadar abu serta kandungan dan aktivitas antioksidan biskuit ($p<0,05$), namun tidak berpengaruh pada karakteristik organoleptik biskuit. Peningkatan taraf substitusi tepung buah kersen meningkatkan aktivitas dan kadar antioksidan biskuit.

Kata kunci: antioksidan, gula pengganti, *Muntingia calabura* L., obesitas, penyakit tidak menular

ABSTRACT

Changes in dietary pattern to unhealthy, such as increased in sugar and low of fruits and vegetables consumption, are among factors contribute to the increase of overweight and obesity prevalence in Indonesia. Overweight and obesity are risk factors of non-communicable diseases. Obese people had increased of metabolic stress, further lead to non-communicable diseases. Calabura fruit (Muntingia calabura L.*) has nutritional and antioxidant potential, which can be utilized in the development of food products. The utilization of Calabura fruit and sugar substitution in biscuits could be done as an effort to make healthy biscuits, contain antioxidants and lower sugar, which may contribute to the prevention of overweight and obesity. This research aims to analyze the effect of utilization of Calabura fruit flour and sugar substitution on the nutritional, antioxidant, antioxidant activity, organoleptic and physical characteristics of biscuits. An experimental study was conducted by using completely randomized factorial design with two factors: the substitution of Calabura fruit flour and sugar substitution. The analysis included nutrients and antioxidants content, antioxidant activity, and hardness of biscuits. The effect of treatment on nutritional content was analyzed using ANOVA and the Kruskal Wallis test for organoleptic. The results show that Calabura fruit flour and sugar substitution significantly affect ash, antioxidants content, and antioxidant activity of biscuit ($p<0,05$), but has no effect on organoleptic characteristics. The increased level of Calabura flour substitution improves antioxidant content and antioxidant activity in biscuits..*

Keywords*— antioxidants, sugar replacer, Muntingia calabura* L.*, obesity, non-communicable diseases*

 Received 14-07-2020, Accepted 11-09-2021, Published online 30-01-2022

PENDAHULUAN

Kondisi *overweight* dan obesitas di Indonesia saat ini semakin mengalami peningkatan dari tahun ke tahun. Prevalensi obesitas pada dewasa usia 18 tahun ke atas meningkat dari 14,8% pada 2013 menjadi 21,8% pada 2018 (Kemenkes, 2018). Kondisi ini erat kaitannya dengan kejadian berbagai penyakit termasuk penyakit tidak menular seperti penyakit jantung, stroke, diabetes mellitus dan sebagainya. Tingkat morbiditas dan mortalitas pada penderita obesitas meningkat dengan umur harapan hidup yang lebih pendek (Syafiq *et al.*, 2014). Pada kondisi obesitas terjadi pembentukan lemak tubuh yang berlebihan, penghambatan pemecahan lemak dan inflamasi (Susantiningsih, 2015). Inflamasi yang disebabkan obesitas secara lebih lanjut menyebabkan perubahan kondisi metabolik seperti stres metabolik. Stres metabolik juga berkaitan dengan stres oksidatif dalam tubuh yaitu ketidakseimbangan antara radikal bebas dan antioksidan. Stres oksidatif dalam tubuh menyebabkan kerusakan sel, jaringan atau organ, yang lebih lanjut memicu patogenesis penyakit-penyakit tidak menular. Protein penanda inflamasi (*C-Reactive Protein*; CRP) pada obesitas 10 kali lebih tinggi dibandingkan normal (Cave, Hurt, & Frazier, 2008).

Perubahan pola konsumsi kepada makanan tinggi lemak, tinggi gula, rendah serat dan antioksidan, serta rendahnya aktivitas fisik merupakan beberapa penyebab *overweight* dan obesitas. Siervo *et al.* (2013) menunjukkan bahwa konsumsi makanan dan minuman tinggi gula berhubungan dengan peningkatan prevalensi berat badan lebih ($\rho = 0,37$, $P<0,001$) dan obesitas ($\rho = 0,31$, $P<0,001$), di mana faktor konsumsi energi dari gula merupakan prediktor obesitas ($B=0,04$, $SE=0,01$, $p=0,009$). Selain itu, rendahnya konsumsi serat dan makanan sumber antioksidan menjadi faktor pencetus kegemukan yang tidak kalah penting. Hal ini ditunjukkan dari rendahnya konsumsi sayur dan buah pada masyarakat Indonesia. Sebagian besar (95,5%) masyarakat usia ≥ 5 tahun mengonsumsi sayur dan buah di bawah anjuran pedoman gizi seimbang 5 porsi sehari (Kemenkes, 2018).

Organisasi Kesehatan Dunia (WHO) menyebutkan bahwa senyawa bioaktif penting untuk pencegahan penyakit diabetes, kanker dan obesitas terutama dari buah-buahan kecil berwarna (Stapleton *et al.*, 2008). Buah kersen (*Muntingia calabura L.*) merupakan buah yang memiliki potensi gizi dan bioaktif antioksidan. Buah ini tumbuh luas di beberapa negara termasuk Indonesia. Kandungan gizi buah kersen meliputi air (77,36%), abu (5,65%), karbohidrat (72,15%), protein (8,29%), lemak (7,79%), serat kasar (5,93%), dan vitamin C (3,30 mg per 100 g), dengan nilai energi total yang rendah (Pereira *et al.*, 2016). Selain itu, buah kersen berkontribusi pada senyawa bioaktif antioksidan seperti asam fenolik, antosianin dan flavonoid yang menunjukkan bioaktivitas antimikroba, antioksidan dan antiinflamasi. Aktivitas antiinflamasi flavons, flavonols (rutin, quercetin, kaempferol, mirisetin) dan beberapa terpenoid pada buah kersen dapat menghambat ekspresi COX dan lipopolisakarida yang bertanggung jawab pada kejadian inflamasi (Gomathi, Anusuya, & Manian, 2013). Buah kersen mengandung senyawa fenolik sebesar 526,55 mg asam tanin ekuivalen (TAE) per 100 g, antosianin 4,08 mg sianidin-3-glukosida ekuivalen (CGE) per 100 g dan aktivitas antioksidan DPPH IC50 (82,25 µg/mL) (Pereira *et al.*, 2016). Namun, potensi dari buah kersen masih belum dimanfaatkan secara optimal. Buah kersen hanya dikonsumsi sesekali dan pohonnya secara umum hanya dimanfaatkan sebagai pohon peneduh pinggir jalan.

Buah kersen berpeluang untuk digunakan dalam menghasilkan produk pangan dengan kandungan gizi dan manfaat bioaktif antioksidan. Produk pangan seperti biskuit memiliki peluang untuk dikembangkan disebabkan tingginya konsumsi, disukai, praktis dan memiliki keawetan yang baik. Biskuit yang beredar di masyarakat umumnya memiliki kandungan karbohidrat dan gula yang tinggi serta rendah serat dan antioksidan. Saat ini, mulai bermunculan produsen makanan yang berupaya menghasilkan produk pangan yang lebih sehat. Selain itu, beberapa penelitian pada produk biskuit dilakukan untuk menghasilkan biskuit yang memiliki kandungan gizi dan memiliki manfaat kesehatan dengan cara mengombinasikan dan memanfaatkan bahan-bahan berpotensi gizi serta meminimalkan penggunaan gula. Oleh karena itu, pemanfaatan buah kersen dalam menghasilkan biskuit yang bergizi dan mengandung antioksidan menarik untuk dilakukan

sebagai upaya menghasilkan produk pangan yang berkontribusi pada pencegahan penyakit tidak menular terutama dari faktor risiko *overweight* dan obesitas. Penelitian ini bertujuan untuk melihat pengaruh pemanfaatan buah kersen dan substitusi gula pada kandungan gizi, antioksidan dan organoleptik biskuit.

METODE

Desain penelitian ini adalah eksperimental menggunakan rancangan acak lengkap faktorial berupa faktor substitusi tepung buah kersen dan substitusi gula pada biskuit berbasis parsial mocaf. Buah kersen diolah menjadi tepung buah kersen sebelum digunakan dalam pembuatan biskuit. Tepung buah kersen dibuat dengan cara pengeringan menggunakan alat vakum evaporator, kemudian penggilingan dan pengayakan 40 mesh. Taraf tepung buah kersen untuk substitusi parsial terigu mocaf yaitu 11%, 17% dan 22% terhadap total tepung terigu dan mocaf, dan taraf substitusi gula yaitu 40% dan 50% dari total gula, menggunakan campuran 2 jenis pemanis yang dihitung setara dengan kemanisan sukrosa. Pemanis yang digunakan adalah sorbitol dan Diabetasol sukralosa. Formulasi biskuit disajikan pada Tabel 1.

Proses pembuatan biskuit dengan metode *creaming*, diawali dengan pencampuran bahan basah kemudian pencampuran bahan kering tepung-tepungan hingga adonan tercampur rata. Selanjutnya, pencetakan adonan setebal 4 mm dan pemanggangan pada suhu 160°C selama 15 menit. Uji organoleptik terhadap biskuit dilakukan menggunakan uji hedonik pada atribut rasa, aroma, warna, tekstur (*mouthfeel*) dan keseluruhan. Skala penilaian dari 1 hingga 7, yaitu 1 (Sangat tidak suka), 2 (Tidak suka), 3 (Agak tidak suka), 4 (Biasa), 5 (Agak suka), 6 (Suka), dan 7 (Sangat suka) oleh 31 orang panelis semi terlatih. Analisis kandungan gizi, sifat fisik kekerasan, aktivitas antioksidan dan kadar antioksidan dilakukan terhadap seluruh formula biskuit. Analisis kandungan gizi meliputi kadar air menggunakan metode oven, kadar abu menggunakan metode gravimetri, kadar protein metode Kjeldahl menggunakan Foss Tecator Kjeltec KT 200, kadar lemak metode Soxhlet menggunakan Foss Soxtec ST 243 dan kadar karbohidrat *by difference* (AOAC, 2005). Aktivitas antioksidan metode DPPH mengacu Molyneux (2004) dan Preethi, Vijayalakshmi, Shamna, & Sasikumar (2010) dengan modifikasi. Analisis kadar antioksidan kuantitatif meliputi total fenol menggunakan metode Folin-Ciocalteau (Vongsak, Sithisarn, & Mangmool, 2013), total flavonoid metode kolorimetri $AlCl_3$ (Recuenco, Lacsamana, & Sabularse, 2016), dan antosianin total (Lao

Tabel 1. Formulasi Biskuit

Formula (g)	Berat bahan (g)						
	kontrol	F1	F2	F3	F4	F5	F6
Tepung terigu	45	40	37,5	35	40	37,5	35
Tepung mocaf	45	40	37,5	35	40	37,5	35
Pati jagung	10	10	10	10	10	10	10
Tepung kersen*	-	10	15	20	10	15	20
Susu bubuk skim	2	2	2	2	2	2	2
Kuning telur	10	10	10	10	10	10	10
Garam	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Gula aren*	25	15	15	15	12,5	12,5	12,5
Sorbitol*	-	13,5	13,5	13,5	16,5	16,5	16,5
Gula sukralosa*	-	0,2	0,2	0,2	0,25	0,25	0,25
Mentega	16	16	16	16	16	16	16
Margarin	16	16	16	16	16	16	16
Vanili esens	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Baking powder	0,25	0,25	0,25	0,25	0,25	0,25	0,25
Total adonan	170	175	175	175	175	175	175

Keterangan: *variabel perlakuan

& Giusti, 2015). Analisis fisik kekerasan diukur menggunakan Stevens-LFRA *Texture Analyzer*.

Data yang terkumpul ditabulasi dan dianalisis menggunakan Excel dan SPSS 16.0 *for Windows*. Semua data diuji normalitas sebelum diuji statistik. Data hasil uji organoleptik dianalisis menggunakan *Kruskal Wallis* yang disajikan dalam nilai modus dan persentase panelis. Hasil analisis kimia dianalisis secara statistik menggunakan *two-way* ANOVA (α=0,05), diikuti dengan uji lanjut Duncan bila terdapat pengaruh signifikan. *Sifat* fisik kekerasan biskuit dianalisis secara deskriptif.

HASIL DAN PEMBAHASAN

Uji Organoleptik Biskuit

Hasil uji organoleptik disajikan pada Tabel 2. Berdasarkan uji statistik *Kruskal Wallis*, seluruh perlakuan tidak berpengaruh signifikan (p>0,05) terhadap tingkat kesukaan panelis pada atribut warna, rasa, aroma, tekstur (*mouthfeel*) dan keseluruhan. Namun, berdasarkan kecenderungan data, F5 paling disukai (modus 6) dengan persentase jumlah panelis tertinggi pada atribut warna. Warna biskuit relatif cokelat. Kombinasi penggunaan tepung buah kersen dengan warna °Hue kuning merah dan gula aren memberikan warna coklat pada biskuit, selain efek reaksi *Maillard* yang terjadi selama pemanggangan. Warna coklat juga berasal dari interaksi antioksidan fenol dengan bahan biskuit. Oksidasi fenol oleh pengaruh enzim, pemanasan dan pH tinggi menghasilkan quinon yang menghasilkan pigmen warna coklat (Bittner, 2006). Hal ini sebagaimana (Ou & Wang, 2019) dimana senyawa fenolik, taraf penambahan bahan mengandung fenolik dan suhu pemanggangan dapat mempengaruhi warna Berdasarkan rasa, F1 disukai dengan persen modus tertinggi (40%). F1 juga paling disukai dari segi aroma dengan nilai modus 6 (suka) dan persentase panelis tertinggi (40%).

Atribut sensori produk panggang dapat dipengaruhi oleh penggunaan *by-product* yang mengandung antioksidan fenolik. Penambahan 20% pomace buah campuran blackcurrant, rowan, rosehip dan elderberry pada *cookies* menurunkan penilaian terhadap aroma dengan aroma panggang yang rendah (Tańska, Roszkowska, & Czaplicki, 2016). Keberadaan polifenol menghambat pembentukan senyawa aroma dan *flavor* yang dihasilkan dari reaksi mekanisme penangkapan senyawa karbonil dari fragmentasi gula selama pemanggangan pada produk panggang (Ou & Wang, 2019).

Peningkatan taraf substitusi gula menurunkan jumlah gula yang terlibat pada reaksi *Maillard* sehingga senyawa karbonil yang terbentuk lebih sedikit. Kandungan fenolik dalam tepung buah dan interaksinya dengan gula dapat menurunkan pembentukan senyawa flavor dan aroma biskuit. Pengaruh taraf substitusi tepung buah kersen dan gula terhadap atribut sensori pada penelitian ini tidak berbeda signifikan, namun dilaporkan menghasilkan aroma dan rasa buah kersen yang lemah yang masih disukai panelis.

Atribut tekstur disukai oleh panelis (modus 6) pada formula F2 dan F4. Formula F6 memiliki modus tekstur terendah yaitu 4 (biasa) di antara formula lainnya. Penggunaan tepung buah kersen pada tingkat substitusi tertinggi pada

Tabel 2. Hasil Uji Kesukaan (Hedonik)

Formula	Atribut				
	Warna	Rasa	Aroma	Tekstur	Keseluruhan
F1	5 (33,3)[a]	6 (40,0)[a]	6 (40,0)[a]	5 (33,3)[a]	6 (36,7)[a]
F2	6 (46,7)[a]	6 (30,0)[a]	4 (33,3)[a]	6 (40,0)[a]	6 (30,0)[a]
F3	6 (40,0)[a]	5 (30,0)[a]	4 (26,7)[a]	5 (33,3)[a]	5 (26,7)[a]
F4	6 (33,3)[a]	5 (26,7)[a]	6 (30,0)[a]	6 (30,0)[a]	5 (36,7)[a]
F5	6 (50,0)[a]	6 (26,7)[a]	6 (26,7)[a]	5 (33,3)[a]	5 (36,7)[a]
F6	5 (33,3)[a]	5 (43,3)[a]	6 (33,3)[a]	4 (30,0)[a]	6 (30,0)[a]
Nilai p	0,202	0,360	0,833	0,305	0,580

Keterangan: Skala 1= sangat tidak suka, 2= tidak suka, 3= agak tidak suka, 4= biasa, 5= agak suka, 6= suka, 7= sangat suka. Tepung kersen (TK), Substitusi gula (SG). Formula=TK:SG. F1= 11%:40% , F2 = 17%:40%, F3 = 22%:40%, F4 = 11:50% , F5= 17%:50% dan F6= 22%:50%. Huruf yang sama pada kolom yang sama menunjukkan tidak berbeda signifikan (p>0,05).

F6 menyebabkan tekstur yang kurang disukai. Beberapa panelis melaporkan tekstur biskuit yang kurang rapuh beremah dan *crunchy* renyah. Atribut keseluruhan menunjukkan bahwa formula yang disukai panelis (modus 6) yaitu F1, F2 dan F6. Nilai persentase panelis tertinggi terhadap kesukaan atribut keseluruhan biskuit kersen diperoleh oleh F1.

Kandungan Zat Gizi Biskuit

Kadar air biskuit kersen berkisar 2,99–4,58% (Tabel 3). Kadar air biskuit tidak berbeda signifikan (p>0,05) antar taraf dan interaksi substitusi tepung buah kersen dan gula. Namun, kadar air biskuit memperlihatkan kecenderungan peningkatan seiring peningkatan substitusi tepung buah kersen. Tepung buah kersen mengandung air yang akan meningkatkan kadar air biskuit seiring peningkatan substitusi tepung. Selain itu, peningkatan taraf substitusi gula menunjukkan kecenderungan penurunan kadar air biskuit. Hal ini disebabkan terbentuknya air terikat dalam biskuit oleh perlakuan substitusi gula. Air terikat adalah air yang berikatan suatu senyawa. Penggunaan gula sorbitol dan keberadaan gum arab dalam tepung buah kersen bersifat mengikat air (higroskopis). Air terikat ini akan sulit dan sedikit diuapkan ketika proses pemanggangan sehingga kadar air dalam biskuit tertahan (Barbosa-Cánovas *et al*., 2003). Kadar air yang sedikit teruapkan menyebabkan penilaian kadar air menjadi lebih rendah.

Kadar abu biskuit berkisar 1,51–1,97%. Interaksi perlakuan substitusi tepung buah kersen dan substitusi gula tidak memberikan perbedaan kadar abu yang signifikan. Kadar abu menunjukkan perbedaan signifikan dari perbedaan taraf substitusi tepung buah kersen berdasarkan uji *two-way* ANOVA (p<0,05). Semakin tinggi substitusi tepung buah kersen meningkatkan kadar abu biskuit. Kadar abu total menunjukkan kandungan mineral total dalam makanan (Nielsen, 2010). Buah kersen mengandung mineral yang berkontribusi pada peningkatan kadar abu biskuit. Buah kersen mengandung kadar abu dengan kandungan 16 jenis mineral di mana zat besi (Fe) sebagai mineral mikro tertinggi dan kalium sebagai mineral makro tertinggi (Muslimin *et al*., 2019).

Kadar protein, lemak dan karbohidrat biskuit tidak berbeda signifikan oleh perbedaan taraf dan interaksi substitusi tepung buah kersen dan substitusi gula. Kadar protein, lemak dan karbohidrat biskuit berkisar 4,58–4,96 %, 19,62–19,90 % dan 73,43–74,02%, secara berturut-turut. Kandungan protein, lemak, karbohidrat pada buah kersen kurang memberi kontribusi signifikan pada biskuit. Peningkatan taraf substitusi gula juga tidak memberikan pengaruh signifikan terutama pada karbohidrat diduga disebabkan perbedaan antar perlakuan taraf substitusi gula yang kecil.

Aktivitas dan kadar antioksidan biskuit Interaksi taraf substitusi tepung buah kersen dan gula menunjukkan pengaruh signifikan (p<0,05) terhadap persen penghambatan, total fenol, antosianin dan aktivitas antioksidan. Aktivitas antioksidan biskuit dinyatakan dalam persen penghambatan dan kesetaraan dengan asam

Tabel 3. Kandungan Gizi Biskuit per 100 g

Formula	Kandungan gizi (x ± SD)				
	Air	Abu	Protein	Lemak	Karbohidrat
F1	3,49^{a} ± 0,13	1,62^{ab} ± 0,07	4,96^{a} ± 0,32	19,90^{a} ± 0,36	73,52^{a} ± 0,76
F2	4,17^{a} ± 0,92	1,69^{ab} ± 0,05	4,63^{a} ± 0,09	19,64^{a} ± 0,38	74,02^{a} ± 0,53
F3	4,58^{a} ± 0,67	1,97^{c} ± 0,17	4,91^{a} ± 0,32	19,69^{a} ± 0,58	73,43^{a} ± 1,08
F4	2,99^{a} ± 0,79	1,51^{a} ± 0,07	4,84^{a} ± 0,11	19,62^{a} ± 0,80	74,02^{a} ± 0,83
F5	3,62^{a} ± 1,59	1,72^{ab} ± 0,09	4,58^{a} ± 0,01	19,85^{a} ± 0,73	73,84^{a} ± 0,81
F6	3,92^{a} ± 0,16	1,79^{bc} ± 0,01	4,83^{a} ± 0,0007	19,68^{a} ± 0,57	73,68^{a} ± 0,56
Nilai p					
Faktor A	0,316	0,010	0,143	0,982	0,803
Faktor B	0,299	0,160	0,502	0,948	0,689
Interaksi	0,991	0,356	0,969	0,850	0,825

Keterangan: Faktor A=Tepung kersen (TK), Faktor B= substitusi gula (SG). Formula=TK:SG. F1= 11%:40% , F2 = 17%:40%, F3 = 22%:40%, F4 = 11:50% , F5= 17%:50% dan F6= 22%:50%. Huruf yang sama pada kolom yang sama menunjukkan tidak berbeda signifikan (p>0,05).

askorbat (*Ascorbic acid Equivalent Antioxidant Capacity*; AEAC).

Persen penghambatan biskuit kersen berkisar 48,78% hingga tertinggi sebesar 93,84% (Tabel 4). Taraf minimal substitusi tepung buah kersen ke dalam biskuit sebesar 11% memiliki persen penghambatan sebesar 48,78% (F1) dan 65,56% (F4). Persen penghambatan ini tidak berbeda jauh dengan hasil penelitian Srivastava, Indrani, & Singh (2014) menggunakan tepung kulit delima, di mana biskuit dengan substitusi 7,5% tepung kulit delima menunjukkan persen penghambatan sebesar 52,71%. Penggunaan substitusi tepung buah pada biskuit memiliki kemampuan meredam radikal bebas DPPH setara dengan 82,16 mg hingga 159,33 mg asam askorbat per 100 g biskuit. Aktivitas antioksidan biskuit ini tidak berbeda dengan *cookies* sagu 7,5% pegagan (Saputri & Damayanthi, 2015) dengan aktivitas antioksidan 140 mg asam askorbat per 100 g. Peningkatan substitusi tepung buah kersen meningkatkan aktivitas antioksidan biskuit. Hasil ini sejalan dengan beberapa penelitian. Penggunaan tepung buah mangga pada biskuit meningkatkan antioksidan dan

polifenol (Ajila, Leelavathi, & Rao, 2008). Srivastava *et al.* (2014) menunjukkan adanya peningkatan persen aktivitas antioksidan biskuit dengan peningkatan tepung kulit buah delima dibandingkan kontrol. Aktivitas antioksidan biskuit disebabkan masih ada senyawa antioksidan alami yang tertahan selama pemanggangan dari tepung buah kersen. Buah kersen mengandung kadar fenolik tinggi terutama asam fenolik dan flavonoid dengan aktivitas antioksidan tinggi DPPH IC50 82,25 µg/mL (Pereira *et al.*, 2016). Besar aktivitas antioksidan biskuit mungkin juga disumbang oleh senyawa melanoidin yang dihasilkan dari reaksi *Maillard* selama pemanggangan. Melanoidin memiliki aktivitas antioksidan tinggi (Manzocco, *et al.*, 2001).

Fenol adalah antioksidan kuat yang memiliki peran penting pada kesehatan. Kadar total fenol biskuit berkisar 81,68–140,77 mg GAE/100 g. Peningkatan substitusi tepung buah kersen dan gula cenderung menghasilkan biskuit dengan kadar fenol yang berbeda signifikan ($p<0,05$). Kadar fenol biskuit meningkat seiring peningkatan substitusi tepung buah kersen. Hal ini juga ditunjukkan oleh Aksoylu & Çag (2015) di mana terdapat peningkatan aktivitas antioksidan dan total fenol dengan penggunaan *blueberry* atau tepung biji anggur pada biskuit.

Kadar total flavonoid biskuit berkisar 17,96–29,43 mg quercetin/100 g. Total flavonoid biskuit tidak berbeda signifikan ($p>0,05$) oleh pengaruh interaksi taraf substitusi tepung buah kersen dan gula. Namun, perbedaan taraf substitusi tepung buah kersen menunjukkan perbedaan yang signifikan ($p<0,05$). Hasil ini sejalan dengan Pasqualone *et al.* (2014) di mana terdapat peningkatan kadar flavonoid dengan penggunaan semolina dan ekstrak ampas anggur yang berkontribusi pada senyawa volatil.

Kadar total antosianin biskuit berada pada kisaran 1,47–2,33 mg/100 g. Antosianin merupakan

Tabel 4. Aktivitas dan Kadar Antioksidan Biskuit

Formula	Aktivitas antioksidan		Fenol (mg GAE/100 g)	Flavonoid (mg quercetin/100 g)	Antosianin (mg/100 g)
	% penghambatan	AEAC (mg/100 g)			
F1	$48,78^{a} \pm 3,92$	$82,16^{a} \pm 6,55$	$81,68^{a} \pm 5,07$	$17,96^{a} \pm 4,06$	$1,51^{a} \pm 0,014$
F2	$84,49^{b} \pm 1,76$	$142,88^{b} \pm 2,96$	$127,21^{b} \pm 0,44$	$24,96^{bc} \pm 2,55$	$1,68^{b} \pm 0,00$
F3	$93,84^{c} \pm 0,06$	$159,33^{c} \pm 0,11$	$127,67^{b} \pm 0,29$	$29,43^{c} \pm 2,57$	$2,33^{c} \pm 0,01$
F4	$65,56^{d} \pm 0,50$	$109,65^{d} \pm 0,83$	$106,47^{c} \pm 2,81$	$19,30^{ab} \pm 2,02$	$1,47^{d} \pm 0,00$
F5	$86,33^{b} \pm 5,48$	$145,15^{b} \pm 9,18$	$119,52^{b} \pm 0,72$	$19,79^{ab} \pm 1,53$	$1,62^{e} \pm 0,00$
F6	$91,27^{bc} \pm 0,00$	$153,91^{bc} \pm 0,09$	$140,77^{d} \pm 8,43$	$23,81^{abc} \pm 0,00$	$2,12^{f} \pm 0,01$
Nilai p					
Faktor A	0,000	0,000	0,000	0,011	0,000
Faktor B	0,017	0,026	0,006	0,068	0,000
Interaksi	0,007	0,007	0,004	0,160	0,000

Keterangan: Faktor A=Tepung kersen (TK), Faktor B= substitusi gula (SG). Formula=TK:SG. F1= 10%:40% , F2 = 15%:40%, F3 = 20%:40%, F4 = 10:50% , F5= 15%:50% dan F6= 20%:50%. Huruf yang sama pada kolom yang sama menunjukkan tidak berbeda signifikan ($p>0.05$).

antioksidan yang tidak stabil selama pengolahan terutama rusak akibat perlakuan panas dan pH. Kadar antosianin biskuit kersen tidak berbeda jauh dengan antosianin biskuit dari tepung gandum ungu (Pasqualone *et al.*, 2015) sebesar 1,38 mg/100 g.

Aktivitas antioksidan, fenol, flavonoid dan antosianin menunjukkan peningkatan dengan penggunaan tepung buah kersen pada biskuit, namun pengaruh gula belum terlihat jelas meski hasil statistik menunjukkan perbedaan signifikan. Meskipun demikian, diduga antioksidan fenolik memiliki interaksi dengan gula. Beberapa polifenol menangkap senyawa karbonil dan aldehid hasil dari pemecahan gula dan oksidasi lemak, serta bereaksi dengan senyawa flavor pada produk panggang (Ou & Wang, 2019). Antioksidan polifenol termasuk flavonoid dan antosianin dapat memberikan manfaat kesehatan dengan menurunkan inflamasi dan disfungsi metabolik terkait stres oksidatif, salah satunya melalui perbaikan biomarker status antioksidan (Bindels *et al.*, 2013; Farrell *et al.*, 2015; Gentile *et al.*, 2018).

Korelasi Fenol dengan Aktivitas Antioksidan dan Antioksidan

Kadar fenol yang meningkat seiring peningkatan tepung buah kersen berhubungan positif yang sangat kuat dengan peningkatan aktivitas antioksidan pada biskuit (r=0,886) (Tabel 5). Hasil ini sejalan dengan penelitian Kumar, Sandhir, & Ojha (2014) yang menunjukkan hubungan positif antara aktivitas antioksidan dan kadar fenol pada ekstrak daun lantana camara (r = 0,994). Hubungan yang sangat kuat menunjukkan senyawa fenol berkontribusi utama pada aktivitas antioksidan biskuit kersen. Nilai aktivitas antioksidan total mengikuti tren yang sama dengan kandungan fenol dalam ekstrak (Kumar *et al.*, 2014).

Fenol merupakan kelompok besar antioksidan yang meliputi flavonoid dan antosianin. Aktivitas antioksidan menggambarkan gabungan pengaruh dari senyawa fenolik, flavonoid dan senyawa lainnya dalam ekstrak tanaman. Sun *et al*. (2002) menyatakan bahwa keberadaan fenol, flavonoid dan antosianin pada makanan berhubungan dengan aktivitas antioksidan. Hal ini didukung oleh Pereira *et al*. (2018) bahwa buah kersen menunjukkan aktivitas antioksidan yang tinggi karena keberadaan antosianin, asam fenolik dan flavonoid.

Tabel 5. Korelasi Fenol dengan Aktivitas Antioksidan, Flavonoid dan Antosianin

Variabel korelasi	p	r
Fenol – % penghambatan	0,000	0,886**
Fenol – flavonoid	0,021	0,656*
Fenol – antosianin	0,001	0,837**

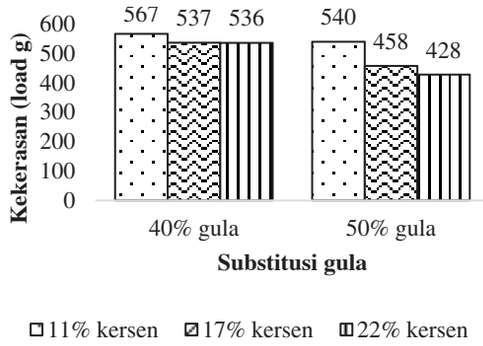
Keterangan:*korelasi kuat, **korelasi sangat kuat

Flavonoid dan antosianin berkontribusi signifikan terhadap total fenol pada biskuit ditunjukkan dengan korelasi yang kuat antara fenol dan flavonoid serta korelasi sangat kuat antara fenol dan antosianin. Flavonoid diperkirakan menyusun 2/3 dari fenol. Flavonoid pada buah kersen berupa rutin, quercetin, mirisetin. Penelitian *in vitro* oksidasi menunjukkan quercetin, mirisetin dan rutin bertindak sebagai antioksidan yang lebih kuat daripada vitamin (Miean & Mohamed, 2001). Pereira et al. (2018) menyebutkan bahwa antiosianin utama pada buah kersen adalah cyanidin-3-O-glukosida (97% dari fraksi antosianin). Cyanidin-3-O-glukosida memiliki aktivitas antioksidan yang lebih kuat dibanding peonidin atau malvidin glikosida (Wang, Cao, & Prior, 1997). Antosianin terutama terdapat pada kulit buah kersen. Penelitian ini menggunakan semua bagian buah kersen dalam pembuatan tepung buah kersen sebagai bahan substitusi biskuit.

Kekerasan Biskuit

Uji kekerasan biskuit dilakukan menggunakan uji penetrasi. Kekerasan menunjukkan ketahanan suatu bahan untuk pecah akibat pemberian gaya tekan. Selama proses pemanggangan biskuit, kepadatan adonan mengalami penurunan dan terbentuk struktur berongga. Pada saat yang sama tekstur yang penting dari biskuit terbentuk berupa kerenyahan disebabkan rendahnya kandungan gluten dan kelembaban.

Kekerasan biskuit kersen cenderung menurun dengan semakin meningkatnya substitusi buah kersen dan substitusi gula. Tepung buah kersen mengandung gum arab sebagai bahan pengisi atau enkapsulat. Hasil ini sejalan dengan penelitian Mudgil, Barak, & Khatkar (2017) yang



Gambar 1. Kekerasan Biskuit

menggunakan guar gum pada *cookies*. Guar gum menurunkan kekerasan *cookies* secara signifikan. Peningkatan substitusi gula dengan campuran gula sorbitol dan sukralosa juga turut berkontribusi pada penurunan kekerasan biskuit. Peningkatan sorbitol dalam biskuit bebas gluten menghasilkan tekstur yang kurang renyah (Aini, Affandi, & Basito, 2016). Sorbitol bersifat mengikat air atau higroskopis. Penggunaan sorbitol pada produk panggang berbasis terigu menghasilkan penurunan kekerasan dibandingkan sukrosa (Srikaeo & Thongta, 2015).

KESIMPULAN DAN SARAN

Pemanfaatan buah kersen dan substitusi gula dapat menghasilkan biskuit, mengandung gizi, antioksidan, dan lebih rendah kandungan gulanya. Buah kersen dapat meningkatkan aktivitas dan kadar antioksidan biskuit. Peningkatan subsitusi tepung buah kersen dan gula menurunkan kekerasan biskuit. Biskuit kersen memiliki peluang dikembangkan sebagai biskuit yang mengandung gizi dan antioksidan yang berguna untuk pencegahan faktor risiko penyakit tidak menular, *overweight* dan obesitas. Pengembangan lebih lanjut diperlukan pada penggunaan substitusi gula sorbitol yang lebih rendah atau kombinasi gula lainnya untuk meningkatkan karakteristik organoleptik dan fisik biskuit yang lebih disukai.

ACKNOWLEDGEMENT

Penelitian ini merupakan bagian dari tesis dengan judul Pemanfaatan Buah Kersen (*Muntingia calabura* L.) pada Biskuit sebagai Pangan Sumber Serat dan Antioksidan. Ucapan terima kasih peneliti sampaikan kepada Lembaga Penelitian dan Pengabdian Masyarakat (LPPM) IPB University melalui hibah Penelitian Dasar Unggulan Perguruan Tinggi (PDUPT) yang telah mendanai sebagian penelitian ini. Ucapan terima kasih juga kepada komisi pembimbing yang telah memberikan saran dan masukan dalam pelaksanaan penelitian.

DAFTAR PUSTAKA

Aini, F. Y., Affandi, D. R., & Basito. (2016). Kajian penggunaan pemanis sorbitol sebagai pengganti sukrosa terhadap karakteristik fisik dan kimia biskuit berbasis tepung jagung (*Zea mays*) dan tepung kacang merah (*Phaseoulus vulgaris* L.). *Jurnal Teknologi Hasil Pertanian*, *IX*(2).

Ajila, C. M., Leelavathi, K., & Prasada Rao, U. J. S. (2008). Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder. *Journal of Cereal Science*, *48*(2), 319–326. doi: 10.1016/j.jcs.2007.10.001

Aksoylu, Z., & Çag, Ö. (2015). Effects of blueberry , grape seed powder and poppy seed incorporation on physicochemical and sensory. *Journal of Food Quality*, *38*, 164–174.

AOAC. (2005). *Official Methods of Analysis of international*. Gaithersburg, MD, USA: AOAC

Barbosa-Cánovas, G., Fernández-Molina, J., Alzamora, S., Tapia, M., López Malo, A., & Chanes, J. (2003). *Handling and preservation of fruits and vegetables by combined methods for rural areas: technical manual FAO agricultural services*. Roma: Food and Agriculture Organization of the United Nations.

Bindels, L. B., Backer, F. De, Cani, P. D., Neyrinck, A. M., He, V. F. Van, & Delzenne, N. M. (2013). Polyphenol-rich extract of pomegranate peel alleviates tissue inflammation and hypercholesterolaemia in high-fat diet-induced obese mice : potential implication of the gut microbiota. *British Journal of Nutrition*, (109), 802–809. doi: 10.1017/S0007114512002206

Bittner, S. (2006). When quinones meet amino acids: chemical, physical and biological consequences. *Amino Acids*, *30*, 205–224.

Cave, M., Hurt, R., & Frazier, T. (2008). Obesity, inflammation, and the potential application of pharmaconutrition. *Nutr Clin Prac*, *23*, 16–34.

Farrell, N. J., Norris, G. H., Ryan, J., Porter, C. M., Jiang, C., & Blesso, C. N. (2015). Black

elderberry extract attenuates inflammation and metabolic dysfunction in diet-induced obese mice. *British Journal of Nutrition*, (114), 1123–1131. doi: 10.1017/S0007114515002962

Gentile, D., Fornai, M., Pellegrini, C., Colucci, R., Blandizzi, C., & Antonioli, L. (2018). Dietary flavonoids as a potential intervention to improve redox balance in obesity and related co-morbidities : a review. *Nutrition Research Reviews*, 1–9. doi: 10.1017/S0954422418000082

Gomathi, R., Anusuya, N., & Manian, S. (2013). A dietary antioxidant supplementation of Jamaican cherries (*Muntingia calabura* L.) attenuates inflammatory related disorders. *Food Science and Biotechnology*, *22*(3), 787–794. https://doi.org/10.1007/s10068-013-0146-1

Kemenkes. (2018). *Laporan Nasional Riskesdas 2018*. Retrieved from www.litbang.kemkes.go.id

Kumar, S., Sandhir, R., & Ojha, S. (2014). Evaluation of antioxidant activity and total phenol in different varieties of *Lantana camara* leaves. *BMC Research Notes*, *7*, 560. doi: 10.1186/1756-0500-7-560

Lao, F., & Giusti, M. M. (2015). Quantification of purple corn (*Zea mays* L.) anthocyanins using spectrophotometric and HPLC approaches : method comparison and correlation. *Food Anal. Methods*. doi: 10.1007/s12161-015-0318-0

Manzocco, L., Calligaris, S., Mastrocola, D., Nicoli, M., & Lerici, C. (2001). Review of non-enzymatic browning and antioxidant capacity in processed foods. *Trends Food Sci. Tech*, *11*, 340–346.

Miean, K. H., & Mohamed, S. (2001). Flavonoid (myricetin, quercetin, kaempferol, luteolin, and apigenin) content of edible tropical plants. *J. Agric. Food Chem*, *49*, 3106–3112.

Molyneux, P. (2004). The use of the stable free radical diphenylpicryl-hydrazyl (DPPH) for estimating antioxidant activity. *Songklanakarin J. Sci. Technol*, *26*(2), 211–219.

Mudgil, D., Barak, S., & Khatkar, B. S. (2017). Acceptability of cookies as a function of soluble dietary fiber, baking time and different water levels. *LWT - Food Science and Technology*, *80*, 537–539.

Muslimin, L., Hasyim, I., Yusuf, N. F., Mubarak, F., & Yulianty, R. (2019). Nutrient content, mineral content and antioxidant activity of *Muntingia calabura* Linn. *Pakistan Journal of Nutrition*, *18*, 726–732. doi: 10.3923/pjn.2019.726.732

Nielsen, S. S. (Ed.). (2010). *Food Analysis* (4th ed.). New York, USA: Springer. doi: 10.1007/978-1-4419-1478-1

Ou, J., & Wang, M. (2019). Positive and negative effects of polyphenol incorporation in baked foods. *Food Chemistry*, *284*, 90–99. doi: 10.1016/j.foodchem.2019.01.096

Pasqualone, A., Bianco, A. M., Paradiso, V. M., Summo, C., Gambacorta, G., & Caponio, F. (2014). Physico-chemical, sensory and volatile profiles of biscuits enriched with grape marc extract. *FRIN*, *65*, 385–393. doi: 10.1016/j.foodres.2014.07.014

Pasqualone, A., Maria, A., Michele, V., Summo, C., Gambacorta, G., Caponio, F., & Blanco, A. (2015). Production and characterization of functional biscuits obtained from purple wheat. *Food Chemistry*, *180*, 64–70. doi: 10.1016/j.foodchem.2015.02.025

Pereira, G. A., Arruda, H. S., de Morais, D. R., Eberlin, M. N., & Pastore, G. M. (2018). Carbohydrates, volatile and phenolic compounds composition, and antioxidant activity of calabura (*Muntingia calabura* L.) fruit. *Food Research International*, *108*, 264–273. doi: 10.1016/j.foodres.2018.03.046

Pereira, G. A., Tomé, P. H. F., Arruda, H. S., Fragiorge, E. J., & Ribeiro, P. R. (2016). Physicochemical characterization and antioxidant activity of Calabura fruit (*Muntingia calabura* L.). *Brazilian Journal of Food Research*, *7*(2), 67. doi: 10.3895/rebrapa.v7n2.3526

Preethi, K., Vijayalakshmi, N., Shamna, R., & Sasikumar, J. M. (2010). In vitro antioxidant activity of extracts from fruits of *Muntingia calabura linn*. from India. *Pharmacognosy Journal*, *2*(14), 11–18. doi: 10.1016/S0975-3575(10)80065-3

Recuenco, M., Lacsamana, M. S., & Sabularse, V. (2016). Total phenolic and total flavonoid contents of selected fruits in the Philippines. *Philippine Journal of Science*, *145 (3)*(January), 275–281.

Saputri, I., & Damayanthi, E. (2015). Penambahan pegagan (*Centella asiatica*) dengan berbagai konsentrasi dan pengaruhnya terhadap sifat fisiko-kimia cookies sagu. *Jurnal Gizi Dan Pangan*, *10*(2), 149–156. https://doi.org/10.25182/jgp.2015.10.2.%p

Siervo, M., Montagnese, C., Mathers, J. C., Soroka, K. R., Stephan, B. C. M., & Wells, J. C. K. (2013). Sugar consumption and global prevalence of obesity and hypertension : an ecological

analysis. *Public Health Nutrition*, *17*(3), 587–596. doi: 10.1017/S1368980013000141

Srikaeo, K., & Thongta, R. (2015). Effects of sugarcane, palm sugar, coconut sugar and sorbitol on starch digestibility and physicochemical properties of wheat based foods. *International Food Research Journal*, *22*, 923–929.

Srivastava, P., Indrani, D., & Singh, R. P. (2014). Effect of dried pomegranate (*Punica granatum*) peel powder (DPPP) on textural, organoleptic and nutritional characteristics of biscuits. *Food Science and Nutrition*, *65*(7), 827–833. doi: 10.3109/09637486.2014.937797

Stapleton, A. P., James, E. M., Goodwill, G. A., & Frisbee, J. C. (2008). Obesity and vascular dysfunction. *Pathophysiology*, *15*, 79–89.

Sun, J., Chu, Y., Wu, X., Hai, R., & Liu. (2002). Antioxidant and antiproliferative activities of common fruits. *Journal of Agricultural and Food Chemistry*, *50*, 7449–7454.

Susantiningsih, T. (2015). Obesitas dan Stres Oksidatif. *Jurnal Kesehatan Unila*, *5*.

Syafiq, A., Setiarini, A., Utari, D.M., Achadi, e.l., Fatmah, Kusharisupeni, ...Indrawani, Y.M. (2014). *Gizi dan Kesehatan Masyarakat*. Jakarta: Rajawali Pers.

Tańska, M., Roszkowska, B., & Czaplicki, S. (2016). Effect of fruit pomace addition on shortbread cookies to improve their physical and nutritional values. *Plant Foods Hum Nutr*, *71*, 307–313. doi: 10.1007/s11130-016-0561-6

Vongsak, B., Sithisarn, P., & Mangmool, S. (2013). Maximizing total phenolics, total flavonoids contents and antioxidant activity of *Moringa oleifera* leaf extract by the appropriate extraction method. *Industrial Crops & Products*, *44*(November 2017), 566–571. doi: 10.1016/j.indcrop.2012.09.021

Wang, H., Cao, G. H., & Prior, R. L. (1997). Oxygen radical absorbing capacity of anthocyanins. *J. Agric. Food Chem*, *45*, 304–309.

APPLICATION OF DIABETES SELF-MANAGEMENT EDUCATION AND SUPPORT TO NUTRITIONAL STATUS, EATING HABITS AND GLYCEMIC CONTROL IN OUTPATIENTS WITH TYPE II DIABETES MELLITUS

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ABSTRACT

Education through self-management and support plays an important role in providing knowledge and instilling an awareness of the importance of healthy living. The purpose of this study was to determine the effect of Diabetes Self-Management Education and Support on eating habits, body weight, nutritional status, and glycemic control. The design of this study was quasi-experimental with the experimental design of the pre test post test without a control group. The number of samples was 60 patients who were taken by purposive sampling with predefined inclusion and exclusion criteria. Interventions were conducted 2 times a month for 6 months. From this study, it is known that for 6 months there was an increase in the consumption of vegetables, fruit, and milk (p<0,05), a significant decrease in the consumption of tubers and starches (p <0.05), while the consumption of rice and side dishes did not experience a significant change (p> 0, 05). Besides, there was a significant decrease in glycemic control (p <0.05) but there was no significant reduction in body weight and nutritional status (p> 0.05). The application of Diabetes Self-Management Education and Support for 6 months can influence glycemic control and change eating habits.

Keywords: eating habits, education, glycemic control, support, type II diabetes mellitus

INTRODUCTION

Diabetes Mellitus is a chronic disease whose prevalence continues to increase. Based on data from the International Diabetes Federation, in 2019 around 463 million adults (20–79 years) were diagnosed with diabetes and it is estimated that this will increase to 700 million by 2045 (International Diabetes Federation, 2019). The results of Basic Health Research (Riskesdas) in Indonesia reported that there was a significant increase in the prevalence of diabetes, from 6.9% in 2013 to 8.5% in 2018 (Riskesdas, 2018). Currently, Indonesia is in the sixth category with the highest number of people with diabetes aged 20–79 years in the world after China, India, the United States, Brazil, and Mexico (Kemenkes RI, 2018).

From 4 pillar form diabetes management, dietitian focus to pillar education and medical nutrition therapy (PERKENI, 2019). In general, the goal of managing medical nutritional therapy in diabetes mellitus patients is to promote and support a healthy diet so that they can achieve and maintain a normal weight, glycemic control, blood pressure, and normal blood lipids. Finally, the goal of medical nutritional therapy is to prevent macro vascular and microvascular comorbidities (Evert et al., 2019). Diabetes mellitus is a chronic disease that cannot be cured but can be controlled by increasing knowledge and self-control management (PERKENI, 2019).

The success of achieving a good outcome depends on the decisions made by the patient himself. The main objectives of self-management in type 2 diabetes mellitus patients are to facilitate the acquisition of knowledge and skills to modify diet and to support informed decision-making and self-care to improve clinical outcomes, health status, and quality of life (Burke et al., 2014). Therefore nutrition education that is centered on the needs of the patient is needed. Several studies have reported that comprehensive education can help patients understand themselves so that they can control sugar levels which is the main goal of intervention in type 2 diabetes mellitus patients (Kosti & Kanakari, 2012). Comprehensive

 Received 26-01-2020, Accepted 19-05-2021, Published online 30-01-2022

education is education that does not only refer to increasing knowledge, but also increasing skills, abilities, and motivation for self-management. The educational interventions that are most frequently provided are nutritional counseling, promotion of physical activity, education on foot care, control of hypoglycemia and hyperglycemia, and medication (Agrimon & Street, 2016).

Some of the educational methods for diabetic patients that show the most results are counseling based on self-regulating psychological principles, which means that the goals and behavioral change actions are determined by the patient, the counselor only strengthens and accompanies. Therefore, education in diabetes mellitus patients cannot be done in a short time but must be studied in depth so that it can be seen which behavior needs modification so that the effect is real and can increase patient motivation to continue trying new behavior (Mulder et al., 2015). Counselors who work to help diabetes patients should be trained counselors so that they have knowledge and skills about handling diabetes patients from the aspects of medical, nutrition, medicine, and pedagogy, as well as communication so that it makes it easier for patients to manage themselves to overcome their problems. The role of this educator is to contribute to providing education individually and to drive behavior changes including eating behavior (Gvozdanović et al., 2019). Therefore, diabetes education with support in the form of assistance has been agreed to accelerate behavior change (Davies et al., 2018).

Research by Ahmazadeh et al. (2019) proves that intervention with BASNEF-Based Nutrition Education for 3 months can control eating habits. The composition of food intake as recommended, especially the adequate intake of vegetables (Dias & Imai, 2017), fruit, and milk (Eussen et al., 2016) can help control glycemic control (Wang et al., 2016). Besides, vegetables and fruits contain many antioxidants that can fight oxidative oxidation which affects the development of type 2 diabetes mellitus (Carter et al., 2013). Zareban et al., (2014) research showed that a 3-month self-care education program can significantly change the value of HbA1C (Zareban et al., 2014). Research conducted by Gvozdanovic et al. (2019) reports that education has the effect of increasing adherence to a diabetes diet and controlling blood sugar levels after one month of education with assistance. However, after 2 years, the patient returned to non-adherence and it turned out that the sugar levels were out of control again. Interventions in diabetic patients will be considered successful if they can change their eating habits and control HbA1C, to prevent complications from occurring. HbA1C is an indicator that describes the average blood glycemic rate for 3 months. So it is quite effective in evaluating diabetes interventions (American Diabetes Association, 2018).

Judging from these various backgrounds, the researchers wanted to know whether Diabetes Self-Management Education and Support during 6 months for diabetes sufferers could improve nutritional status, dietary habits, especially the fulfillment of carbohydrate, fat, protein, and fiber intake. and how is the effect on controlling blood sugar levels, both blood sugar levels at any time, 2 hours postprandial or HbA1C.

METHODS

The design of this research was Quasi-Experimental and the experimental design used was The Pretest-Post-test design without a control group. This data was taken from a study entitled "Macro Nutrient Intake, HbA1C Value and Blood Lipid Profiles in Outpatients with Type II Diabetes Mellitus Receiving Assistance for 6 months at RSUPN Dr. Cipto Mangunkusumo in 2017". The intervention in this study was self-management education and support. The intervention was given twice for 6 months, once in a month. The education provided consists of 12 topics, namely related to understanding and management during diabetes, medication, self-management, hypoglycemia, nutritional therapy, physical activity, complications of the disease, diabetic foot, handling when sick, diabetes mellitus during special conditions (travel, fasting, and diabetes). One educational topic is given for 30 minutes. Education Meanwhile, support is provided on 6 topics related to motivation and readiness for behavior change. Each 1 theme consists of 2 sessions for 45–60 minutes. Education and support are delivered by related health workers such as doctors, nurses, dietitians, and pharmacists specifically for diabetes.

A sample of 60 people were taken by purposive sampling with inclusion and exclusion criteria determined by the researcher. The inclusion criteria were having complete data in previous studies, HbA1C levels > 7.5%, and age 30–60 years. While the exclusion criteria were having comorbidities that affected memory, don't have a complete food record file, and incomplete blood biochemical data.

Anthropometric data on body weight and height have been carried out by previous researchers. Collecting weight data using digital scales and height data using a stadiometer. BMI is calculated as weight in kilograms divided by the square of the height in meters (kg/m^2) and is categorized into four groups according to the Asian-Pacific cut off points: 25 underweight (<18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23–24.9 kg/m^2), and obese (≥25 kg/m^2).

Data on the frequency of consumption of foodstuffs were obtained through a 3×24 hours food record form. To obtain data on the frequency of foodstuffs, a food tally was carried out based on the data in the food record. Previously, when filling out the food record form, respondents had been given training on how to fill it out. Then the food record data is revalidated by dietitians through a 3×24 hours food recall. The nurses were collecting data on weight and height. Blood biochemical data collection, namely fasting blood glucose, blood glucose 2 hours postprandial, and HbA1C were carried out by a medical analyst. Intake data, body weight, and blood biochemistry were collected 3 times, namely before the intervention, three months after the intervention, and six months after the intervention. Method section driven from previous articles is allowed. The research period should be verified.

The data analysis used was Kolmogorov-Smirnov to find out which data was obtained either parametric or non-parametric. Data analysis using SPSS 17, to determine the changes that occur during the intervention used the paired-sample t-test if the data obtained is parametric and uses the Wilcoxon test if it can be obtained non-parametric. This research has passed the ethical review of FKUI-RSCM with number KET.1020/ UN2.F1 / ETIK / PPM.00.02 / 2019.

Table 1. Characteristics of Respondent (n=60)

Characteristics	n	%
Gender		
Men	20	33.3
Women	40	66.7
Aged Group		
30–35 years	2	3.3
36–45 years	4	6.7
46–55 years	20	43.3
56–65 years	34	46.7
Profession		
Work	20	33.3
Housewife	40	66.7
Nutritional Status		
Underweight	2	3.3
Normal Weight	16	26.7
Overweight	10	16.7
Obesity	32	53.3

RESULTS AND DISCUSSIONS

Respondent Characteristics

Table 1 shows that most of the respondents were female (66.7%) with the largest ages ranging from 56–65 years (46.7%). Most of the respondents did not work or work as housewives (66.7%). Based on the nutritional status with the calculation of BMI according to the Asia Pacific classification, it appears that most of the respondents fall into the obesity category (53.3%), followed by good nutrition (26.7%), overweight (16.7%) and the lowest is malnutrition (3.3%).

Bodyweight and Nutritional Status during the Diabetes Self-Management Education and Support Application

Table 2 shows that there was a decrease in body weight and nutritional status during education and mentoring for 3 months and 6 months but it was not statistically significant (P> 0.05). The table shows that the average body weight of the respondents at 3 months was 69.01 ± 15.579 kg. likewise in the second 3 months the average body weight of the respondents was 68.811 ± 0.284 kg and after 6 months of education and assistance obtained an average body weight was 68.471 ± 0.600 kg.

The relationship with nutritional status as shown in table 2 shows that in the first 3 months

Table 2. Body weight and Nutritional Status during the Diabetes Self-Management Education and Support application

Variabel	Mean ± SD	p-value
Weight (kg)		
1–3 Months	69.071 ± 15.579	0.426
3–6 Months	68.811 ± 14.284	0.417
1–6 Months	68.471 ± 13.615	0.251
BMI		
1–3 Months	28.0236 ± 5.862	0.44
3–6 Months	27.923 ± 5.333	0.459
1–6 Months	27.800 ± 5.142	0.283

*) Statistical test paired sample t test, significant p <0.05

the average BMI of respondents was 28.0236 ± 5.862 kg / cm2. In the second 3 months the average BMI of the respondents was 27.923 ± 5.333 and after education and mentoring for 6 months the average BMI of the respondents was 27.800 ± 5.142.

The results of this study revealed 53.3% of the participation of type II diabetes mellitus patients in RSCM had obese nutritional status. This prevalence is still lower when compared to the results of Fajarini's (2019) study which revealed that there were 63.9% of Prolanis type II diabetes mellitus patients at the Jatinegara Health Center, East Jakarta (Fajarini & Sartika. 2019). Even in the world, more than 90% of diabetic patients have obese nutritional status (Bramante et al., 2017). The most common co-diabetes disease is obesity (Garvey et al., 2016). So it needs extra handling so that there is no increase in the risk of other comorbidities such as cardiovascular disease, hypertension, and kidney disease (American Diabetes Association, 2018).

Glycemic Control during the Diabetes Self-Management Education and Support Application

In table 3, it appears that education and mentoring of 60 type II diabetes mellitus patients for 6 months has a real effect on reducing blood sugar levels but has not been able to normalize blood sugar levels both fasting blood sugar, blood sugar 2 hours postprandial, and HBA1C values. The average fasting blood sugar levels up to 6 months of intervention were 156.415±55.657 mg/dL, blood sugar 2 hours postprandial was

Tabel 3. Glycemic control during the Diabetes Self-Management Education and Support application

Variabel	Mean ± SD	p-value
Fasting Blood Glucose		
1–3 Months	183.735 ± 67.563	0.190
3–6 Months	158.452 ± 72.292	0.856
1–6 Months	156.415 ± 55.657	0.031*
Glucose 2 Hours PP		
1–3 Months	242.717 ± 91.459	0.102
3–6 Months	218.603 ± 101.870	0.138
1–6 Months	192.717 ± 103.962	0.008*
HbA1C		
1–3 Months	9.379 ± 1.638	0.000*
3–6 Months	7.969 ± 1.638	0.045*
1–6 Months	8.362 ± 1.960	0.000*

*) Statistical test paired sample t test. significant p <0.05

192.717±103.962 mg/dL, and HbA1C was 8.362±1.960 mg/dL.

After the intervention in 60 participating type II diabetes mellitus patients, it is known that education and mentoring carried out for 6 months in the hospital can improve blood glucose in the body. Three parameters of blood glucose dropped significantly (p <0.05) after 6 months of education and assistance, namely fasting blood glucose (p = 0.031), blood glucose 2 hours postprandial (p = 0.008) and HbA1C (p = 0.000). However. the education and assistance carried out could not affect the body weight and nutritional status of the participating type II diabetes mellitus patients (p> 0.05).

Diabetes is a chronic disease that cannot be cured but can be controlled by increasing knowledge and self-control management (PERKENI, 2019). In this study, knowledge, and self-control were enhanced through education and mentoring. Education is one of the 4 pillars of diabetes management which functions to increase patient knowledge so that patients can carry out monitoring of their health at home. To strengthen the results of this education, assistance is provided. Mentoring is a self-empowerment that aims to build self-confidence, reduce stress, and encourage oneself to make changes (Gardiarini et al., 2017). So that the changes that occur are the patient's own decisions and awareness without coercion from others. Several studies have proven that mentoring

can improve the glycemic load of diabetes patients. Diana's research (2015) proves that mentoring given to type 2 diabetes mellitus patients can change habits and can significantly reduce HbA1C levels (Gardiarini et al., 2017). Marizeh (2015) revealed that the assistance provided by health workers is effective in improving the quality of life of elderly women (Jahromi et al., 2015).

This study revealed that the combination of education and mentoring that was carried out twice a month for 6 months could significantly reduce blood glucose levels, both fasting blood glucose. GD2PP and HbA1C, but had not been able to control body weight and nutritional status. The 6 months of mentoring time is still considered insufficient, even though the results of glycemic control have decreased significantly, but the values of each glycemic control are still above normal. Zhang and Chu's (2018) research results also state that the results of systematic education consist of nine components namely giving color booklets, motivational videos, eating plate rules, group chat, proper medication rules, doctor visits, lifestyle intervention and education and 2 years of self-control management decreased 0.67% HbA1C but did not significantly reduce the patient's BMI (Zhang & Chu, 2018). Research by Ahmazadeh et al. (2019) proved that intervention with BASNEF-Based Nutrition Education for 3 months was able to control blood glucose levels and was able to increase the intake of vegetables, fruit, and milk (Ahmadzadeh et al., 2019).

Eating Habits during the Diabetes Self-Management Education and Support Application

From Table 4, the description of the frequency of food consumption above, it is known that most patients still consume rice with an average frequency of up to 6 months of intervention, namely 2.57 ± 0.586 times a day. Not only rice consumption, but the patients also consumed several types of staple foods such as noodles (0.10 ± 0.305 times), tubers (0.10 ± 0.305 times), and bread and flour (0.17 ± 0.379 times).

Based on the results of the paired sample t-test, it was found that there was no significant change in rice consumption during the 6 months of the intervention. However, there was a significant

Table 4. Eating Habits during the Diabetes Self-Management Education and Support Application

Variable	Mean ± SD	p-value
Rice		
1–3 Months	2.33 ± 0.661	1.000
3–6 Months	2.33 ± 0.711	0.129
1–6 Months	2.57 ± 0.568	0.147
Noodle		
1–3 Months	0.17 ± 0.461	0.573
3–6 Months	0.10 ± 0.403	1.000
1–6 Months	0.10 ± 0.305	0.536
Tubers		
1–3 Months	0.37 ± 0.615	0.255
3–6 Months	0.23 ± 0.504	0.211
1–6 Months	0.10 ± 0.305	0.030*
Bread and Flour		
1–3 Months	0.53 ± 0.860	0.630
3–6 Months	0.43 ± 0.774	0.043*
1–6 Months	0.17 ± 0.379	0.019*
Chicken		
1–3 Months	0.60 ± 0.724	0.610
3–6 Months	0.50 ± 0.682	1.000
1–6 Months	0.50 ± 0.777	0.669
Fish		
1–3 Months	0.77 ± 0.774	0.526
3–6 Months	0.63 ± 0.809	0.326
1–6 Months	0.80 ± 0.761	0.851
Eggs		
1–3 Months	0.53 ± 0.776	0.264
3–6 Months	0.73 ± 0.907	0.639
1–6 Months	0.63 ± 0.850	0.541
Tofu		
1–3 Months	0.60 ± 0.675	0.344
3–6 Months	0.43 ± 0.568	1.000
1–6 Months	0.43 ± 0.626	0.305
Tempeh		
1–3 Months	0.77 ± 0.817	0.555
3–6 Months	0.63 ± 0.928	0.310
1–6 Months	0.90 ± 0.885	0.573
Vegetables		
1–3 Months	1.17 ± 0.699	0.031*
3–6 Months	1.57 ± 0.858	0.002*
1–6 Months	2.13 ± 0.681	0.000*
Fruits		
1–3 Months	0.90± 0.885	0.662
3–6 Months	1.00 ± 0.947	0.004*
1–6 Months	1.63 ± 1.066	0.000*
Milk		
1–3 Months	0.10 ±0.305	0.255
3–6 Months	0.23 ± 0.504	0.231
1–6 Months	0.40 ± 0.563	0.010*

decrease ($p < 0.05$) in the consumption of tubers ($p = 0.030$), bread and flour ($p = 0.019$).

From Table 4 it is known that the consumption of protein intake is very diverse namely, there are chickens with an average consumption of 0.50 ± 0.777 times during the intervention. Fish 0.80 ± 0 .761 times. eggs 0.63 ± 0.850 times, tofu 0.43 ± 0.626 times, and tempeh 0.90 ± 0.885 times. In general, the protein food group experienced an increase during the 6 months of the intervention, but the increase in consumption was not significant ($p > 0.05$).

From table 4 it can be seen that the average frequency of vegetable consumption during the 6 months of the intervention was 2.13 ± 0.681 time, the fruit was 1.63 ± 1.0667 and milk was 0.40 ± 0.563. Vegetable consumption increased significantly ($p < 0.05$) each month during the intervention. Followed by fruit and milk consumption, there was a significant increase in the third and sixth months ($p < 0.05$).

This study also proved that education in type 2 diabetes mellitus patients was able to control the consumption of staple foods such as flour, bread, and tubers and was able to increase consumption of vegetables, fruit, and milk. The increased consumption of vegetables, fruit, and milk are very beneficial for type II diabetes mellitus patients in controlling glycemic control. The fiber content that can be obtained from vegetables and fruit is known to reduce the death rate of people with diabetes. Several studies stated that consumption of fiber 50 grams/ day can reduce HbA1C 0.2–0.3%. However, it has not been determined that the reduction in HbA1C is solely from fiber (Evert et al., 2013).

CONCLUSION

The intervention given in the form of education and mentoring for 6 months was able to significantly reduce glycemic control, both fasting blood glucose, 2 hours postprandial glucose, and HbA1C. As well as being able to change eating habits, namely by increasing the consumption of vegetables, fruit and milk significantly and reducing the consumption of tubers, flour and bread. However, these interventions have not been able to reduce the patient's body weight and body mass index. Therefore, researchers suggest adding physical activity interventions as one of the pillars of diabetes control in an effort to reduce patient weight and control glycemic control to normal.

ACKNOWLEDGMENTS

Dr. Johan Arief Budiman from Trisakti University helped checking the format of the manuscripts and to collect the necessary data.

REFERENCE

Ahmadzadeh, N., Shojaeizadeh, D., Sum, S., & Hajian, K. (2019). Effect of BASNEF - based education on nutritional behaviors among elderly people and Mini Nutritional Assesment on nutritional status ini eldery with T2DM. *Journal Education Health Promotion*, *8*(94). Retrieved from https://pubmed.ncbi.nlm.nih.gov/31143811/

American Diabetes Association. (2018). Glycemic Targets: Standards of Medical Care in Diabetes 2018. *Diabetes Care 2018*, *41*(1), S55–S64. Retrieved from https://care.diabetesjournals.org/content/41/Supplement_1/S55

Bramante, C. T., Lee, C. J., & Gudzune, K. A. (2017). Treatment of Obesity in Patients With Diabetes. *Diabetes Spectrum*, *30*(4), 237–243. https://doi.org/10.2337/ds17-0030 Retrieved from https://spectrum.diabetesjournals.org/content/30/4/237

Burke, S. D., Sherr, D., & Lipman, R. D. (2014). Partnering with diabetes educators to improve patient outcomes. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *7*, 45–53. Retrieved from https://www.dovepress.com/partnering-with-diabetes-educators-to-improve-patient-outcomes-peer-reviewed-article-DMSO

Carter, P., Gray, L. J., Talbot, D., Morris, D. H., Khunti, K., & Davies, M. J. (2013). Fruit and vegetable intake and the association with glucose parameters: A cross-sectional analysis of the Let's Prevent Diabetes Study. *European Journal of Clinical Nutrition*, *67*(1), 12–17. Retrieved from https://www.nature.com/articles/ejcn2012174

Davies, M. J., Alessio, D. A. D., Fradkin, J., Kernan, W. N., Mathieu, C., & Mingrone, G. (2018). Management of Hyperglycemia in Type 2 Diabetes, 2018. A Consensus Report by the American Diabetes Association

(ADA) and theEuropeanAssociation for the Study of Diabetes (EASD). *Diabetes Care*, *2012*(4), 1–33. Retrieved from https://care.diabetesjournals.org/content/41/12/2669

Dias, J., & Imai, S. (2017). Vegetables Consumption and its Benefits on Diabetes. *Journal of Nutritional Therapeutics*, *6*(1), 1–10. Retrieved from https://www.lifescienceglobal.com/journals/journal-of-nutritional-therapeutics/volume-6-number-1/87-abstract/jnt/1134-abstract-vegetables-consumption-and-its-benefits-on-diabetes

Eussen, S. J. P. M., Van Dongen, M. C. J. M., Wijckmans, N., Den Biggelaar, L., Oude Elferink, S. J. W. H., Singh-Povel, C. M., … Dagnelie, P. C. (2016). Consumption of dairy foods in relation to impaired glucose metabolism and type 2 diabetes mellitus: The Maastricht Study. *British Journal of Nutrition*, *115*(8), 1453–1461. Retrieved from https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/consumption-of-dairy-foods-in-relation-to-impaired-glucose-metabolism-and-type-2-diabetes-mellitus-the-maastricht-study/FCB37A7652AFF33A8BD97E595BAB82A4

Evert, A. B., Boucher, J. L., Cypress, M., Dunbar, S. A., Franz, M. J., Mayer-Davis, E. J., Neumiller, J. J., Nwankwo, R., Verdi, C. L., Urbanski, P., & Yancy, W. S. (2013). Nutrition therapy recommendations for the management of adults with diabetes. *Diabetes Care*, *36*(11), 3821–3842. Retrieved from https://care.diabetesjournals.org/content/36/11/3821

Evert, A. B., Dennison, M., Gardner, C. D., Timothy Garvey, W., Karen Lau, K. H., MacLeod, J., Mitri, J., Pereira, R. F., Rawlings, K., Robinson, S., Saslow, L., Uelmen, S., Urbanski, P. B., & Yancy, W. S. (2019). Nutrition therapy for adults with diabetes or prediabetes: A consensus report. *Diabetes Care*, *42*(5), 731–754. 4 Retrieved from https://care.diabetesjournals.org/content/42/5/731

Fajarini, I. A., & Sartika, R. A. D. (2019). Obesity as a common type-2 diabetes comorbidity: Eating behaviors and other determinants in Jakarta, Indonesia. *Kesmas*, *13*(4), 157–163. Retrieved from https://journal.fkm.ui.ac.id/kesmas/article/view/2483

Gardiarini, P., Sudargo, T., & Pramantara, I. D. P. (2017). Kualitas Diet, Sosio-Demografi, dan Dukungan Keluarga Hubungannya dengan Pengendalian Gula Darah pada Penderita Diabetes Mellitus Tipe 2 di Rumah Sakit Kanujoso Sjatiwibowo (RSKD), Balikpapan. *Journal of the Indonesia Nutrion Association*, *40*(2), 89–100. Retrieved from https://persagi.org/ejournal/index.php/Gizi_Indon/article/view/237

Garvey, W. T., Mechanick, J. I., Brett, E. M., Garber, A. J., Hurley, D. L., Jastreboff, A. M., Nadolsky, K., Pessah-Pollack, R., & Plodkowski, R. (2016). American association of clinical endocrinologists and American college of endocrinology comprehensive clinical practice guidelines for medical care of patients with obesity. *Endocrine Practice*, *22*(July), 1–203. Retrieved from https://www.endocrinepractice.org/article/S1530-891X(20)44630-0/fulltext

Gvozdanović, Z., Farčić, N., Placento, H., Lovrić, R., Dujmić, Ž., Jurić, A., Miškić, B., & Prlić, N. (2019). Diet education as a success factor of glycemia regulation in diabetes patients: A prospective study. *International Journal of Environmental Research and Public Health*, *16*(20), 1–10. Retrieved from https://www.mdpi.com/1660-4601/16/20/4003

Hilman Agrimon, O., & Street, J. (2016). Developing Comprehensive Diabetes Education Materials for Structured Patient Education Programs in Primary Care Setting. *International Journal of Public Health Science (IJPHS)*, *5*(1), 16. Retrieved from http://ijphs.iaescore.com/index.php/IJPHS/article/view/4758

International Diabetes Federation. (2019). IDF Diabetes Atlas. In *9th Edition*. International Diabetes Federation, 2019. Retrieved from https://www.idf.org/e-library/welcome/copyright-permission.html

Kargar Jahromi, M., Ramezanli, S., & Taheri, L. (2015). Effectiveness of diabetes self-management education on quality of life in diabetic elderly females. *Global Journal of Health Science*, *7*(1), 10–15. Retrieved from http://www.ccsenet.org/journal/index.php/gjhs/article/view/37675

Kemenkes RI. (2018). Cegah, cegah, cegah : Suara Dunia Perangi Diabetes. In *Biro Komunikasi dan Pelayanan Masyarakat*. Retrieved from http://www.depkes.go.id/article/view/18121200001/prevent-prevent-and-prevent-the-voice-of-the-world-fight-diabetes.html

Kosti, M., & Kanakari, M. (2012). Education and diabetes mellitus. *Health Science Journal*, *6*(4), 654–662. Retrieved from https://www.researchgate.net/publication/288764054_

Education_and_diabetes_mellitus

Mulder, B. C., Lokhorst, A. M., Rutten, G. E. H. M., & van Woerkum, C. M. J. (2015). Effective Nurse Communication With Type 2 Diabetes Patients: A Review. *Western Journal of Nursing Research*, *37*(8), 1100–1131. 531077 Retrieved from https://journals.sagepub.com/doi/10.1177/0193945914531077

PERKENI. (2019). Pedoman pengelolaan dan pencegahan diabetes mellitus tipe 2 dewasa di Indonesia 2019. In *PB. PERKENI*. Retrieved from https://pbperkeni.or.id/wp-content/uploads/2020/07/Pedoman-Pengelolaan-DM-Tipe-2-Dewasa-di-Indonesia-eBook-PDF-1.pdf

Riskesdas, 2018. (2018). *Hasil utama riskesdas 2018*. Retrieved from https://kesmas.kemkes.go.id/assets/upload/dir_519d41d8cd98f00/files/Hasil-riskesdas-2018_1274.pdf

Wang, P. Y., Fang, J. C., Gao, Z. H., Zhang, C., & Xie, S. Y. (2016). Higher intake of fruits, vegetables or their fiber reduces the risk of type 2 diabetes: A meta-analysis. *Journal of Diabetes Investigation*, *7*(1), 56–69. Retrieved from https://onlinelibrary.wiley.com/doi/10.1111/jdi.12376

Zareban, I., Karimy, M., Niknami, S., Haidarnia, A., & Rakhahani, F. (2014). The Effect of Self-care Education Program on Reducong HbA1c Leves in Patients with Type 2 Diabetes. *Journal of Education and Health Promotion*, *3*(123). Retrieved from http://ncbi.nlm.nih.gov/pmc/articles/PMC4275624

Zhang, Y., & Chu, L. (2018). Effectiveness of Systematic Health Education Model for Type 2 Diabetes Patients. *International Journal of Endocrinology*, *2018*. Retrieved from https://www.hindawi.com/journals/ije/2018/6530607/.

EATING VEGETABLES BEFORE CARBOHYDRATES DECREASE ENERGY INTAKE OF TYPE-2 DIABETES MELLITUS PATIENTS

Urutan Makan Sayur Sebelum Karbohidrat Menurunkan Asupan Energi pada Pasien Diabetes Melitus Tipe 2

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ABSTRACT

Diabetes mellitus is a non-communicable disease that has increased significantly in Indonesia and worldwide. Dietary arrangements through diet therapy are beneficial for improving the performance of the pancreas in producing and stimulating the work of insulin. This study aimed to determine the effect of the order of vegetable and carbohydrate consumptions on the decrease of energy intake. Method used randomized control trial with pre-post design. A total of 24 people with non-complicating type-2 diabetes mellitus aged 18-65 years were assigned into 3 groups; control group (C), vegetable before carbohydrate group (P1), and vegetable with carbohydrate group (P2) . Energy intake before and after the intervention was measured using a 24-hours food recall. To compare pre-post intervention, paired T-test were used, meanwhile to compare difference among groups data were analysed using ANOVA. A significant decrease in energy intake was found in P1 where the mean values of C and P1 were 17.75 ± 12.40 kcal and 155.27 ± 23.40 calories ($p < 0.001$), and mean values of P1 and P2 were 155.27 ± 23.40 kcal and 4.54 ± 48.99 kcal ($p < 0.001$). The order of vegetable before carbohydrate consumption decreases energy intake of type-2 diabetes mellitus patients.

Keywords: diabetes mellitus, energy intake, food order

INTRODUCTION

Diabetes mellitus (DM) is a non-communicable disease that is increasing in number in various countries including Indonesia (Perkeni, 2015). The effect of chronic hyperglycemia as one of the typical symptoms of DM is correlated with organ dysfunction and damage, often leading to multiple organ failure. Management of DM aims to control blood glucose levels and prevent further complications that result in organ failure through the implementation of four pillars, namely education, diet therapy, physical activity, and pharmacological therapy (Kemenkes, 2018).

Diet therapy is one pillar that supports the success of controlling blood glucose levels. Energy intake excess spurs insulin resistance through increasing blood glucose levels and the free fatty acids inside blood, apart from that also causes an increase in fat body, causing obesity which is closely related to resistance insulin (Immawati and Wirawanni, 2014). Energy intake for diabetics is 25–30 kcal / kg ideal body weight depend on nutritional status, age, gender, activity and complications (ADA, 2018).

The order of vegetable and carbohydrate consumptions is one of the nutritional interventions that can be implemented for type-2 diabetes mellitus (DMT2) patients, where eating vegetables before carbohydrates could support the fulfillment of fiber intake as one of the recommended diets for DMT2 patients (Imai *et al.*, 2011). Fiber, especially soluble fiber from vegetables, is useful in controlling blood glucose levels for DMT2 patients. Fiber that enters the digestive tract will slow down the food digestion process in the stomach. Fiber with food will absorb water in the stomach and change food to be more viscous (Wang *et al.*, 2016). This mechanism can prolong satiety and reduce food intake, slowing down the absorption of nutrients including glucose (Tremblay and Bellisle, 2015). This study aims to determine the effect of the order of eating vegetables with carbohydrates on changes in

 Received 12-02-2020, Accepted 19-05-2021, Published online 30-01-2022

energy intake. Previous research related to a decrease in energy intake in diabetics was based on a cross-sectional study, whereas in this study used a different intervention to eat vegetables before and with carbohydrates to analyze the effects of reduced energy intake from both interventions.

METHOD

In this randomized experimental study with pre-post group design, the subjects willing to participate had been explained about the research procedure and had filled in the informed consent. This study has passed ethical eligibility by the Health Research Ethics Commission of dr. Moewardi General Hospital Surakarta number 136/I/HREC/2020.

This study was conducted in February 2020 with a population of all DMT2 patients. The population of T2DM patients is all outpatients at Manyaran Public Health Center, Semarang City, Central Java in 2019 as many as 1061 people. Determination of research subjects through inclusion criteria and grouping into experimental groups through randomization. The inclusion criteria were DMT2 patients who received oral hypoglycemic drugs, aged 18–65 years, were male or female, like to eat of vegetables, and performed low intensity physical activity. The exclusion criteria were having micro vascular or macro vascular complications (chronic kidney disease, heart disease, and hyperuricemia), having difficulty chewing and swallowing, having gastroenteritis, being pregnant, smoking, taking glucose-lowering supplements/herbal medicines, and getting insulin therapy. The number of research subjects was calculated using the hypothesis testing formula in two populations on average, resulting in 24 subjects including the loss of follow-up with 8 people in each group.

This study was conducted by giving intervention to the subjects in the form of breakfast consisting of rice, animal side dishes, vegetable side dishes, and vegetables. Processing of side dishes and vegetables by sauteing. The caloric value of the intervention menu was obtained from the average nutritional needs of the subjects, and 20% of its composition was taken as breakfast. The nutritional composition of the average intervention was 387.24 calories of energy, 18.22 grams of protein, 14.60 grams of fat, 53.14 grams of carbohydrates, and 7.07 grams of fiber. The macronutrient composition in the test meal was 14.8% protein, 20% fat, and 64.9% carbohydrates. Subjects were assigned into 3 groups, namely the intervention group eating vegetables before rice/carbohydrates (T1), the intervention group eating vegetables with rice/carbohydrates (T2), and the control group was only given nutrition education in the form of diabetes mellitus diet. The intervention was carried out for 10 days. Before the intervention, the subjects were required to fast for 10 hours; then, in the next morning, the pre-intervention fasting blood glucose levels were measured. After the 10-day intervention, the subjects were also required to fast for 10 hours and their fasting blood glucose levels were measured the next day as post-intervention blood glucose levels. Measurement of fasting blood sugar levels using the hexokinase method, using a spectrophotometer. Venous blood sampling was carried out by analysts from the CITO Laboratory in Semarang. Anthropometric measurements were carried out by researchers.

Bodyweight was measured using a digital weight scale with brand “Digipounds SC-05” a maximum capacity of 180 kg, with an accuracy of 0.1 kg and height was measured using a wireless body height meter “Gea Medical HT721” with an accuracy of 0.1 cm; both were used to calculate Body Mass Index (BMI) and determine the nutritional needs of each subject.

Data were analyzed using SPSS (Statistical Package for Social Science) version 23.0 For the analysis of the average difference in energy intake, Paired T-Test was used. The data on the effect of the order of vegetable before carbohydrate consumption on the decrease in energy intake using ANOVA test are presented in mean ± SD.

Table 1. Components of Breakfast Meal Test in Research Subjects

Menu Order	Amount (gram)
Rice	100
Animal based protein	50
plant-based protein	50
Vegetable	100
Oil	5

The p-value was determined with a significance level of < 0.05. The composition and type of food in the vegetable eating order treatment group can be seen in Table 1.

RESULT AND DISCUSSION

A total of 9 women and 15 men with DMT2 who received oral blood-glucose-lowering drug therapy participated in this study. Most of the research subjects were male and the ages between groups were not significantly different. More than 50% of the subjects were overweight. There were differences in food intake before the intervention in the three groups; intake of protein, fat, carbohydrates and fiber. Confounding variables were controlled by means of strict randomized subject selection and based on inclusion and exclusion criteria.

Energy intake data before and after the study were obtained based on the average energy intake using the 24-hours food recall method. Changes in average energy intakes before and after the study can be seen in Table 3.

Based on the results of the study, the group eating order of vegetables before carbohydrates significantly decreased energy intake during the 10 days of intervention (p = 0.000). In line with research (Imai et al., 2014) that vegetables eaten before protein and carbohydrates can reduce energy intake and increase fiber intake from vegetables.

The decrease in energy intake is a goal of dietary therapy management in patients who want to consume large portions of food (Raynor, 2014), such as DMT2 patients. The results of this study indicated that the patient's energy intake was within the normal basal metabolic limit (25–30 kcal/kg IBW). Furthermore, at the level of fasting blood sugar levels, it can also be seen that a decrease in energy intake was significant (p < 0,001) in the T1 group (Table 4). A calorie deficit can have an impact on weight loss and repair of pancreatic beta cells and insulin sensitivity, so that blood sugar levels are controlled (Zubrzycki *et al.*, 2018).

In this study, the strategy of reducing energy intake through the meal order method, namely prioritizing vegetable consumption before carbohydrates and protein, means reducing energy intake and controlling blood sugar. Control of food consumption can be promoted through dietary arrangements that can reduce food intake. One approach that can help prevent excess food intake is achieving an optimal satiety response (Gibbons *et al.*, 2019).

In this study, the level of satiety was determined by the order of food consumption method, namely sorting the type of food to consume. Prioritizing vegetable consumption

Table 2. Characteristic of Respondence

Characteristic	Research Group			p
	C(n=8)	T1(n=8)	T2(n=8)	
Age (year)	55.63 ± 3.66	57.00 ± 4.47	55.50 ± 5.45	0..771
Weight (kg)	66.31 ±7.31	62.91 ± 10.63	64.60 ± 14.24	0.833
Height (m)	1.54±7.63	1.53 ± 4.66	1.56 ±10.25	0.722
BMI (kg/m^2)	27.68 ± 3.15	27.34 ± 4.94	2.68 ± 4.35	0.962
Nutritional Status				
Normal	1 (12.5%)	2 (25 %)	2 (25%)	0.777
Overweight	7 (87.5%)	6 (75%)	6 (75%)	
Duration of DM (year)	3.63 ± 1.84	6.25 ± 4.95	3.25 ± 0.70	0.129
Sex				
Male	2 (25%)	6 (75%)	7 (87.5%)	0.741
Female	6 (75%)	2 (25%)	1 (12.5%)	
Drug Therapy				
Biguanid	4 (50%)	1 (12.5%)	0 (0%)	
Sulfonylurea	0 (0%)	0 (0%)	1 (12.5%)	0.085
Combination	4 (50%)	7 (87.5%)	7 (87.5%)	

https://doi.org/10.204736/mgi.v17i1.51–55

Table 3. Average of Energy Intake Before and After Dietary Intervention

Group	Energy Intake (kcal)			p
	Before	After	Δ(Mean ± SD)	
C	1100.70±265.59	1084.70±265.45	17.75±12.40	0.004
T1	1149.31±121.45	994.03±135.23	155.27±23.40	<0.001
T2	1207.10±154.49	1202.56±175.16	4.54± 48.99	0.801

Data in the form of mean ± SD, Paired T-Test. Significance level p < 0.05.

Table 4. Average of Blood Fasting Glucose Before and After Dietary Intervention

Group	Blood Fasting Glucose (mg/dL)			p
	Before	After	Δ(Mean ± SD)	
C	104.50 ± 36.84	94.0 ± 10.90	-10.50 ± 32.81	0.396
T1	148.88 ± 100.88	100.88 ± 14.59	-48.00 ± 23.19	0.001*
T2	167.00 ± 98.70	137.38 ± 98.70	-29.62 ± 51.16	0.145

Data in the form of mean ± SD, Paired T-Test. Significance level p < 0.05.

Table 5. Average Difference in Energy Intake After Intervention

Group (n=8)	Difference in energy intake (kcal)	p
C	17.75 ± 12.40	< 0.001
T1	155.27 ± 23.40	
C	17.75 ± 12.40	0.694
T2	4.54 ± 48.99	
T1	155.27 ± 23.40	< 0.001
T2	4.54 ± 48.99	

Data in the form of mean ± SD , Anova. Significance level p < 0.05.

before carbohydrates can significantly improve the satiety response of DMT2 patients (Kimiko *et al.*, 2018). Vegetables are a highly-recommended food component for consumption by DMT2 patients (Toumpanakis, Turnbull and Alba-barba, 2018). Vegetables as one type of soluble fiber play a role in optimizing the satiety response. The fiber that first enters the digestive tract with water will be more viscous so that the digestive process runs slower and has gastric retention to the small intestine, resulting in long-lasting satiety (Mahan and Raymond, 2016).

Furthermore, undigested fiber is fermented by bacteria in the colon and produces SCFA (Short Chain Fatty Acids) which has the potential to improve insulin sensitivity and blood glucose levels (Hervik, 2019). SCFA regulates satiety response with its important role in regulating appetite. It can bind to FFA (Free Fatty Acid 2 and 3) receptors in L cells of the small intestine. These cells are endocrine cells that produce hormone peptide YY (PYY) and Glucagon Like Peptide (GLP-1) which play a role in decreasing appetite and the amount of food intake (Wanders *et al.*, 2011).

The presence of fat and protein will result in the release of cholecystokinin (CCK), whereas glucagon-like peptide 1 and peptide YY (PYY) result from more distal responses (Chaudhri, Small and Bloom, 2006). Also, the viscous nature of fiber causes distension in the stomach, which triggers a signal of satiety and has an effect on reducing food intake (Kristensen and Jensen, 2011).

Other nutrients that must be controlled in controlling blood sugar are carbohydrates. Carbohydrates will be metabolized into glucose in the presence of the hormone insulin. Glucose requires the insulin hormone to stimulate the entry of glucose into in cells to be used as a source of energy and helps store glycogen in cells muscles and heart (Mahan and Raymond, 2016). Data on the amount of intake and types of carbohydrates were not obtained in this study. This is one of the weaknesses in this study.

CONCLUSION

The order of vegetable before carbohydrate consumption decreases energy intake of type-2 diabetes mellitus patients. This method can be used as an alternative for nutrition education in the management of nutritional therapy for type-2 diabetes mellitus patients. In further research, it is

necessary to investigate the effect of the order of eating vegetables on changes in blood sugar levels, as the main indicator of the success of diet therapy and the effect on weight loss, because the most of subject in this study were overweight.

ACKNOWLEDGMENT

The researchers would like to thank the Head of Manyaran Public Health Center Semarang City and the medical team, as well as the respondents who have been willing to participate in this study.

CONFLICT OF INTEREST

No potential conflicts of interest were disclosed.

REFERENCES

American Diabetes Association. (2018). 4. Lifestyle management: standards of medical care in diabetes—2018. *Diabetes care*, *41*(Supplement 1), S38-S50.

Chaudhri, O., Small, C. and Bloom, S. (2006) 'Gastrointestinal hormones regulating appetite', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 361(1471), 1187–1209.

Gibbons, C., Hopkins, M., Beaulieu, K., Oustric, P., & Blundell, J. E. (2019). Issues in measuring and interpreting human appetite (satiety/satiation) and its contribution to obesity. *Current obesity reports*, *8*(2), 77-87.

Hervik, A. K., & Svihus, B. (2019). The role of fiber in energy balance. *Journal of nutrition and metabolism*, *2019*.

Imai, S., Matsuda, M., Hasegawa, G., Fukui, M., Obayashi, H., Ozasa, N., & Kajiyama, S. (2011). A simple meal plan of'eating vegetables before carbohydrate'was more effective for achieving glycemic control than an exchange-based meal plan in Japanese patients with type 2 diabetes. *Asia Pacific journal of clinical nutrition*, *20*(2), 161-168.

Immawati, F.R. & Wirawanni, Y. (2014). Hubungan konsumsi karbohidrat, konsumsi total energi, konsumsi serat, beban glikemik dan latihan jasmani dengan kadar glukosa darah pada pasien diabetes mellitus tipe 2. *Diponegoro Journal of Nutrition and Health*, *2*(3), 89842.

Kementrian Kesehatan RI. 2018. Riset Kesehatan Dasar. Jakarta: Kemenkes RI. Retrived from http://www.depkes.go.id/resources/download/infoterkini/materi_rakorpop_2018/Hasil%20Riskesdas%202018.pdf

Kristensen, M., & Jensen, M. G. (2011). Dietary fibres in the regulation of appetite and food intake. Importance of viscosity. *Appetite*, *56*(1), 65-70.

Mahan, L. K., Raymond, J. L., Escott–stump, S., & Krause's Food, N. (2016). Diet therapy. Copyright Elsevier (USA). *All rights reserved*, *2*, 135-143.

Nishino, K., Sakurai, M., Takeshita, Y., & Takamura, T. (2018). Consuming carbohydrates after meat or vegetables lowers postprandial excursions of glucose and insulin in nondiabetic subjects. *Journal of nutritional science and vitaminology*, *64*(5), 316-320.

Perkeni, P. (2019). Pedoman pengelolaan dan pencegahan diabetes melitus tipe 2 dewasa di Indonesia. *Edisi Pertama. Jakarta: PB Perkeni*.

Raynor, H. A. (2014). What to do about portion sizes? Roundtable discussion at the Forefronts in Portion Size Conference. *International Journal of Obesity*, *38*(1), S34-S36.

Toumpanakis, A., Turnbull, T., & Alba-Barba, I. (2018). Effectiveness of plant-based diets in promoting well-being in the management of type 2 diabetes: a systematic review. *BMJ Open Diabetes Research and Care*, *6*(1).

Tremblay, A., & Bellisle, F. (2015). Nutrients, satiety, and control of energy intake. *Applied Physiology, Nutrition, and Metabolism*, *40*(10), 971-979.

Wanders, A. J., van den Borne, J. J., de Graaf, C., Hulshof, T., Jonathan, M. C., Kristensen, M., ... & Feskens, E. J. (2011). Effects of dietary fibre on subjective appetite, energy intake and body weight: a systematic review of randomized controlled trials. *Obesity reviews*, *12*(9), 724-739.

Wang, P. Y., Fang, J. C., Gao, Z. H., Zhang, C., & Xie, S. Y. (2016). Higher intake of fruits, vegetables or their fiber reduces the risk of type 2 diabetes: A meta-analysis. *Journal of diabetes investigation*, *7*(1), 56-69.

Zubrzycki, A., Cierpka-Kmiec, K., Kmiec, Z., & Wronska, A. (2018). The role of low-calorie diets and intermittent fasting in the treatment of obesity and type-2 diabetes. *J Physiol Pharmacol*, *69*(5), 663-83.

https://doi.org/10.204736/mgi.v17i1.56–61

HUBUNGAN POLA KONSUMSI SUMBER ZAT BESI, *INHIBITOR* DAN *ENHANCER* ZAT BESI DENGAN KEJADIAN ANEMIA PADA SANTRIWATI PONDOK PESANTREN AL-MIZAN MUHAMMADIYAH LAMONGAN

Correlation between Consumption Patterns of Iron Sources, Iron Inhibitor, and Iron Enhancer, with the Occurence of Anemia Among Female Students in Islamic Boarding School Al-Mizan Muhammadiyah Lamongan

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ABSTRAK

Anemia merupakan salah satu permasalahan defisiensi zat gizi yang rentan dialami oleh remaja putri. Anemia adalah kondisi dimana kadar hemoglobin (Hb) lebih rendah dari 12 g/dL. Anemia dapat disebabkan karena kekurangan darah, penyakit infeksi, rendahnya kandungan zat besi pada makanan, rendahnya konsumsi makanan sumber zat besi dan terdapat zat yang dapat menghambat absorbsi zat besi pada makanan. Mengonsumsi sumber zat besi dan *enhancer* zat besi serta mengurangi konsumsi *inhibitor* dapat meningkatkan absorbsi zat besi dalam tubuh. Penelitian ini bertujuan untuk menganalisis hubungan antara pola konsumsi sumber zat besi, *inhibitor* zat besi dan *enhancer* zat besi dengan kejadian anemia pada santriwati. Penelitian ini menggunakan desain *cross sectional* pada 50 santriwati kelas X dan XI di Pondok Pesantren Al-Mizan Muhammadiyah Lamongan. Pemilihan sampel menggunakan metode *proportional random sampling.* Kadar hemoglobin diukur menggunakan alat *hemoglobinmeter digital* dan data pola konsumsi dikumpulkan menggunakan *food frequency questionnaire.* Analisis data menggunakan uji korelasi *Spearman.* Penelitian ini menemukan hubungan antara pola konsumsi sumber zat besi (p=0,036) dan *inhibitor* zat besi (p=0,012) dengan kejadian anemia. Tidak ada hubungan antara pola konsumsi *enhancer* zat besi (p=0,339) dengan kejadian anemia. Kebiasaan mengonsumsi sumber zat besi dan *inhibitor* zat besi dapat meningkatkan kadar zat besi dalam tubuh terutama zat besi heme dan mengurangi konsumsi pangan *inhibitor* zat besi untuk menurunkan risiko terjadinya anemia.

Kata kunci : anemia, pola konsumsi, *enhancer, inhibitor*, zat besi, remaja

ABSTRACT

One of the nutrient deficiency problems for adolescent girls is anemia. Anemia is a condition occurs when the hemoglobin (Hb) level is below 12 g/dL. Anemia can be caused by blood deficiency, infections;low iron contens in the diet, low consumption of food source of iron and the presence of any substances that might inhibit the absorption of iron intake from foods. Consuming iron source foods and iron enhancers, also reducing iron inhibitor intake can enhance iron absorption in body. The obstruction of iron absorption in body can increase the risk of anemia for adolescent girls. This study aimed to analyze the correlation between consumption patterns of iron sources, iron inhibitor, and iron enhancer, with the occurrence of anemia among adolescent girls. This research was an analytic observational study that performed cross-sectional design on 50 female students from grade X to XI at Islamic Boarding School Al-Mizan Muhammadiyah Lamongan. The participants were selected based on proportional random sampling method. The hemoglobin levels data were collected using digital hemoglobinmeter and the consumption patterns data were collected using food frequency questionnaire. Spearman correlation test was performed to analyze the data. The results showed there was a correlation between consumption patterns of iron source (p=0.036) and iron inhibitor (p=0.012) with the occurrence of anemia. However, there was no correlation between consumption patterns of iron enhancers (p=0.339) with the occurrence of anemia. In conclusion, a habit of consuming iron-rich-foods and iron inhibitor in diets contributes to the occurrence of anemia in female students. Therefore, they are expected to consume more iron-rich foods especially heme iron and minimalize consuming iron inhibitor foods to decrease the risk of anemia.

Keywords: *anemia, consumption patterns, enhancer, inhibitor, iron, adolescent*

 Received 27-10-2020, Accepted 10-02-2021, Published online 30-01-2022

INTRODUCTION

Anemia yaitu kondisi kurangnya total sel darah merah atau kadar hemoglobin sebagai *carrier* oksigen dalam darah sehingga kebutuhan fisiologis tubuh tidak tercukupi (Riskesdas, 2013). *World Health Organization* (WHO, 2013) menyatakan bahwa di dunia prevalensi anemia sebanyak 40-88%. Berdasarkan Riset Kesehatan Dasar tahun 2013 diketahui bahwa kejadian anemia pada perempuan yaitu sebesar 23,9% dan mengalami peningkatan menjadi 27,2% pada tahun 2018 (Riskesdas, 2018).

Anemia dapat terjadi dikarenakan beberapa faktor diantaranya terdapat peningkatan kebutuhan tubuh, kekurangan sel darah merah, derajat sosial dan ekonomi, kandungan zat besi yang rendah dalam makanan yang dikonsumsi, rendahnya penyerapan zat besi, rendahnya pengetahuan mengenai zat besi, serta adanya *inhibitor* absorbsi zat besi dalam makanan (Puji *et al*., 2010). Rendahnya kandungan zat besi dalam makanan dapat menyebabkan defisiensi asupan zat besi, yang apabila terjadi secara terus menerus dapat menyebabkan berkurangnya cadangan besi dalam tubuh sehingga sintesis hemoglobin dapat terganggu (Sya'bani *et al*., 2016). Faktor yang menjadi pendorong (*enhancer*) dan penghambat (*inhibitor*) penyerapan zat besi dari makanan harus diperhatikan untuk menilai asupan zat besi. Menurut Marya (2013) vitamin C, vitamin A dan vitamin B2 merupakan beberapa zat gizi yang dapat membantu penyerapan dari zat besi. selain itu, protein hewani yang berasal dari daging, ikan dan unggas merupakan faktor *enhancer* zat besi yang berperan dalam hematopoisis yaitu pembentukan eritrosit dengan hemoglobin (Sembiring, 2017). Namun, terdapat pula zat yang berperan sebagai *inhibitor* zat besi sehingga penyerapan zat besi menjadi terganggu atau terhambat. Zat gizi dalam makanan yang dapat berperan sebagai *inhibitor* zat besi yaitu fosfat, kalsium, tanin dan fitat apabila dalam besaran yang banyak dikonsumsi (Sizer *et al*., 2013).

Penelitian yang dilakukan oleh Sya'bani *et al.* (2016) menunjukkan bahwa tingkat kecukupan zat besi berhubungan langsung dengan status anemia. Sebesar 62% santriwati yang mengalami anemia memiliki tingkat konsumsi zat besi yang tergolong kurang. Penelitian ini selaras dengan Sembiring (2017) pada siswi SMA Negeri 1 Lubuk Pakam menyatakan siswi yang mengalami anemia sebesar 90,5% biasa mengonsumsi pangan sumber *inhibitor* zat besi dan sebesar 84,4% siswi tidak pernah mengonsumsi pangan sumber *enhancer* zat besi mengalami kejadian anemia.

Salah satu kelompok usia yang rawan mengalami anemia adalah remaja putri (Soetjiningsih, 2010). Banyaknya remaja putri yang mengalami anemia dikarenakan siklus menstruasi setiap bulan. Menurut Marmi (2013) ketersediaan pangan dan pola makan yang salah dapat menyebabkan kurangnya asupan zat gizi sehari-hari sehingga terjadi anemia. Selain itu, penyebab lain anemia pada remaja putri yaitu ingin memiliki bentuk tubuh ideal dengan melakukan diet ketat yang dapat menyebabkan kurangnya asupan makanan seimbang dan bergizi (Sayogo, 2011).

Santriwati merupakan salah satu kelompok yang rentan mengalami anemia. Santriwati adalah panggilan bagi siswi yang bermukim di pondok pesantren untuk menimba ilmu-ilmu agama. Jauh dari orang tua membuat santriwati dituntut untuk hidup mandiri terutama dalam memenuhi kebutuhan makanannya. Menurut Chairunnisa *et al.* (2019) tinggi konsumsi jajanan ringan dan rendah konsumsi sayuran merupakan kebiasaan makan santriwati yang kurang tepat. Hasil penelitian yang dilakukan oleh Emilia (2019) di Pondok Pesantren Hidayatussalikin Air Itam Pangkalpinang menyatakan 63,8% santri putri mengalami anemia. Menurunnya konsentrasi dalam belajar merupakan salah satu akibat dari terjadinya anemia pada remaja (Adriani *et al.*, 2012).

Berdasarkan studi pendahuluan yang dilakukan pada bulan Februari 2020 di Pondok Pesantren Al-Mizan Muhammadiyah Lamongan dengan sampel 10 santriwati diperoleh hasil sebesar 70% santriwati tidak mengetahui apa penyebab anemia, 80% santriwati tidak mengetahui bahan pangan sumber zat besi dan 100% santriwati pernah mengalami gejala anemia 5L (lemah, letih, lesu, lunglai dan lelah). Berdasarkan data tersebut, maka diperlukan adanya penelitian untuk mengetahui hubungan antara pola konsumsi sumber, *inhibitor* dan *enhancer* zat besi dengan kejadian anemia pada santriwati di Pondok Pesantren Al-Mizan Muhammadiyah Lamongan.

https://doi.org/10.204736/mgi.v17i1.56–61

METODE

Penelitian ini merupakan penelitian observasional analitik dengan menggunakan desain *cross sectional*. Populasi pada penelitian merupakan santriwati kelas X dan XI di Pondok Pesantren Al-Mizan Muhammadiyah Lamongan sebanyak 101 orang. Banyaknya sampel dalam penelitian ini adalah 50 santriwati dengan rentang usia 15–18 tahun. Penentuan dan pengambilan sampel populasi masing-masing kelas dilakukan secara *proportional random sampling.*

Pengambilan data dilangsungkan pada Bulan Juli 2020 di Pondok Pesantren Al-Mizan Muhammadiyah Lamongan. Variabel yang diteliti adalah pola konsumsi santriwati selama di pondok pesantren yang meliputi kebiasaan konsumsi pangan sumber zat besi, *inhibitor* zat besi dan *enhancer* zat besi. data mengenai pola konsumsi pangan sumber zat besi, *inhibitor* zat besi dan *enhancer* zat besi diperoleh melalui wawancara menggunakan alat bantu *Food Frequency Questionare* (FFQ) selama 1 bulan terakhir. Frekuensi pola konsumsi dikategorikan menjadi: (1) Biasa dikonsumsi apabila skor ≥ 15–50, (2) Kadang-kadang apabila skor ≥ 10–14,9, (3) Tidak pernah apabila skor ≥ 1–9,9 (Widajanti, 2009).

Dilakukan pemeriksaan kadar hemoglobin pada santriwati menggunakan hemoglobinmeter dengan merk *easy touch* untuk mengetahui status anemia pada santriwati. Pemeriksaan dilakukan oleh tenaga kesehatan yaitu perawat. Hasil pemeriksaan hemoglobin dikategorikan menjadi : (1) Anemia apabila skor Hb < 12g/dL, (2) Tidak anemia apabila skor Hb ≥ 12g/dL (Proverawati *et al.*, 2011). Data pada penelitian ini dilakukan analisis statistik menggunakan uji korelasi *Spearman* dengan tingkat signifikansi α = 0,05. Penelitian ini telah mendapatkan persetujuan dari Komisi Etik Fakultas Keperawatan Universitas Airlangga dengan nomor sertifikat 1972-KEPK tahun 2020.

HASIL DAN PEMBAHASAN

Tabel 1 menunjukkan bahwa sebagian besar responden merupakan kategori usia remaja akhir dengan rentang usia 16–19 tahun yaitu sebesar 96,0%. Remaja perempuan merupakan kelompok usia yang berisiko mengalami anemia. Perempuan yang menstruasi cenderung kekurangan zat besi karena kehilangan zat besi yang terjadi setiap bulannya (Corwin, 2009). Berkurangnya kadar hemoglobin yang berlangsung dalam kurun waktu yang lama dapat menyebabkan terjadinya anemia (Brown *et al. ,* 2011).

Karakteristik responden yang lainnya yaitu uang saku yang digunakan untuk makan dan jajan dalam satu hari. Rata-rata uang saku santriwati dalam satu hari Rp. 6.240 ± 2.403 dengan uang saku minimum Rp. 2.000 dan uang saku maksimum Rp. 10.000. Tabel 1 menunjukkan sebesar 62,0% santriwati memiliki besaran uang saku yang kurang dari rata-rata. Pemenuhan zat gizi dan konsumsi pangan sumber zat besi dipengaruhi oleh keterbatasan uang saku pada remaja yang menyebabkan remaja hanya dapat membeli *snack* (Astuti *et al.,* 2016).

Tabel 1 menunjukkan sebesar 22,0% santriwati di Pondok Pesantren Al-Mizan mengalami anemia. Sebagian besar santriwati berstatus gizi normal. Rata-rata kadar hemoglobin santriwati sebesar 13,34 g/dL dengan nilai minimum sebesar 10,9 g/dL dan nilai maksimum sebesar 16,4 g/dL. Pada penelitian ini santriwati yang mengalami anemia dengan kadar hemoglobin < 12 g/dL sebesar 22%. Prevalensi remaja anemia pada penelitian ini lebih tinggi dibandingkan dengan prevalensi anemia

Tabel 1. Distribusi Karakteristik Individu di Pondok Pesantren Al-Mizan Muhammadiyah Lamongan Tahun 2020.

Karakteristik Individu	n	(%)
Usia (Tahun)		
Remaja Awal (10-12)	0	0,0
Remaja Madya (13-15)	2	4,0
Remaja Akhir (16-19)	48	96,0
Uang Saku (Rupiah)		
≤ Rata-rata (≤ Rp 6.240)	31	62,0
≥ Rata-rata (≥ Rp 6.240)	19	38,0
Status Anemia (Hb)		
Anemia (< 12 g/dL)	11	22,0
Tidak Anemia (≥ 12 g/dL)	39	78,0
Status Gizi		
Sangat Kurus	2	4,0
Kurus	1	2,0
Normal	32	64,0
Gemuk	8	16,0
Obesitas	7	14,0

remaja menurut Riset Kesehatan Dasar tahun 2018 yaitu sebesar 8,1%. Akan tetapi, prevalensi remaja anemia penelitian ini lebih rendah bila dibandingkan dengan prevalensi anemia pada remaja putri di SMA Negeri 3 Kendari yang sebesar 41,7% (Kaimudin *et al.,* 2017). Anemia dapat disebabkan karena rendahnya kandungan zat besi dalam makanan (Puji *et al.*, 2010). Zat besi dapat berperan dalam respirasi seluler sebagai bagian dari hemoglobin dan mioglobin serta membentuk hemoglobin dari eritrosit (Beck *et al.*, 2011).

Rata-rata persen kecukupan zat gizi dikelompokkan menjadi kurang (< 80% AKG), cukup (80–110% AKG) dan lebih (> 110% AKG). Tabel 2 menunjukkan rata-rata persen kecukupan protein, zat besi dan vitamin C santriwati tergolong dalam kategori kurang (< 80% AKG).

Makanan sumber zat besi pada penelitian ini yaitu sayuran hijau seperti bayam, kangkung, sawi, kacang hijau, kacang tanah (beserta olahannya), *seafood* (kerang dan udang). Sumber zat besi yang sering dikonsumsi yaitu kacang hijau dan kacang tanah (beserta olahannya). Santriwati juga mengonsumsi tablet tambah darah yang didapatkan dari pondok pesantren. Makanan *inhibitor* zat besi pada penelitian ini meliputi bahan makanan sumber oksalat, tanin, fitat dan kalsium. Sumber *inhibitor* yang sering dikonsumsi oleh santriwati yaitu tahu dan tempe. Daging, ikan, ayam dan vitamin C yang terkandung dalam buah dan sayur merupakan bahan makanan *enhancer* zat besi pada penelitian ini. Sumber *enhancer* zat besi yang sering dikonsumsi yaitu ikan pindang, ayam dan telur.

Hasil analisis uji hubungan antara pola konsumsi sumber zat besi dengan status anemia menghasilkan nilai *p-value* ≤ 0,05 (p=0,036) berarti diperoleh hubungan yang bermakna antara pola konsumsi sumber zat besi dengan kejadian anemia santriwati di Pondok Pesantren Al-Mizan. Tingginya kejadian anemia dapat dikarenakan jarangnya mengonsumsi makanan sumber zat besi yang mengakibatkan rendahnya hemoglobin dalam tubuh.

Tabel 2. Distribusi Presentase Kecukupan Konsumsi Santriwati di Pondok Pesantren Al-Mizan Muhammadiyah Lamongan Tahun 2020.

Persen Kecukupan	Rata-rata	Kategori Kecukupan
Protein (%)	55,37	Kurang (< 80%)
Zat Besi (%)	28,13	Kurang (< 80%)
Vitamin C (%)	44,87	Kurang (< 80%)

Rendahnya konsumsi sumber zat besi pada penelitian ini disebabkan terbatasnya ketersediaan pangan sumber zat besi heme yang disediakan oleh pondok. Selain itu, kantin di pondok pesantren hanya menjual makanan dan minuman ringan serta tidak diperkenankan untuk menjual makanan berat seperti nasi beserta lauk pauk dimana lauk pauk merupakan salah satu sumber zat besi. Sebagian besar santriwati lebih sering mengonsumsi pangan sumber zat besi non heme yaitu kacang tanah dan kacang hijau. Sumber pangan tersebut sebagian besar diperoleh dari jajanan seperti bubur kacang hijau dan bumbu pentol atau batagor yang hanya bisa dibeli saat jam istirahat sekolah dan didapatkan dari penjual di depan sekolah. Setelah menyelesaikan jam sekolah dan kembali ke pondok, santriwati tidak diperkenankan untuk membeli jajanan yang dijual di depan sekolah. Santriwati lebih sering mengonsumsi pangan sumber zat besi non-heme dengan bioavabilitas yang rendah dikarenakan adanya zat asam fitat dan oksalat yang dapat mengikat zat besi serta menghambat penyerapannya, sehingga hanya

Tabel 3. Hubungan Pola Konsumsi Sumber Zat Besi, *Inhibitor* Zat Besi dan *Enhancer* Zat Besi dengan Kejadian Anemia Santriwati di Pondok Pesantren Al-Mizan Muhammadiyah Lamongan Tahun 2020.

Variabel	Status Anemia				*p value*
	Anemia		Tidak Anemia		
	n	(%)	n	(%)	
Pola Konsumsi Sumber Zat Besi					
Tidak Pernah	10	31,2	22	68,8	0,036*
Kadang-kadang	1	5,6	17	94,4	
Biasa Konsumsi	0	0,0	0	0,0	
***Inhibitor* Zat Besi**					
Tidak Pernah	4	12,1	29	87,9	0,012*
Kadang-kadang	6	37,5	10	62,5	
Biasa Konsumsi	1	100,0	0	0,0	
***Enhancer* Zat Besi**					
Tidak Pernah	10	20,8	38	79,2	0,339
Kadang-kadang	1	50,0	1	50,0	
Biasa Konsumsi	0	0,0	0	0,0	

*Signifikan jika p ≤ 0,05

sedikit total zat besi yang terserap oleh tubuh (Husnah *et al.,* 2014).

Hasil penelitian ini selaras dengan Junengsih, *et al.* (2017) yang menyebutkan bahwa remaja perempuan dengan asupan zat besi yang rendah memiliki risiko 7,9 kali lebih tinggi mengalami anemia. Adanya hubungan bermakna antara asupan zat besi dengan status anemia pada siswi MTs Ciwandan (Pratiwi, 2016).

Hasil analisis uji hubungan antara pola konsumsi pangan sumber *inhibitor* zat besi dengan status anemia diperoleh nilai $p \leq 0,05$ (p=0,012) berarti ada hubungan antara pola konsumsi sumber *inhibitor* zat besi dengan kejadian anemia pada santriwati di Pondok Pesantren Al-Mizan. Semakin jarang santriwati mengonsumsi inhibitor zat besi maka prevalensi santriwati yang tidak anemia juga semakin tinggi. Hal tersebut dikarenakan hampir setiap hari menu di pondok pesantren menyediakan olahan tahu dan tempe. Tahu dan tempe berbahan dasar kacang kedelai yang mengandung zat fitat, dimana zat fitat ini dapat mengikat zat besi sehingga mempersulit penyerapannya. Jajanan berbahan cokelat sering dikonsumsi santriwati dikarenakan mudah ditemukan di kantin serta memiliki harga yang cukup murah, padahal cokelat mengandung asam oksalat yang bisa mengurangi absorbsi zat besi. selain itu, santriwati juga sering mengonsumsi susu yang mengandung kalsium, dimana kalsium apabila berinteraksi dengan zat besi dapat menghambat penyerapan zat besi yang terjadi di mukosa usus (Marina *et al.,* 2015). Kalsium terbukti mempengaruhi penyerapan zat besi, dimana efek negatif status zat besi lebih rentan pada kelompok dengan konsumsi kalsium tingkat tinggi (Kwatra, 2019). Hasil penelitian selaras dengan penelitian Penelitian Jaelani, *et al.* (2017) menyatakan terdapat hubungan pola konsumsi makanan *inhibitor* dengan kejadian anemia pada remaja putri, kejadian anemia akan semakin tinggi apabila sering mengonsumsi *inhibitor* penyerapan zat besi.

Hasil analisis uji hubungan antara pola konsumsi pangan sumber *enhancer* zat besi dengan status anemia memperoleh hasil nilai *p-value* $\geq 0,05$ (p=0,339) yang berarti tidak adanya hubungan kejadian anemia dengan pola konsumsi *enhancer* zat besi pada santriwati. Hal tersebut dapat dikarenakan ketika santriwati mengonsumsi pangan sumber zat besi non-heme yang hanya 10% terabsorbsi oleh tubuh dan tidak dibarengi mengonsumsi pangan *enhancer* zat besi seperti vitamin C dan protein hewani (Pratiwi, 2016). Selain itu, menu makan yang disediakan pondok hanya berupa nasi serta lauk saja, tidak ada buah-buahan, padahal buah-buahan mengandung salah satu zat pendorong absorbsi zat besi yaitu vitamin C. Sebagian besar santriwati hanya mengonsumsi buah-buahan yang didapatkan dari orang tua atau keluarga saat berkunjung. Hasil dari penelitian ini selaras dengan penelitian Pratiwi *et al.* (2018) yang menyebutkan tidak ditemukan hubungan kejadian anemia dengan kebiasaan mengonsumsi makanan sumber *enhancer* zat besi.

KESIMPULAN DAN SARAN

Berdasarkan hasil penelitian pada santriwati di Pondok Pesantren Al-Mizan Muhammadiyah Lamongan, ditemukan hubungan kebiasaan pola konsumsi pangan sumber dan *inhibitor* zat besi dengan kejadian anemia pada santriwati. Semakin jarang mengonsumsi inhibitor zat besi maka kadar prevalensi santriwati yang tidak anemia semakin tinggi. Selain itu, semakin jarang mengonsumsi pangan sumber zat besi menyebabkan santriwati lebih berisiko mengalami anemia. Tidak ditemukan hubungan kejadian anemia dengan pola konsumsi sumber *enhancer* zat besi pada santriwati. Peneliti menyarankan kepada santriwati untuk mengurangi konsumsi pangan sumber *inhibitor* zat besi. Santriwati diharapkan memperbanyak konsumsi sumber besi heme dengan memperbanyak asupan lauk hewani, hal tersebut dilakukan untuk mencegah terjadinya anemia pada santriwati. Selain itu, pihak pesantren dapat menyediakan makanan yang dapat mencukupi kebutuhan zat gizi para santriwati dikarenakan akses terhadap sumber makanan bergizi terbatas hanya dari pesantren. Prospek riset selanjutnya yang perlu diteliti yaitu mengenai kepatuhan mengonsumsi tablet tambah darah, mengingat pondok memiliki program pembagian tablet tambah darah.

DAFTAR PUSTAKA

Adriani, M., & Wirjatmadi, B. (2012). *Peran gizi dalam kehidupan.* Jakarta: Kencana Prenada Media Group.

Astuti, S.D., & Trisna, E. (2016). Faktor-faktor yang berhubungan dengan kejadian anemia pada remaja putri wilayah Lampung Timur. *Jurnal Keperawatan,* vol 5 (2).

Balitbangkes. (2018). *Hasil Riset Kesehatan Dasar (Riskesdas).* Jakarta : Kementrian Kesehatan R.I.

Beck, M.E. (2011). *Ilmu gizi dan diet : Hubungannya dengan penyakit-penyakit untuk perawat dan dokter.* Yogyakarta : Andi Yogyakarta.

Brown, J.E., Issacs., Krinke, J.S., Lechtenberg, U.B., & Murtaugh, E.C.M.A. (2011). *Nutrition through the life cycle fourth edition.* Belmout USA : Wadsworth Cengage Learning.

Chairunnisa, O., Nuryanto & Probosari, E. (2019). Perbedaan kadar hemoglobin pada santriwati dengan puasa daud, ngrowot, dan tidak berpuasa di Pondok Pesantren Temanggung Jawa Tengah. *Journal of Nutrition College* (08)2:58-64. doi : 10.14710/jnc.v8i2.23814.

Corwin, E.J. (2009). *Buku saku patofisiologi.* Jakarta : EGC.

Emilia. (2019). Hubungan asupan zat besi dengan status anemia pada santri putri di Pondok Pesantren Hidayatussalikin Air Item Kota Pangkalpinang Tahun 2017. *Jurnal Kesehatan Poltekkes Kemenkes RI Pangkalpinang* (07)2:64-69. Doi : 10.32922/jkp.v7i2.88.

Husnah, N., Indriasari, R., & Jafar, N. (2014). *Hubungan makanan sumber heme dan non heme terhadap kadar hb remaja putri SMA 10 Makassar Tahun 2014.* Skripsi. Universitas Hassanuddin.

Jaelani, M., Simanjutak, B.Y., & Yuliantini, E. (2017). Faktor risiko yang berhubungan dengan kejadian anemia pada remaja putri. *Jurnal Kesehatan* 08 (3) 358-368. https://doi.org/10.26630/jk.v8i3.625

Junengsih & Yuliasari. (2017). Hubungan asupan zat besi dengan kejadian anemia pada remaja putri SMU 98 di Jakarta Timur. *Jurnal Ilmu dan Teknologi Kesehatan.* Vol 5(1). https://doi.org/10.32668/jitek.v5i1.68

Kaimudin, N., Lestari, H., & Afa, J. (2017). Skrining dan determinan kejadian anemia pada remaja putri SMA Negeri 3 Kendari Tahun 2017. *JIMKESMAS* 2 (6) 1-10.

Kwarta, B. (2019). Calcium and iron absorption : invitro studies. *International Journal of Medical and Biomedical Studies* 3 (12) 59-61. https://doi.org/10.32553/ijmbs.v3i12.801

Marina, M., Indriasari, R., & Jafar, N. (2015). Konsumsi tanin dan fitat sebagai determinan penyebab anemia pada remaja putri di SMA Negeri 10 Makassar. *Jurnal MKMI* 11 (1) 50-58.

Marya, R.K. (2013). *Patofisiologi mekanisme terjadinya penyakit.* Tangerang : Binarupa Aksara.

Pratiwi, E. (2016). *Faktor-faktor yang mempengaruhi anemia.* Skripsi. UIN Syarif Hidayatullah.

Pratiwi, R. & Widari, D. (2018). Hubungan konsumsi sumber pangan *enhancer* dan *inhibitor* zat besi dengan kejadian anemia pada ibu hamil. *Amerta Nutrition* 2 (3) 283-291. https://doi.org/10.20473/amnt.v2i3.2018.283-291

Proverawati, A., & Wati, E.K. (2011). *Ilmu gizi untuk keperawatan dan gizi kesehatan.* Yogyakarta : Nuha Medika.

Puji, A.E, Satriani, S, Nadimin, & Fadliyah. (2010). Hubungan pengetahuan ibu dan pola konsumsi dengan kejadian anemia gizi pada ibu hamil di Puskesmas Kassi-kassi. *Jurnal Media Gizi Pangan.* Vol.X, Edisi 2.

Sayogo, S. (2011). *Gizi remaja putri.* Jakarta : Balai Penerbit Fakultas Kedokteran Universitas Indonesia.

Sembiring, D.B. (2017). Hubungan body image dan pola konsumsi (faktor inhibitor dan enhancer Fe) dengan status anemia remaja putri di SMA Negeri 1 Lubuk Pakam. Skripsi. Politeknik Kesehatan Medan.

Sizer, F.S. & Whitney, E. (2013). *Nutrition : concepts and controversies.* USA : Wadsworth Cengage Learning.

Sya'bani, I.R.N, Sumarmi, S. (2016). Hubungan status gizi dengan kejadian anemia pada santrwati di Pondok Pesantren Darul Ulum Peterongan Jombang. *Jurnal Keperawatan Muhammadiyah,* 1 (2).

Widajanti, L. (2009). *Buku petunjuk praktikum survey konsumsi gizi.* Semarang : Universitas Diponegoro.

World Health Organization (WHO). (2013). *Worldwide prevalency of anemia WHO global database on anemia.* Geneva : WHO Press.

World Health Organization (WHO). (2015). *The global prevalence of anemia in 2011.* Geneva: WHO Press.

https://doi.org/10.204736/mgi.v17i1.62–69

THE COMPOSITION OF CARBOHYDRATE AND FAT CONSUMPTION AMONG OBESE ADOLESCENTS IN SURABAYA AND SIDOARJO

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ABSTRACT

Carbohydrates and fats are macronutrients that have been the most influential factors to obesity. The excess of consumed carbohydrates or fats will be stored as triglycerides in adipocytes. This study aims to analyze the proportion of carbohydrates and fats consumption among obese adolescents from Surabaya and Sidoarjo. This study also revealed the relationship between the proportion with the total calories consumption and body mass index (BMI). This cross-sectional study involved obese adolescents aged 13-18 years old from several junior and senior high schools, conducted during May-September 2020. The subject was selected using a total population sampling method that met inclusion and exclusion criteria. Anthropometries (weight and height) were measured to calculate BMI and determine obesity according to CDC 2000 criteria. A 24-hour-food-recall for the last two days was used to get the dietary information. This study divided carbohydrates consumption into three groups (high (HC), moderate (MC), low (LC)) and fats consumption into two groups (high fats (HF) and non-high fats (Non-HF)). There were 240 obese adolescents participating in this study; 40.4% of them consuming high carbohydrates and 17.5% of them consuming HF on their diets. Although there were several distinctions in carbohydrates and fats composition on diet, the total calorie and the mean BMI were not considerably different based on macronutrients consumption. In conclusion, there were two types of imbalance proportion of macronutrients consumption among our participants, high–carbohydrates-low-fats diet and low-carbohydrates-high-fats-diet.

Keywords: adolescents, carbohydrates, consumption, fats, obesity

INTRODUCTION

Obesity is the result of interaction between dietary patterns, environments, and genetic factors (Ghosh & Bouchard, 2017). It is often handled by not only decreasing total calories consumption, but also arranging balance proportion of the macronutrients (Sjarif et al., 2014). Adolescents are considered to have imbalanced nutritional habits, such as consuming more sweet beverages, fast foods, and less fruits and vegetables. Such habits might have metabolic consequences and indeed experience obesity (Ruiz, et al., 2020). Based on Indonesia's national research on essential health, the obesity case in adolescents has increased two folds in five years (Kementrian Kesehatan RI, 2018).

Excessive consumption of carbohydrates, proteins, or fats possibly increase weight (Febriani et al., 2019). In connection with obesity, adipocytes are hypertrophy and become the storage of triglycerides (TG) (Bessesen et al., 2015). Human body cannot store excessive protein so that it will eventually be converted to glucose (via gluconeogenesis) or ketone. In a state of low energy demand, these metabolites will be stored as glycogens and fats (Clifton & Keogh, 2007). Excessive carbohydrates will also be stored in the form of glycogens and fats (Febriani, et al., 2019).

Every population has its dietary habits that will impede the proportion of consumed macronutrients. Thus, many people have dissimilar types of diet disproportion (Villa, et al., 2015; Mank, et al., 2020).

This study aimed to analyze the proportion of carbohydrate and fat consumption among obese adolescents and reveal the relationship between total calories consumption and BMI. The imbalanced macronutrient patterns described in this study might be considered in conducting obesity management especially in adolescents.

 Received 27-10-2020, Accepted 10-02-2021, Published online 30-01-2022

METHODS

This study used cross-sectional research design to address the research questions undertaken from May to September 2020. The research subjects included obese adolescents from 12 junior and senior high schools in Surabaya and Sidoarjo, East Java Province, Indonesia. The subjects were determined with a total population sampling method that met the inclusion and exclusion criteria. The minimum sample size was counted with formula for estimating a population proportion with specified absolute precision $n = Z^2_{1-\frac{\alpha}{2}} P(1-P)/d^2$. Using $1-\propto = 95$, d (size difference, minimal effect of interest) 0.1, and P (true proportion) 0.5. The minimal sample size is 97.

The inclusion criteria were those adolescents aged 13–18 years with obesity problems. Moreover, the subjects, along with their parents, voluntarily participated in the present study. Adolescents with a history of corticosteroid consumption for more than two up to six months before the study was carried out or the subjects got sick, were excluded.

In accordance with the present study, obesity was determined based on the CDC 2000 criteria, which conveys that the BMI/age was above the 95th percentile according to age and gender. Body weight was measured using a digital weight scale (Seca, Germany No ref. 224 1714009) with a precision of 0.1 kg. Height measurement was performed using stadiometer (Seca, Germany No ref. 224 1714009), with an accuracy of 0.1 cm. The proportion of each macronutrient in the diet was obtained from a 24-hour food recall interview by the researchers for two days (2×24 hours, during weekdays), before the data retrieval process. All gathered data were then converted into total calories, amount of calories from carbohydrates, protein, and fat based on foods exchange list. Data on total calories and total macronutrients consumption were the averages of food recall information for two days. The proportion of carbohydrates was calculated based on the amount of caloric intake in the diet process derived from carbohydrates divided by the total caloric intake, then, multiplied by 100%. The same way was used to determine the proportion of protein and fat in the diet process. Carbohydrate consumption was divided into three groups: (1) a high-carbohydrates (HC) diet when the average energy intake of carbohydrates in the diet was more than 65%, (2) moderate carbohydrates (MC) diet included the average energy intake of carbohydrates diet between 45–65%, and (3) The low-carbohydrates (LC) diet group was an average energy intake from carbohydrates less than 44% (Jung & Choi, 2017). The fat consumption could be classified into two groups: a HF diet group and a non-high fat (HF) diet group. In a HF diet group, when the average energy intake came from fat in the diet, more than 30% of total calories consumed. The non-HF diet group was the total consumption of calories derived from fat 30% or less (Schwingshackl & Hoffmann, 2013).

Total calories and macronutrient proportions were expressed in mean (M) and standard deviation (SD) when the normal distribution was attained. However, if the data were not normally distributed, the minimum and maximum median were used. The analysis of differences in macronutrient proportions based on carbohydrate and fat consumption group used One-way ANOVA, Kruskal-Wallis, t-test, and Mann-Whitney Test by the assistance of SPSS version 21.0. This study had got permission from the ethics committee of The Faculty of Medicine, Airlangga University No. 115/EC/KEPK/FKUA/ 2020. Before conducting the data collection, the researchers had explained to the subjects' parents about the general research information and had informed about the consent.

RESULTS AND DISCUSSIONS

There were 240 obese adolescents aged 13–18 years old involved in the present study consisted of boys (52.1%) and girls (47.9%). This study also classified the subjects by ages, of which there were 44.6% of them less than 15 years old and 55.4% older than or equals to 15 years old. The average of total calories consumed per day from all the subjects was 2474.8±416 kcal, with the composition of 61.7%±10.5 carbohydrates, 15.3%±3.0 proteins, and 22.3%±9.8 fats. The mean of carbohydrate consumption per day from all subjects was 383.9±141 gram. The mean of fat consumption per day from all subjects was 66.8±45.7 gram. The total calories consumed by boys were 2487±419 kcal (62.4% carbohydrates, 15.5% proteins, and 20.1% fats) with mean of

carbohydrates consumption per day 364.7±149.7 gram and mean of fats consumption per day 52.7±34.3 gram. Whereas, the total calories consumed by girls were 2461.6±414 kcal (61.0% carbohydrates, 15.2% proteins, and 22.4% fats) with mean of carbohydrates consumption per day 404.9±129.3 gram and mean of fats consumption per day 82.0±51.5 gram. Both data conveyed by sexes were not significantly difference.

In accordance with the total calories consumed based on the age group, those in the less than 15 years old group consumed 2454.9±392 kcal (61.3% carbohydrates, 15.8% proteins, and 21.1% fats) with mean of carbohydrates consumption per day 397.3±141.5 gram and mean of fats consumption per day 64.6±42.0 grams. In the older group, the average of total calories consumption was 2490.9±435 kcal (62.1% carbohydrates, 14.9% proteins, and 14.6% fats) with mean of carbohydrates consumption per day 373.3±141.2 gram and mean of fats consumption per day 64.6±42.0 gram. The average protein proportion on diet in the 15 years old or older group was significantly lower ($p<0.03$).

According to the carbohydrate and fat consumption categories, dietary compositions revealed no significant difference in total calorie (Table 1). A total of 15 students (6.3%) consumed LC, 128 students (53.3%) consumed MC, and 97 students (40.4%) consumed HC diet. On the other hand, the total subjects with HF diet were 42 students (17.5%), and the rest of them consumed fats less than 30% (Non-HF).

The number of fats and protein consumption differed significantly based on carbohydrates consumption (see Table 2). The LC group consumed 356.8±128.3-gram carbohydrate and 72.9±44.2-gram fats per day. The MC group consumed 381.1±161.5-gram carbohydrates and fats 60.2±41.0-gram per day. The HC group consumed 404.8±146.1gram carbohydrates and 59.7±47.7-gram fats per day.

Subjects in the LC group consumed higher fats than the other two groups based on carbohydrates proportion on a diet. In contrast, the HC diet group consumed significantly lower fats and proteins (see Figure 1). Based on the fat proportion on diet, the HF diet group consumed fewer carbohydrates proportion than the Non-HF diet group (see Table 3).

Table 1. Total Calories Consumptions based on Carbohydrates and Fat Diets Category

	Total Calories (kcal)	p
Carbohydrate diet categories		
LC	2460.9±355	
MC	2503.9±427	0.51
HC	2438.6±410	
Fat diet categories		
HF	2570±520	0.10
Non-HF	2454±389	

Table 2. Fat and Protein Proportions According to Carbohydrates Consumption on Diet

Carbohydrate Diet	Fat Proportions (%)	p
LC	45.4% (31.8–54.5%)	
MC	16.1% (9.1–25.1%)	0.00
HC	13.6% (8.3–18.8%)	
Carbohydrate Diet	**Protein Proportions (%)**	**p**
LC	16.7%±2.9	
MC	16.4%±2.9	0.00
HC	13.7%±2.4	

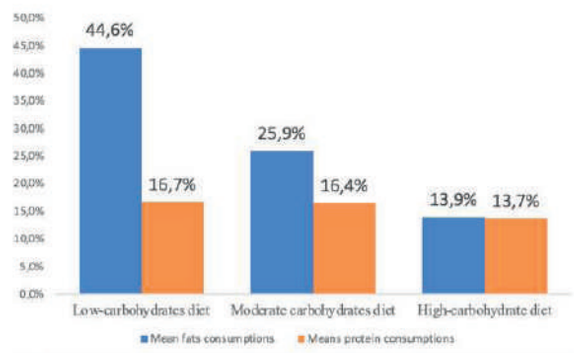

Figure 1. Means of Fat and Protein Proportion based on Carbohydrate Consumption Categories

Table 3. Carbohydrate and Protein Proportions According to Fat Consumptions on Diet

Fat diet	Carbohydrate proportions (%)	p
HF	46.9%±6.1	0.00
Non-HF	64.9%±8.2	
Fat diet	**Protein proportions (%)**	**p**
HF	16.0%±2.7	0.10
Non-HF	15.2%±3.1	

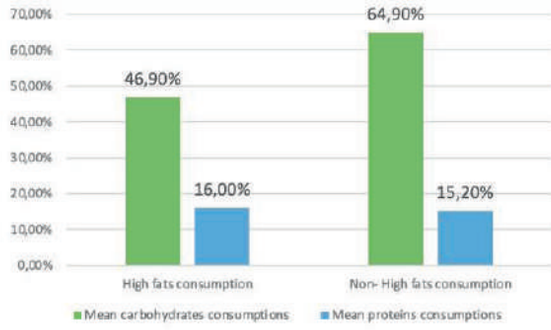

Figure 2. Means of Carbohydrate and Protein Proportion based on Fats Consumption Categories

The HF group consumed 68.36±48.1-gram fats and 379.8±138.8-gram carbohydrates per day. The Non-HF group consumed 59.3±31.6-gram fats and 403.3±153.9-gram carbohydrates per day. On the other hand, the proportion of protein consumptions between the two groups did not significantly different (see Table 3 and Figure 2). The carbohydrate proportion on diet in the Non-HF group was significantly higher than the HF diet group (see Figure 2). In regard to BMI, there was no significant difference from the average BMI based on the proportion of fats and carbohydrates consumption in the diet (see Table 4).

Adolescents are less likely to achieve a balanced nutrient consumption that could increase the risk of obesity. Obesity at the age of 12–19 years might negatively impact the form of excessive fatty tissue that can manifest in hypertension, hyperglycemia, and dyslipidemia (Ruiz et al., 2020) . Recommended composition of different macronutrients ranges from 45% to 65% of carbohydrates, 25% to 35% of fats, and 10% to 20% of proteins (Kim & Chung, 2020). The recommended balanced macronutrient composition based on the Indonesian Pediatric Society Guidelines on management of obesity should contain 50–60% of carbohydrates, 30% of fats, and 15–20% of proteins (Sjarif et al., 2014). This study portrays that the subjects' average carbohydrates consumption as obese adolescents was slightly above the recommendations (61.7% ± 10.5) with an average protein consumption of 15.3%±3.0 and an average fat consumption of 22.3%±9.8. This average fat consumption was also slightly lower than the recommendation from Indonesian Pediatric Society. Based on these data, the management of obesity should give special attention to macronutrients proportion. In normalizing our adolescents diet proportion, the decrease in carbohydrate consumption must be accompanied with increasing consumption of several food ingredients containing fats in the form of Polyunsaturated Fatty Acid (PUFA), like omega-3 and omega-6.

Table 4. Relationship between Carbohydrate and Fat Proportion on Diet with BMI in Obese Adolescents

	BMI (kg/m^2)	p
Carbohydrate Diet Categories		
LC	31.5(27.0–44.7)	
MC	31.4(25.3–47.8)	0.82
HC	32.2(25.3–44.6)	
Fat Diet Categories		
HF	31.5(25.3–45.6)	0.99
Non-HF	31.7(25.3–47.8)	

In addition, the subjects' average total calories consumption was 2487±419 kcal for boys and 2461±414 kcal for girls. Ozdemir (2016) stated that the average daily calories needed for female adolescents ranged from 1800–2500 kcal and 2500–3500 kcal for male adolescents. The daily calories based on Indonesian Minister of Health regulation No.28 in year 2019, the male adolescent age 13–18 years-old need 2400–2650 kcal and female adolescent in the same age need 2050–2100 kcal. Thus, the average total calories in obese adolescents were within the recommended range in boys but higher than recommended range in girls. In addition to calories intake, the amount of physical activity also needs to be further considered as a cause of obesity.

This study also found that there were no significant differences in the composition of macronutrient consumption between boys and girls and between age groups. However, there was a significant difference found in the low-protein consumption in the age group of 15 years or older compared to those in the age group of less than 15 years. The decrease in the amount of protein consumption was followed by an increase in the number of carbohydrates consumed in the same age group.

WHO recommends the consumption of 0.8 grams/kg/day of protein in female adolescents and in male 1.0 grams/kg/day. The needs of protein in adolescents increases due to the increasing muscle age and hormonal changes. In female adolescent, the needs of protein are higher at the age of 11–14 years old, while the demand for protein increases at the age of 15–18 years old for male. It is recommended that 50% of protein needs contain 50% of vegetable proteins and 50% of animal proteins. Most of animal protein sources can be obtained from dairy products (70–80%) (Ozdemir, 2016).

Dror & Allen (2014) found that proteins consumption, especially in dairy products, decrease along with the increasing ages. One of the influential factors that affects the decrease milk consumption in adolescents is the consumption of sweet beverages and fruit juices that substitute the consumption of the dairy products (Dror & Allen, 2014). However, in general, the amount of protein consumed in this study was close to the recommended amount which is 15–20% of total daily energy derived from protein (Sjarif et al., 2014). This study also conveyed that the difference in the amount of protein consumption based on age could be caused by the same thing, where the amount of protein consumption appeared to decrease in the diet undertaken by the high carbohydrate-consumption group.

Another study found that high carbohydrate consumption in adolescents did not significantly increase the risk of overweight/obesity than the excessive consumption of fats and proteins (Febriani et al., 2019). The role of excessive carbohydrate composition on the risk of obesity is still on a debate. A systematic review and meta-analysis have not concluded whether a diet of high carbohydrates increases the risk of obesity (Sartorius et al., 2018). However, evidence has been found that the obesity cases have increased along with ascending production of foods containing carbohydrates and sugars. Thus, people should be aware of carbohydrate types that contribute to increasing the risk of obesity. Adolescents are particularly susceptible to the habits of consuming simple carbohydrates and sugars, one of which is through the consumption of sweet beverages. Consumption of sweet beverages has increased by 300% in the last 20 years, and 56–85% of school children consumed at least one serving per day. Consumption of a glass of sweet beverages will increase the risk of obesity 1.6 times. Such relationship is related to high sugar content, no satiety, and a high glycemic index. A high glycemic index contributes to obesity in adolescents through increasing insulin resistance and excessive energy (Harrington, 2008; Keller & Torre, 2015). This study did not distinguish the types of carbohydrates consumed as simple carbohydrates or complex carbohydrates. Rather, the study used the entire subjects of obesity, so that it was unable to analyze the increasing risk of obesity due to a HC diet. However, this study showed that there was an imbalance of macronutrient intake in obese adolescents.

In the HC diet group, fat and protein intake decreased. Meanwhile, in the low-carbohydrate diet group, the fat intake increased (see Figure 1 and 2). Thus, two types of dietary imbalances were obtained in this study, a high-carbohydrates-low-fats and low-carbohydrates-high-fats dietary pattern. A diet of high carbohydrates consumption is similar to a typical Korean diet with white rice as the main dish. Increasing consumption of carbohydrates and low fats is not associated with an increasing risk of obesity. However, it is associated with increasing triglycerides and decreasing HDL (Lee, Song, and Song, 2018). Merchant et al. (2009) precisely found that individuals who consumed carbohydrates less than or equal to 47% of total daily calorie consumption had a greater risk of being overweight and obese than those who consumed 47–64% of total daily calories. This may be due to individuals who consumed more carbohydrates had more fruits and vegetable intakes (Merchant et al., 2009). Other studies suggested that a person who consumed enough fruits and vegetables had a lower risk of being obese than those who consumed less fruits and vegetables, regardless the amount of fat consumption (Ledikwe et al., 2006).

A HF diet was stated as one of the central obesity risk factors, especially in women (Sun & Su, 2020). A HF diet increased the risk of obesity by 1.2 times (95%CI: 1.1–1.4) (Roman et al., 2019). The influence of both types of dietary imbalances on obesity may be related to hunger

and satiety. In accordance with the comparison of high-fats-low-carbohydrates dietary patterns and low-fats-high-carbohydrates dietary patterns in overweight and obese individuals, Hopkins et al. (2016) showed the total amount of energy consumed in high-fats-low-carbohydrates diets was higher but lacks of satiety. Moreover, a high-carbohydrates diet provided more satiety (Hopkins et al., 2016).

This study also depicted that there was no significant difference in BMI based on the number of carbohydrates or fats consumption. In line with Ibrahim et al (2019), total calorie intake and macronutrient amounts were not associated with the degree of obesity described with BMI. Similar results were also obtained in Korea (Kim & Song, 2019). As opposed to Lyles et al. (2006), BMI was related to the consumption of proteins and carbohydrates. These differences may be related to population differences in the undertaken research. This study involved only obese adolescents and did not include adolescents with normal BMI, so that it could not adequately see the relationship between macronutrient consumption with BMI.

The differences found in the present study results might occur due to using the classification of HC and HF diet. However, there was the data collection on dietary macronutrients obtained by using the 24-hours food recall method, which had a high risk of recall bias caused by the different perception between the portion of food consumed by the subjects and the amount meant by the researchers. To overcome this lacks, the researchers used food models during the interview process. To address the risk of under-reporting food recall, this study used a 2×24-hours food recall. This period of times can estimate daily dietary intake that is significantly closer to daily energy expenditure than a once 24-hour food recall (Ma et al., 2009).

Further study will be needed by considering the interaction of physical activity and macronutrients consumption as a cause of obesity.

CONCLUSION

Generally, the obese adolescents consumed higher amount of carbohydrates and less amount of fat based on recommendation from Indonesian Pediatric Society. There were two types of imbalance proportion of macronutrients consumption among our participants, high–carbohydrates-low-fats diet and low-carbohydrates-high-fats-diet. The macronutrients proportion might consider in management of obesity, not only for decreasing body weight but also preventing the dyslipidemia in obese adolescents.

ACKNOWLEDGEMENT

This research is part of a thesis conducted by Widjaja et al. (2020). Author would like to thank the 12 high schools in Surabaya and Sidoarjo who volunteered as respondents. We would thank all headmasters and counselling teachers who gathered our respondents along with their parents with us before and during the data collection.

REFERENCES

Bessesen, D. H., Cox-York, K.A., Hernandez, T.L., Erickson, C.B., Wang, H. J., Jackman, M.R., & Van Pelt, R.E. (2015). Postprandial triglycerides and adipose tissue storage of dietary fatty acids: Impact of menopause and estradiol. *Obesity,* 23(1), 145–53. doi: 10.1002/oby.20935

Clifton, P. M. & Keogh, J. (2007). Metabolic effects of high-protein diets. *Curr Atheroscler Rep*, 9(6), 472–78. doi: 10.1007/s11883-007-0063-y

Dror, D. K. & Allen, L.H. (2014). Dairy product intake in children and adolescents in developed countries: trends, nutritional contribution, and a review of association with health outcomes. *Nutr Rev*, 72(2), 68–81. doi: 10.1111/nure.12078.

Febriani, R.T., Soesetidjo, A., & Tiyas, F. W. (2019). Consumption of fat, protein, and carbohydrate among adolescent with overweight/ obesity. *JMCH,* 70–6. doi: 10.26911/thejmch.2019.04.02.02.

Ghosh, S. & Bouchard, C. (2017). Convergence between biological, behavioural and genetic determinants of obesity. *Nat Rev Genet,* 18(12), 731–748. doi: 10.1038/nrg.2017.72.

Hamdy, O., Tasabehji, M.W., Elseaidy, T., Tomah, S., Ashrafzadeh, S., & Mottalib, A.(2018). Fat versus carbohydrate-based energy restricted diets for weight loss in patients with type 2 diabetes. *Curr Diab Rep,* 18(12), 128–32. doi: 10.1007/s11892-018-1103-4.

Harrington, S. (2008). The role of sugar-sweetened

beverage consumption in adolescent obesity: A review of the literature, *J Sch Nurs,* 24(1), 3–12. doi: 10.1177/1059840508024 0010201.

Hopkins, M., Gibbons, C., Cudwell, P., *et al.* (2016). Differing effects of high-fat or high-carbohydrate meals on food hedonics in overweight and obese individuals. *Br J Nutr*, 115(10), pp. 1875–84. doi: 10.1017/S0007114516000775.

Ibrahim, R. H., Hendarto, A., Bardosono, S., *et al.* (2019). Hubungan asupan kalori total dan makronutrien dengan derajat obesitas pada remaja obesitas usia 14-18 tahun di Jakarta. *Sari Pediatri*, 21(3), 159-63. doi: 10.14238/sp21.3.2019.159-63.

Jung, C. H. & Choi, K. M. (2017). Impact of high-carbohydrate diet on metabolic parameters in patients with type 2 diabetes. *Nutrients*, 9(4), 2–21. doi: 10.3390/nu90403 22.

Keller, A. & Torre, S. B. (2015). Sugar-sweetened beverages and obesity among children and adolescents: A review of systematic literature reviews, *Child Obes*, 11(4), 338-46. doi: 10.1089/chi.2014.0117.

Kementrian Kesehatan RI. (2018). *Laporan nasional RISKESDAS 2018*. Jakarta : Badan Penelitian dan Pengembangan Kesehatan Kementrian Kesehatan RI.

Kim, H. N. & Song, S. W. (2019) Associations between macronutrient intakes and obesity/metabolic risk phenotypes: findings of the korean national health and nutrition examination survey. *Nutrients,* 11(3), 1–11. doi: 10.3390/nu11030628.

Kim, O. Y., Kim, E. M. & Chung, S. (2020). Impacts of dietary macronutrient pattern on adolescent body composition and metabolic risk: current and future health status—A narrative review. *Nutrients.* 12(12), 1–16. doi: 10.3390/nu12123722.

Ledikwe, J. H., Blanck, H.M., Khan, L.K., Serdula, M.K., Seymour, J.D., Tohill, B.C., & Rolls, B.J. (2006). Dietary energy density is associated with energy intake and weight status in US adults, *Am J Clin Nutr,* 83(6), 1362–68. doi: 10.1093/ajcn/83.6. 1362.

Lee, Y. J., Song, S. & Song Y. (2018). High-carbohydrate diets and food patterns and their associations with metabolic disease in the Korean population, *Yonsei Med J,* 59(7), 834–42. doi: 10.3349/ymj.2018.59. 7.834.

Lyles, 3rd, T. E., Desmond, R., Faulk, L.E., Henson, S., Hubbert, K., Heimburger, D.C., & Ard, J.D. (2006). Diet variety based on macronutrient intake and its relationship with body mass index. *MedGenMed.* 8(3), 39 Retrieved from https://pubmed.ncbi.nlm.nih. gov/17406172/

Ma, Y., Olendzki, B.C., Pagoto, S.L., Hurley, T.G., Magner, R.P., Ockene, I.S., Schneider, K.L., Merriam, P.A., & Hebert, J.R. (2009). Number of 24-hour diet recalls needed to estimate energy intake. *Ann of Epidemiol,* 19(8), 553–9.doi: 10.1016/j.annepidem. 2009.04. 010.

Mank, I., Vandormael, A., Traore, I., Ouédraogo, w.A., Suerborn, R., & Danquah, I. (2020). Dietary habits associated with growth development of children aged < 5 years in the Nouna Health and Demographic Surveillance System, Burkina Faso, *Nutrition Journal*, 19(1), 1–14. doi: 10.1186/s12937-020-00591-3.

Merchant, A. T. Vatabparast, H., Barlas, S., Dehghan, M., Ali Shah, S.M., De Koning, L., & Steck, S.E. (2009). Carbohydrate intake and overweight and obesity among healthy adults, *J Am Diet Assoc,* 109(7), 1165–72. doi: 10.1016/j.jada.2009.04.002.

Ozdemir, A. (2016). Macronutrients in adolescence. *International Journal of Caring Sciences,* 9(3), 1162–7. Accesed from www.internationaljournalofcaringsciences.org.

Roman, G., Rusu, A., Graur, M., Creteanu, G., Morosanu, M., Radulian, G., Amorin, P., Timar, R., Pircalaboiu, L., & Bala, C. (2019). Dietary patterns and their association with obesity: A cross-sectional study. *Acta Endocrinol (Buchar),* 15(1), 86–95. doi: 10.4 183/aeb.2019.86.

Ruiz, L. D., Zuelch, M.L., Dimitratos, S.M., & Scherr,R.E. (2020). Adolescent obesity: diet quality, psychosocial health, and cardiometabolic risk factors. *Nutrients*, 12(43), 1–22. doi: 10.3390/nu12010043

Sartorius, K., Sartorius B., Madiba, T.E., & Stefan, C. (2018). Does high-carbohydrate intake lead to increased risk of obesity? A systematic review and meta-analysis. *BMJ Open*, 8(2), 1–10. doi:10.1136/bmjopen-2017018449.

Schwingshackl, L & Hoffmann, G. (2013). Comparison of effects of long-term low-fat vs high-fat diets on blood lipid levels in overweight or obese patients: A systematic review and meta-analysis. *Journal of the Acad of Nutr Diet*, 113(12), 1640–61.doi: 10.1016/j.jand.2013.07.010.

Sjarif, D. R., Gultom, L.D., Hendarto, A., Lestari, E.D., Sidiartha, I.G.L., & Mexitalia, M. (2014) *Diagnosis, Tata Laksana dan Pencegahan Obesitas*. (first edition), Ikatan Dokter Anak

Indonesia. Jakarta: Ikatan Dokter Anak Indonesia.

Villa, J. K. D., Santos, T.S.S., Ribeiro, A.Q., E Silva, A.R., Pessoa, M.C., & da Rocha Sant'Ana, L.F. (2015). Dietary patterns of children and socioeconomical, behavioral and maternal determinants. *Revista Paulista de Pediatria (English Edition)*, 33(3), 302–309. doi: 10.1016/j.rppede.20 15.06.012.

Zhao, J., Sun, J & Su, C. (2020). Gender differences in the relationship between dietary energy and macronutrients intake and body weight outcomes in chinese adults. *Nutrition Journal*, 19(1), 1–9. doi: 10.1186/s12937-020-00564-6..

https://doi.org/10.204736/mgi.v17i1.70–75

FOOD INTAKE, FOOD PURCHASING ACCESS, AND STRESS DURING THE COVID-19 PANDEMIC: A DESCRIPTIVE STUDY AMONG COLLEGE STUDENTS OF JENDERAL SOEDIRMAN UNIVERSITY

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ABSTRACT

The COVID-19 pandemic is causing social restrictions that leads to school form home. Long period of online learning system will likely make excessive food intakes and adolescent would try popular diet, got high stress due to staying at home for a long period of time, and decreased of food purchasing access. This study aimed to describe the food intakes, food purchasing access, and stress level among college students of Jenderal Soedirman University during pandemic period. This study was crossectional design study with data collection using purposive sampling. Total samples were 361 students from Jenderal Soedirman University Students. Descriptive Analytical data was shown using percentage, mean, and standard deviation. Food intake data was collected using 24 hours food recall and food purchasing access was determined by the online questionnaire with question about how the respondents get the access to buy food during pandemic Energy intakes, macro nutrients, vitamins C and vitamins A of Jenderal Soedirman University Students during pandemic era were inadequate compared to their nutritional needs. Most of the students feel stressed during pandemic because they were worried they might get infected by COVID-19 either themselves or their family.

Keywords: COVID-19, food intake, food purchasing access, stress, college students

INTRODUCTION

Year of 2020 became a very different and challenging year in all around the world because of the Coronavirus Disease 2019 (COVID-19) that has been evoluted from an isolated disease in Wuhan City, China (AMJC, 2020). Indonesia has reported that the first positive case confirmed was on March 2nd 2020 and then transpasses from person to person. On March 11th 2020, World Health Organization (WHO) declared that COVID-19 is a world pandemic disease. In order to decrease the number of the case, Indonesian government has stated social restrictions in several cities and it was being extended because the case is still increasing, in February 14th 2021, there was 6765 positive COVID-19 cases confirmed and as a result Indonesia has reached 1.217.468 positive COVID-19 cases (UNICEF et al., 2020).

Social restrictions can impact daily routines and life style such as food purchasing access and food consumptions, outdoor activities, traveling, education and sport activities (Hossain et al., 2020). The effects of the social restrictions implicated the eating ability becomes off-schedule and the consumption of snacks could affect high calories intakes (Scully et al., 2019). The changes that have occurred during the COVID-19 pandemic are related to feelings of fear, anxiety, and stress experienced by large part of society (Anton & Miller, 2015).

In the middle of March 2020, hundred millions of students especially young adults had to face schools being closed down or experiencing learning from home (Xiang et al., 2020). The implementations of social restrictions and schools close down with unknown period of time will have long term effects on young adults' well being. Previous study has shown that students who don't go to school such as during weekends and long holiday would likely has excessive food intake and tried popular diet for adolescents that could affect on the increasing of body weight (Brazendale et al., 2017; Lin et al., 2018).

Pandemic era has made most of people limits their activities outside their house, one of them was food and food ingredients purchases. Most of individuals would buy food ingredients in the store when they need to buy fruits (80.1%) and

 Received 29-03-2021, Accepted 15-06-2021, Published online 30-01-2022

vegetables (77.2%) (Zhao et al., 2020). This study has shown that every new confirmed COVID-19 cases would increase online sales up to 5.7% and the amount of new customers increased 4.9% (Chang & Meyerhoefer, 2020), and during the lockdown, online food delivery has increased 9% (Di Renzo et al., 2020). The types of food items that were mostly purchased during the lockdown period were energy-dense foods and processed foods with many stages or ultra-processed foods such as sausages and corned beef.

Based on the above backgrounds and the lack of research literature examined in Indonesia, in this study, researchers examined food intake, food purchasing access and stress during the COVID-19 pandemic among students of Jenderal Soedirman University.

METHODS

This study used an observational analytic research design with a cross-sectional design study. The population in this study were college students of Jenderal Soedirman University who were doing study from home because of COVID-19 Pandemic. Data collections were conducted on June 10th to 22nd 2020. Respondents were selected by purposive sampling with total of 361 students as respondents.

The data was collected using questionnaire through google form in order to limit from physical meeting with the respondents during COVID-19 pandemic. Questionnaire was used to asses behaviour such as food intakes, food access and stress during social restriction in students of Jenderal Soedirman University. Food intake data was collected using 24 hours food recall with phone call to determine portion size and then the data was processed using Nutrisurvey in order to calculate the quantity of food intake and they were grouped by the food item ingredients which mostly consumed during pandemic. Food purchasing access was determined by the online questionnaire with question about how the respondents get the access to buy food during pandemic. The stress data experienced by respondents were determined based on a questionnaire with questions about feeling of fear during lockdown as well as respondents' concerns about being exposed to the COVID-19.

Data analysis that used was in percentage form and mean in each variables. This data was analyzed using SPSS software version 23. This study has been approved by the Ethics Committee of the faculty of health sciences Jenderal Soedirman University number 0105/EC/KEPEK/VI/2020.

RESULT AND DISCUSSION

The characteristics of respondents in this study were shown in **Table 1.** Most of the respondents were in the age range of ≥ 21 years old and have normal nutritional status.

The average nutritional intake of students during the pandemic was shown in **Table 2.** The average nutritional intake of the respondents was 1109.3 kcal, compared to the 2018 Recommended Dietary Allowance (RDA) Indonesia for males, which was 2650 kcal and 2100 kcal for females aged 16–18 years old. Based on these data mentioned, most of the respondents only meet 41.8–52.8% of their energy needs per day. The average of respondents' carbohydrate intake was 128 g and compared to the 2018 RDA Indonesia, most of respondents only meet 32–42.7% of their carbohydrates need per day. Inadequate food intake may occur due to limited access to adequate and nutritious food. Limited access to food for students is caused by social restrictions and job losses during the COVID-19 pandemic. Some students reported travel restrictions in residential areas so they were more likely to experience food insecurity (Payne et al., 2018). In addition, the possibility of losing a job at a part-time student job or a parent's main job is a factor in food insecurity (Wolfson, 2020).

Inadequate intake of macro nutrients in respondents could happen due to family's financial

Table 1. The Characteristics of Respondents

Variable	n (%)
Age	
< 21 years old	60 (16.6)
≥ 21 years old	301 (83.4)
Nutritional Status	
Normal	290 (80.3)
Overweight	26 (7.2)
Obesity	45 (12.5)
Nutritional Status (kg/m^2)	22.2 ± 4,1

situation. Previous studies have shown that during adolescents, the family financial situation worsened during the pandemic, which had an impact on their intakes (Allabadi et al., 2020). The effect of low energy intake for a certain period of time will cause a decrease in nutritional status and if the energy intake is balanced it will help to maintain normal nutritional status (Indartanti & Kartini, 2014).

Thus adequate intake of vitamin A was one of the ways to prevent infection of the lungs in COVID-19 cases (Michele et al., 2020). In addition, vitamin E intake can improve immune function and affect the host, one of them is such as reducing the risk of viral infection (Michele et al., 2020). Meanwhile the vitamin C intake can prevent susceptibility to lower respiratory tract infections under certain conditions such as improvement of lung inflammation (Michele et al., 2020). The respondents' average intake of Vitamins E and C was 3.5 mcg dan 45.7 mg and compared to the 2018 RDA, the respondents only meet 23% and 50.8% of their needs. Vitamins intake in this study was not yet included with their consumption of multivitamin supplements. However, in case of vitamin A intake, the average intake was 877 RE or 134% sufficient.

During this pandemic period, 26.9% respondents tend to consume instant foods and snacks such as instant noodles, sweet biscuits or high calories street foods, those will be shown in **Table 2**. Respondents often consume instant meals and snacks due to ease of processing due to limited sources of fresh food during social restrictions. Previous study has shown that 7,1% of the respondents chose to not consume healthy foods during the lockdown period because they faced various temptations to eat instant foods and get bored easily when they were at home. Other study shown that there was 17,7% of the respondents who chose to buy foods with long shelf life, 11,1% frozen foods, and 3,1% chose instant foods (Poelman et al., 2021).

Vegetables and fruits intake has shown very interesting results in this study. Based on **Table 2**, during this pandemic period, 23.5% of students chose vegetables and fruits to be consumed, to meet their vitamin and mineral needs. This was also confirmed by previous research, in which 9.6% of people tended to choose healthier foods during the lockdown because they thought the need for micronutrients was increasing in order to maintain our immune system (Poelman et al., 2021).

Table 2. College Students' Intake during Pandemic Period

Variable	n (SD)
Energy (kcal)	1109.3 (407.7)
Carbohydrates (g)	128.0 (54.4)
Protein (g)	43.3 (19.8)
Fat (g)	51.4 (24.1)
Vitamin A (RE)	877.9 (921.5)
Vitamin E (mcg)	3.5 (2.3)
Vitamin C (mg)	45.7 (54.6)
Food Types (n(%))	
Rice	50 (16.6)
Animal Proteins	94 (26)
Vegetable Proteins	25 (6.9)
Vegetables & Fruits	85 (23.5)
Instant foods & snacks	97 (26.9)

Food purchasing access during pandemic become something that needs to be addressed due to the limited access for people to get daily needs. In the time of lockdown period, most of the students were in their house and the foods they consumes were home cooking foods (48,2%), which can be seen in **Table 3**. The previous study shown that 30,3% of the family has extra time to prepare meal for their family during pandemic (Poelman et al., 2021).

Buying cooked foods during pandemic using a delivery order service became the second most common choice (29.9%), based on **Table 3.** Social distancing allows people to have limited interaction with the social people residing at home and have a limited chance to spread the coronavirus, among others. Social isolation or distancing can lead to food delivery, as delivery services provide a way of bonding socially while being physically isolated (Sukumaran, 2020). During the lockdown period, 29.5% of respondents used food delivery services more often than before the lockdown period (Poelman et al., 2021).

The COVID-19 pandemic has an impact on several students' mental health. This pandemic raises new stresses such as feeling of fear and worry of themselves and loved ones, boredom

Table 3. Food Access and Purchases of the Students during Pandemic

Variable	n (%)
Food Access and Purchases	
Cooked by parents or other family member	174 (48.2)
Self cooking	78 (21.6)
Buys cooked foods	108 (29.9)

Table 4. College Students' Stress during Pandemic

Variable	n (%)
Boredom during lockdown	
Yes	303 (83.9)
No	58 (16.1)
Started to Feel Boredom	
Didn't Give Answer	65 (18.0)
In The First 1 week	78 (21.6)
In The First 1 month	110 (30.5)
In The First 2 months	81 (22.4)
In The First 3 months	27 (7.5)
Activities when feeling bored	
Didn't Give Answer	58 (16.1)
Entertains	216 (59.8)
Sports	28 (7.8)
Doing Chores	43 (11.9)
Lecture Tasks	16 (4.4)
Follow News Update about COVID-19	
Yes	340 (90.2)
No	21 (5.8)
Source of COVID-19 News Update	
Didn't Know	15 (4.4)
Social Media	2799 (77.3)
Electronic News	3 (0.8)
Television	63 (17.5)
Anxious Over COVID-19	
Yes	295 (81.7)
No	66 (18.3)

at home during the lockdown period and sudden changes in lifestyle (Xie et al., 2020). Some respondents felt bored at home (83.9%) and boredom began to be felt in the first one month of the lockdown period (30.5%), which were listed in **Table 4**. Activities that were often carried out during the quarantine period were doing some entertaining activities (59.8%), such as watching movies, playing games, and other screen time activities. Previous research reported that 45% of adolescents did not do physical activity (such as walking, running, or doing housework) during the pandemic, they spent more time on watching television and using gadgets during the pandemic compared to before the pandemic period (Allabadi et al., 2020). Tractions such as social media, internet, video, and games have reduced the concentration of students in receiving learning during the pandemic (Son et al., 2020).

During the pandemic period, 90.2% of students followed the news of COVID-19, such as the number of new cases and deaths. Most of the students saw these news through social media (77.3%). This news caused the majority of students or 81.7% to be very anxious about this contagious disease (Table 4). Previous research also found that 43% of respondents were worried about the wellbeing of themselves and their loved ones, especially in more vulnerable groups such as parents, grandparents and nephews who are still under five. In addition, severe anxiety was also found when students experienced a slight cough or other signs of COVID-19, they felt worried about being exposed to COVID-19 (Son et al., 2020).

CONCLUSIONS

Energy intake, macro nutrient, and vitamins C and A for students of Jenderal Soedirman University during the pandemic did not meet the recommended nutritional needs. During the pandemic, students eat by getting food from their parents or family. Most students feel stressed during this pandemic because they were worried that they might get exposed to COVID-19 either both themselves or their family.

Furthermore, the university and students themselves must be able to prevent the negative impact of COVID-19 which affects intake and stress on students. Sufficient macro and micronutrient intake, clean and safe food sources, and prevention of stress in students can be developed by the university through using virtual spaces and telemedicine programs to promote nutritional programs. Future research is expected to examine the differences before and during this pandemic period on food intake, weight gain, and changes in hygiene and sanitation patterns in college students.

ACKNOWLEDGEMENTS

This research was funded by Research Institutions and Community Service, Jenderal Soedirman University.

REFERENCES

AMJC. (2020). *A timeline of COVID-19 developments in 2020*. Retrieved from https://www.ajmc.com/view/a-timeline-of-covid19-developments-in-2020

Anton, S. D., & Miller, P. M. (2015). Do negative emotions predict alcohol consumption, saturated fat intake, and physical activity in older adults? *Behavior Modification*, *29*(4), 677–688. doi: 10.1177/0145445503261164

Brazendale, K., Beets, M. W., Weaver, R. G., Pate, R. R., Turner-McGrievy, G. M., Kaczynski, A. T., Chandler, J. L., Bohnert, A., & von Hippel, P. T. (2017). Understanding differences between summer vs. school obesogenic behaviors of children: the structured days hypothesis. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 1–14. doi: 10.1186/s12966-017-0555-2

Chang, H., & Meyerhoefer, C. D. (2020). COVID-19 and the Demand for Online Food Shopping Services: Empirical Evidence from Taiwan. *American Journal of Agricultural Economics*, *103*(2), 448–465. doi: 10.1111/ajae.12170

Di Renzo, L., Gualtieri, P., Pivari, F., Soldati, L., Attinà, A., Cinelli, G., Leggeri, C., Caparello, G., Barrea, L., & Scerbo, F. (2020). Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. *Journal of Translational Medicine*, *18*, 1–15. doi: 10.1186/s12967-020-02399-5.

Hossain, M. M., Sultana, A., & Purohit, N. (2020). Mental health outcomes of quarantine and isolation for infection prevention: a systematic umbrella review of the global evidence. *Epidemiology Health*, *42, 1-11*. doi: 10.4178/epih.e2020038

Indartanti, D., & Kartini, A. (2014). Hubungan status gizi dengan kejadian anemia pada remaja putri. *Journal of Nutrition College*, *3*(2), 310–316. doi: 10.14710/jnc.v3i2.5438

Lin, Y., Tremblay, M. S., Katzmarzyk, P. T., Fogelholm, M., Hu, G., Lambert, E. V, Maher, C., Maia, J., Olds, T., & Sarmiento, O. L. (2018). Temporal and bi-directional associations between sleep duration and physical activity/sedentary time in children: An international comparison. *Preventive Medicine*, *111*, 436–441. doi: 10.1016/j.ypmed.2017.12.006

Michele, C. A., Angel, B., Valeria, L., Teresa, M., Giuseppe, C., Giovanni, M., Ernestina, P., & Mario, B. (2020). Vitamin supplements in the Era of SARS-Cov2 pandemic. *GSC Biological and Pharmaceutical Sciences*, *11*(2), 7–19. doi: 10.30574/gscbps.2020.11.2.0114

Payne-Sturges, D. C., Tjaden, A., Caldeira, K. M., Vincent, K. B., & Arria, A. M. (2018). Student hunger on campus: Food insecurity among college students and implications for academic institutions. American Journal of Health Promotion, 32(2), 349-354. doi: doi.org/10.1177/0890117117719620

Poelman, M. P., Gillebaart, M., Schlinkert, C., Dijkstra, S. C., Derksen, E., Mensink, F., Hermans, R. C. J., Aardening, P., de Ridder, D., & de Vet, E. (2021). Eating behavior and food purchases during the COVID-19 lockdown: A cross-sectional study among adults in the Netherlands. *Appetite*, *157*, 105002. doi: 10.1016/j.appet.2020.105002

Scully, M., Dixon, H., & Wakefield, M. (2019). Association between commercial television exposure and fast-food consumption among adults. *Public Health Nutrition*, *12*(1), 105–110. doi : 10.1017/S1368980008002012

Son, C., Hegde, S., Smith, A., Wang, X., & Sasangohar, F. (2020). Effects of COVID-19 on college students' mental health in the United States: Interview survey study. *Journal of Medical Internet Research*, *22*(9), e21279. doi: 10.2196/21279

Sukumaran, T. (2020). Coronavirus: Malaysia warns of "tsunami-like" third wave of infections if lockdown not respected. This Week in Asia. Retrieved from https://www.scmp.com/week-asia/economics/article/3075778/malaysias-coronavirus-lockdown-confusion-uncertainty-and-some

UNICEF, WHO, & World Bank. (2020). Levels and trends in child malnutrition: Key findings of the 2020 Edition of the Joint Child Malnutrition Estimates. In *WHO*, 24(2). Retrieved from https://www.who.int/publications/i/item/jme-2020-edition

Wolfson, J. A., & Leung, C. W. (2020). Food insecurity and COVID-19: Disparities in early effects for US adults. Nutrients, 12(6), 1648. doi: 10.3390/nu12061648

Xiang, M., Zhang, Z., & Kuwahara, K. (2020). Impact of COVID-19 pandemic on children

and adolescents' lifestyle behavior larger than expected. Progress in cardiovascular diseases, 63(4), 531–532. doi: 10.1016/j.pcad.2020.04.013

Xie, X., Xue, Q., Zhou, Y., Zhu, K., Liu, Q., Zhang, J., & Song, R. (2020). Mental health status among children in home confinement during the coronavirus disease 2019 outbreak in Hubei Province, China. *JAMA Pediatrics*, *174*(9), 898–900. doi: 10.1001/jamapediatrics.2020.1619

Zhao, A., Li, Z., Ke, Y., Huo, S., Ma, Y., Zhang, Y., Zhang, J., & Ren, Z. (2020). Dietary diversity among Chinese residents during the COVID-19 outbreak and its associated factors. *Nutrients*, *12*(6), 1699. doi: /10.3390/nu12061699

CLINICAL MANIFESTATION OF BMI, TLC, ALBUMIN AND CD4 AFTER PROVISION OF SNAKEHEAD NUGGET AND COLORED FRUIT JUICE TO PEOPLE WITH HIV

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ABSTRACT

Snakehead fish has high content of zinc and albumin, it can be given to people with immune disorder. Snakehead fish can be made into various kind of food product that are high in nutrients, have aesthetic value, and taste like nugget. The effectiveness of zinc and albumin function can work optimally when the consumption is combined with food ingredient that are high in bioactive substances such as lycopene, anthocyanin, flavonoid, karetonoid, bromelain, papain and quercetin. The purpose of this study was to analyze the effect of snakehead nugget administration and colored fruit juices simultaneously on clinical manifestation, BMI, TLC, albumin and CD4 value in PLHIV at HIV/AIDS Rehabilitation Center in Medan. The design of research was quasy experimental with pre and post test design. The subjects was 40 people who lived at HIV/AIDS Rehabilitation Center in Medan and given snakehead fish nugget and colored fruit juice for 24 days. The data analysis used dependent T-test, after data normality test had previously been carried out. There was effect before and after administration of snakehead fish nuggets and colored fruit juice on clinical manifestation, BMI, TLC and CD4 levels with p value <0.05. It is necessary to provide treatment in longer term as preventive measure for the emergence of various clinical manifestations as well as to increase BMI, TLC, albumin and CD4 in PLHIV at HIV/AIDS Rehabilitation Center in Medan.

Keywords: HIV, snakehead fish, colored fruit extract, clinical manifestation

INTRODUCTION

Acquired Immune Deficiency Syndrome (AIDS) is a collection of symptoms caused by the Human Immunodeficiency Virus (HIV). This virus damages human immune system which causes a decrease or loss of immunity (Kemenkes, 2010). It is marked the decreasing number of TLC and CD4 among people living with HIV (PLHIV) then followed by symptoms like persistent diarrhoea, drastic weight loss without knowing the reason, fever and muscle ache (Pitri, 2013). As a result, PLHIV will experience nutritional status disorders, which is marked by a low BMI score (Pusdiklat, 2014; Brennan, 2019). Excessive catabolism occurs followed by lower levels of albumin in the blood. (Yuniarti, 2013; Adiningsih, 2017).

The state of malnutrition will worsen the nutritional status of PLHIV as assessed by lower body mass index. The causes are multifactorial, particularly due to lack of food intake, impaired absorption and metabolism of nutrients, emergence of opportunistic infections, marked by a decrease in the total immunity response of cluster of differentiation 4 and total lymphocyte count (Anderson, 2017). Macronutrients such as proteins, which is part of antibody-forming substances, also play a role in building cells damaged by opportunistic infection. Other nutrient such as vitamin C can suppress the formation of free radicals and can also increase the resistance of PLHIV (Almatsier, 2018).

Snakehead fish is a food that has been researched by many people. It can be made into various kind of food products that have high aesthetic value and taste but still contain nutrient, one of which is snakehead fish nugget with the addition of red bean. In 100 g of snakehead fish nugget contain 2.28 g of albumin, 18.66 g of protein, and 6.70 mg of zinc. 100 gram of snakehead fish nugget was given every day. The results of Pettalolo research (2015), zinc and albumin content in snakehead fish extract was proven to increase the amount of TLC in PLHIV.

 Received 16-04-2021, Accepted 06-09-2021, Published online 30-01-2022

The effectiveness of snakehead fish nuggets should be combined with food containing vitamin C and bioactive substances derived from natural ingredient which can be obtained from the content of colorful fruit and vegetable. These colored fruit and vegetable are used as a juice. These colored fruit juice contain bioactive substances in the form of Vitamin C, lycopene, anthocyanin, flavonoid, karetonoid, beta-carotene, bromelain, papain and quercetin. Colored fruit juice is given 250 mL together with snakehead fish nugget (Winarti, 2017). The purpose of this study was analyze effect of snakehead nugget distribution and colored fruit juice on clinical manifestations, BMI, TLC, albumin and CD4 in PLHIV at HIV/AIDS Rehabilitation Center in Medan.

METHOD

Design of this research was quasi experimental study with one group pre and post test design (Rahmat, 2015). The research was conducted at HIV/AIDS Rehabilitation Center in Medan. The population in this study were all PLHIV at HIV/AIDS Rehabilitation Center in Medan. Total Sampling was done to the entire population that amount of 40 respondents.

The intervention was given for 24 consecutive days directly by researcher who was assisted by 7 enumerators who were already briefed. Duration of intervention phased on albumin half-life is 19–24 days. Respondent were given 2 nuggets (100 g) of snakehead fish a day (Supariasa, 2016; Prastowo, 2016). Snakehead fish nuggets are made in Food Technology Laboratory in Department of Nutrition, Poltekkes Kemenkes Medan. The ingredients of this nuggets were snakehead fish, carrots, red beans, wheat flour, eggs, shallots, garlic, pepper, and salt. Nutrition content of 100 grams snakehead fish nuggets can be seen in table 1.

Table 1. Nutrition Content of 100 grams Snakehead Fish Nuggets

Nutrient	Content
Albumin	2.28 gr
Calcium	81.59 gr
Iron	2.95 mg
Carbohydrates	9.12 gr
Fat	13.76 gr
Protein	18.66 gr
Zinc	6.70 mg

The examination of proximate test regarding the nutrient content was carried out in MIPA laboratory of Universitas Brawijaya, by sending samples of snakehead fish nuggets in January 2019. Colored fruit juice is selected every day for one colored fruit/vegetable as much as 200 g by adding enough water and 18 g sugar then blended and extracted to get one glass of colored fruit juice as much as 250 mL. Colored fruit juice do not prioritize nutritional content, but focus on function of bioactive substances contained in colored fruits and vegetables, such as, guava, dragon fruits, carrot, pineapple, red and yellow watermelon, star fruit, papaya, tomato, cucumber and orange.

BMI data were obtained by measuring body weight using a digital scale with an accuracy of 0.01 kg, meanwhile body height using microtoise with an accuracy of 0.1 cm then interpreted the BMI results obtained into the BMI standard table according to (Negara et al., 2015). Blood sampling for blood biochemical examination was carried out twice during study, before and after treatment administration. Blood was drawn using 3 mL syringe from left arm, the work was carried out by health analyst and then checked in Pathology Laboratory. TLC data is obtained from examination of the type of leucocytes and total leucocytes on routine blood tests with cyanmethemoglobin method using spectofotometry tool. CD4 data is done using Flow Cytometri method. Blood albumin data were examined by BCG method (Brom Cresol Green).

Clinical manifestation data were collected through direct interviews with the respondents and direct observation using clinical manifestation form. The questionnaire contains 16 items of clinical manifestation symptoms, each of it has clinical symptom based on clinical manifestation form, each item of symptom worth 1 score. Data was previously tested for data normality with Kolmogorov Smirnov test and continued with dependent T test (paired). The study was conducted after got the ethics permission from the research ethics commission at Poltekkes Kemenkes Medan with no: 044 / KEPK / POLTEKKES KEMENKES MEDAN / 2019.

https://doi.org/10.204736/mgi.v17i1.76–81

RESULTS AND DISCUSSION

The 21–30 year old group was the largest respondents as much as 19 people (47.5%), with the youngest being 20 years old and the oldest 54 years old. The most of respondents is male 90% (36 people). The percentage of respondent education is mostly having high school as many 30 people (75%). Respondent characteristics can be seen in table 2.

For the average value of TLC, albumin, CD4, clinical manifestations and BMI before and after treatment showed in Table 3 below:

Table 2. Distribution of Respondent Characteristics.

Respondent Characteristics		Total	
		n	%
Age	11–20 y.o	2	5
	21–30 y.o	19	47.5
	31–40 y.o	15	37.5
	41–50 y.o	3	7.5
	51–60 y.o	1	2.5
Sex	Male	36	90
	Female	4	10
Education	Elementary	1	2.5
	Junior High	4	10
	Senior High	30	75
	University	5	12.5

Table 3 showed that difference between before and after giving treatment TLC levels were 2.7 mm^3. The difference between before and after giving treatment albumin levels is 0.3 gr/dL. The difference between before treatment and after treatment, CD4 levels were 47.6 cells/mL. The difference between before and after giving treatment clinical manifestations is 1.4. The difference between before and after giving BMI treatment was 0.3 kg/m^2.

When viewed by category, the BMI variable changed from being thin (BMI <18.5) before giving treatment by 11 people (27.5%) to 9 people (22.5%) after giving treatment. While CD4 variable, PLHIV also experienced changes, where the category <200 cells/mL was 11 people (27.5%) to 8 people (20%). The distribution of BMI and CD4 changes before and after treatment can be seen in table 4.

There was a significant difference before and after treatment ($p<0.05$) meaning that treatment of snakehead fish nugget and colored fruit juice will give effect on TLC levels albumin, CD4, clinical manifestations and BMI. Nugget is a popular snack variation to eliminate hunger for a while, provides a small supply of energy to the body, or something to eat enjoying the taste and would be better if consumed with colored juice. The snack

Table 3. Distribution of TLC, Albumin, CD4, Clinical Manifestation and BMI

Indicators		n	Min	Max	Mean	Deviation Std.	p value
TLC Level	Before	40	9	54	32.2	10.8	0.016
	After	40	19	59	34.9	8.8	
Albumin Level	Before	40	2.7	5.1	4.1	0.4	0.009
	After	40	2.1	5.0	4.4	0.5	
CD4 level	Before	40	18	750	315.3	169.3	0.001*
	After	40	8	856	362.9	183.2	
Clinical Manifestation	Before	40	3	14	5.45	2.3	0.001*
	After	40	2	14	4.05	2.5	
BMI	Before	40	13.6	29.5	21.2	3.9	0.008
	After	40	13.4	30	21.5	4.0	

Table 4. Distribution of Changes in BMI and CD4 Before and After Giving Treatment

No	Treatment	BMI (kg/m^2)				Total		CD4 (sel/mL)				Total	
		Wasting		Normal				<200		≥200			
		n	%	n	%	n	%	n	%	n	%	N	%
	Before	11	27.5	29	72.5	40	100	11	27.5	29	72.5	40	100
	After	9	22.5	31	77.5	40	100	8	20	32	80	40	100

that was used as treatment contain 198.7 kcal of energy, 12.8 g of protein, 3.25 g of fat, 25.1 g of carbohydrates, 29.2 mg of zinc, 331.5 mg of iron and bioactive substance as functional food. This snack is given in the form of snakehead fish nugget and colored fruit juice which have tendency to increase TLC, albumin, CD4 value, clinical manifestation, nutrient intake and body mass index value which tends to decrease in people with HIV at HIV/AIDS Rehabilitation Center in Medan.

Research by Pettalolo (2015) stated that there was an increase in the number of lymphocyte, CD4 and leucocyte in snakehead fish extract group with mineral content of zinc which can affect immune function, as well as being useful in restoring immunity function by influencing the activity of catalase enzyme and superoxide dismutase (SOD) and increase lymphokine production, so that leukocyte cells are able to differentiate and proliferate. While Warouw study (2016) stated that snakehead fish and red beans contain essential amino acids that can increase CD4 cytokine levels. Great number of CD4 count in PLHIV people is a predictor of decreasing clinical symptom.

Treatment of snakehead fish nuggets and colored fruit juices containing necessary to fulfill macronutrient and micronutrient to PLHIV. Snakehead fish contain protein that needed by body to build and maintain body tissues and replace damaged cells. Protein also protect body from foreign substance or organism that enter body. Protein act as antibody-forming component in the body. With fulfillment of protein needs, the formation of antibody will be more optimal and more protective, so body can defend itself from disease, such as HIV. The more adequate protein intake, the higher formation of body tissue and muscle, which can be seen from changes in BMI value (Kartasapoetra, 2011; Petalolo, 2015).

Snakehead fish nugget contain high albumin that help metabolism and replace damage tissue because of HIV. The other role of Albumin in HIV case is to help increasing metabolic rate of Zn and binding to drugs and heavy metal that do not dissolve easily in blood. Albumin is also able to work as trapper and scavenger against oxidant and free radical and able to improve immune function (Awan, 2014).

Albumin is suitable to be given to patients who were not experienced severe infections, such as respondent in this study that did not examine people with AIDS. Determination of PLHIV severity is not only determined by CD4 levels in the blood, but it can be seen from clinical symptom and opportunistic infection that accompanying PLHIV, where there are no symptoms such as anorexia, the appearance of candida in the mouth, prolonged diarrhea and PLHIV do not have tuberculosis and herpes simplex (PUSDIKLAT NAKES, 2014).

This is also in accordance with the criteria for patients admitted to the center, especially people who are newly infected with HIV (PLHIV). The increase in albumin level in PLHIV patient is expected to help the process where HIV-infected people are susceptible to an increase in catabolic responses (Pettalolo, 2015). With the increase in albumin levels after distribution of snakehead fish albumin, the body will create a new balance by reducing tissue protein intake, so that the depletion process (tissue remodeling) that often occurs when people newly infected with HIV can be stopped by giving albumin (Hartono, 2002). Research by Wahyuni (2014) at dr. Iskak Tulungagung hospital showed that as many as 85% of postoperative patients with hypoalbumin experienced an increase in albumin levels after being given snakehead fish extract for 7 consecutive days.

In this study, snakehead fish nuggets was given together with colored fruit juice containing vitamin C, lycopene, anthocyanin, flavonoid, karetonoid, beta-carotene, bromelain, papain and quercetin, which come from natural ingredient. Vitamin C in colored fruit juice have function as antioxidant that suppress cell damage due to infection, help to stop the process of cell destruction, also act as anti-inflammatory (Puertollano et al., 2011; Almatsier, 2016). In conditions of prolonged fever that generally occur in people infected with HIV, bioactive substance and vitamin C also function to regulate lymphocyte formation and transport lymphocyte to the site of infection (Arifin, 2009).

The effectiveness of snakehead fish extract should be combined with drink containing vitamin C sourced from natural ingredient that can be obtained from fruit content because it contain bioactive substance such as flavonoid, karetonoid, anthocyanin, papain, bromelain, and quercetin. These substance can be found in watermelon,

orange, mango, star fruit, red guava, pineapple, carrots, dragon fruit, papaya, cucumber, tomato, passion fruit, and tamarillo. These substance can help recovery from infection because of its benefits that play role in protecting cell and tissue against damage. Meanwhile, enzyme content of bromelain in pineapple juice has potential as alternative treatments to reduce the symptom such as sore and throbbing pain in PLHIV (Winarti, 2017).

Snakehead fish nugget have higher zinc due to the addition of red bean which are also high in zinc. Zinc is a metal that effectively bound albumin that has function to increase the effectiveness of T and B lymphocytes function. In addition, zinc is also able to close wounds and reduce inflammatory reaction in tissues caused by HIV virus. (Noviyanti, 2010; Candra, 2018). The role of zinc from snakehead and red bean nugget will have effect if combined with vitamin C which comes from colored fruit juice, where vitamin C acts as an antioxidant and increases immunity so that PLHIV do not get sick easily and catabolic processes that can reduce BMI do not occur (Warouw et al., 2016). The content of bioactive substances in fruits can work as proteolytic, also destroy HIV virus horn made of protein. Bioactive substance (papain, bromolain, anthocyanin, lycopene, etc.) can damage protein wall of HIV virus so that T helper lymphocytes and CD4 do not experience destruction due to HIV infection (Wardani, 2016).

CONCLUSIONS

The provision of 100 grams snakehead fish nuggets and 250 mL colored fruit juices a day for 24 days improve clinical manifestation, BMI, TLC and CD4 level with p value <0.05. It is necessary to provide treatment in longer term as a preventive measure for the emergence of various clinical manifestation and to increase TLC, CD4 and BMI in PLHIV at HIV/AIDS Rehabilitation Center in Medan.

REFERENCES

Adiningsih, S. & Wirna, W. (2017). Resiko malnutrisi terhadap jumlah CD4 orang dengan HIV/AIDS yang menjalani terapi antiretroviral di Miminka. *Jurnal Kedokteran Brawijaya.* 30(1): 41-46. Doi 10.21776/ub.jkb.2018.030.01.8

Almatsier, S. (2016). *Prinsip dasar ilmu gizi*. Jakarta: PT Gramedia Pustaka Utama.

Almatsier, S. (2018). *Penuntun diet*. Jakarta: PT Gramedia Pustaka Utama.

Anderson, K. (2017) Hubungan Status Gizi dengan Kualitas Hidup Orang dengan HIV/AIDS di Semarang. *Jurnal Kedokteran Diponegoro*, April 2017:692-704. Doi: dmj.v6i2.18587

Arifin H. (2009). Peranan glutamin. *Majalah Kedokteran Nusantara*; 42(1):66-71 retrieved from: https://jurnal.ugm.ac.id/jgki

Astuti, N., Awan, S.A. (2014). Manfaat Suplementasi Ekstrak Ikan Gabus terhadap Kadar Albumin, MDA pada Luka Bakar Derajat II. *JST Kesehatan*, Oktober 2014: 385-393.

Brennan, T.A. (2019). Growth Curve Modelling to Determine Distinct Body Mass Index Trajectory Groups in HIV-Positive Adults on ART in South Africa. *Jurnal AIDS* 2019 November 01;33(13):2049-2059. doi: 10.1097/QAD.0000000000002302

Candra, A. (2018). Suplementasi Seng untuk Pencegahan Penyakit Infeksi. *JNH: Journal of Nutrition and Healthy*. 6(1): 31-36. Doi: jnh.6.1.2018.31-36.

Emuchay, I.C. (2014) Correlation Between Total Lymphocyte Count, Hemoglobin, Hematocrit and CD4 Count in HIV Patients in Nigeria. *Pakistan Journal of Biological Sciences*, doi: 10.3923/pjbs.

Fitri, A.S., Djatnika, S., & Herry, G. (2013). Korelasi Total Lymphocyte Count terhadap CD4 anak dengan Infeksi Human Immundeficiency Virus. *Departemen Ilmu Kesehatan Anak FK UNPAD*. 15 (2).

Hartono, A. (2014). *Terapi Gizi dan Diet Rumah Sakit*. Jakarta: Penerbit EGC.

Kementrian Kesehatan RI. (2010). *Pedoman Pelayanan Gizi Bagi ODHA 2010*. Jakarta: KEMENKES RI.

Negara, K.N.D.P., Ari, W. & Susy, P. (2015). Relationship Between Body Mass Index (BMI) Overweight and Obes Categories With Low Back Pain (LBP) Complaints Among Medical Faculty Students of Udayana University. *Majalah Ilmiah Fisioterapi Indonesia*, Vol 3. Doi: 10.24843/MIFI.2015.v03.i03.p01.

Pettalolo, S.R. (2015). Efek Suplementasi Ekstrak Ikan Gabus dan Vitamin C Terhadap Kadar Hemoglobin, Leukosit, Limfosit, Albumin, dan IMT pada Pasien HIV/AIDS. *Gizi Indonesia*. Doi: 10.36457/gizindo.v38i1.166.

Puertollano, M., Puertallano, E., Cienfuegos, G., & Pablo, M. (2011). Dietary Antioxidants: Immunity and Host Defense. *Curr Top Med Chem*. 2011;11(14):1752-66.

Pusdiklat Nakes. (2014). *Modul Pelatihan Manajemen HIV-AIDS Bagi Tenaga Pendidik*.

Prastowo, A., Wiriyatun, L., Siti, N., & Retno, S. (2016). Efektifitas Pemberian Ekstra Putih Telur terhadap Peningkatan Kadar Albumin dan IL-6 pada Pasien Tuberkulosis dengan Hipoalbumin. *Jurnal Kesehatan*. Vol 1. No 1. doi: 10.23917/ jk.v9i1.3373.

Rachmat, M. (2015). *Metodologi Penelitian Gizi dan Kesehatan*. Jakarta: Penerbit Buku Kedokteran.

Restiana, T. & Bukhari. (2011). *Pengaruh Pemberian Ekstrak Ikan Gabus Terhadap Kadar Albumin dan Status Gizi Penderita HIV/AIDS yang mendapatkan Terapi ARV*. FK Universitas Hasanuddin. Makassar.

Riyadi H & Widodo S. (2015). Perbaikan Status Gizi Anak Balita dengan Intervensi Biskuit Berbasis Blondo, Ikan Gabus (*Channa Striata),* dan Beras Merah (*Oryza Nivara)*. *Jurnal Gizi Pangan*, Juli 2015, 10(2):85-92. Doi: 10.25182/ jgp.2015.10.2.%p.

Supariasa I,D.N. (2016). *Penilaian Status Gizi*. Jakarta: ECG.

Wahyuni, S., Yuly, P., Sandu, S. (2014). *Pengaruh Pemberian (Albumin) Ikan Kutuk Terhadap Peningkatan Kadar Albumin Pada Pasien Post Operasi Hipoalbumin RSUD dr.Iskak Tulungagung*. 1-9.

Wahyuningsih, U., Ali, K., & Karina, R.E. (2014). Asupan Zat Gizi dan Status Anemia pada Remaja Laki-laki Pengguna Narkoba di Lembaga Permasyarakatan Anak Pria Tangerang. *Jurnal Gizi dan Pangan*, 9(1). Doi: 10.25182/jgp.2014.9.1.%p.

Wardhani, P. & Nurbani. (2016). Efektifitas pemberian jus nanas dan jus pepaya sebagai pendamping ARV dalam meningkatkan kadar CD. *Jurnal vokasi kesehatan*, Vol II 1 Januari 2016, hlm 78-83. Doi: 10.30602/jvk.v2i1.59.

Warouw, H, N., As'ad, S., Hatta, M., Hadju, V. (2016). The Effect of Snakehead Fish Extract Supplements to the Enhancement of Nutritional Status, Level of Albumin, Hemoglobin and Level of CD4 on Pregnant Women with HIV AIDS Who Acquired Antiretroviral Therapy in Papua. *International JournalofSciences : Basic and Applied Research (IJSBAR). 30(04): 384-397*. Retrieved from: http:// gssrr.org/ index.php?journal=JournalOfBasic And Applied.

Winarti, Sri. (2017). *Makanan Fungsional*. Yogyakarta: Graha Ilmu.

Yuniarti. (2013). Pengaruh Konseling Gizi dan Penambahan Makanan Terhadap Asupan Zat Gizi dan Status Gizi Pasien HIV/AIDS. *Jurnal Gizi Klinik Indonesia*, Januari 2013:132-138. doi: 10.22146/ ijcn.15446.

https://doi.org/10.204736/mgi.v17i1.82–94

CURCUMIN BIOACTIVE SUBSTANCE TO PREVENT DIABETIC RETINOPATHY DUE TO DIABETES MELLITUS COMPLICATIONS: A LITERATURE REVIEW

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ABSTRACT

Diabetes Mellitus is characterized by hyperglycemia, and if it continues, the patients are at risk of having a macrovascular or microvascular complication. One of the most frequent microvascular complications is Diabetic Retinopathy, with a prevalence of 42.6%. Most of the blindness due to Diabetic Retinopathy is a permanent condition and cannot be treated, so prevention is vital in reducing this disease. This literature aimed at providing the recent information related to the effect of curcumin in preventing Diabetic Retinopathy from occurring in patients with Diabetes Mellitus and becoming a source of the latest product innovation in preventing this disease. The writing began by electronic database searching via Google Scholar, Science Direct, Medline, and Research Gate. Only articles in English were taken as a literature review with the following research variables, namely the decrease in ROS *(Reactive Oxygen Species)*, the decline in inflammation, morphological changes in the retina, and reduction in levels of VEGF (Vascular Endothelial Growth Factor) which is an angiogenic factor. Twelve studies showed the following measurement results, namely five studies showed a significant result for giving curcumin extract to decrease ROS; ten studies showed that curcumin extract could significantly improve the morphology of the retina; four studies showed that curcumin extract could significantly help the anti-inflammation process, and four studies showed a significant reduction in VEGF levels. Based on twelve articles reviewed, curcumin can act as a bioactive substance in preventing Diabetic Retinopathy in Patients with Diabetes Mellitus.

Keywords: Curcumin, Diabetic Retinopathy, Diabetes Mellitus, High Glucose Levels, Antioxidant

INTRODUCTION

Diabetes Mellitus is a severe and chronic disease because the pancreas does not produce an adequate amount of insulin (a hormone that regulates blood glucose or glucose) or the body cannot effectively use the insulin produced (WHO, 2016). The most significant number of people with Diabetes Mellitus is estimated at 96 million from Southeast Asia and 131 million from the West Pacific considering around half of the global diabetes cases. The number of patients with Diabetes Mellitus over the world has increased four times, namely 108 million to 422 million from 1980 to 2014 (WHO, 2016). Indonesia Society for Endocrinology (Perkeni) (2015), state that Diabetes Mellitus in Indonesia increased by 4%, from 6.9% (2013) and 10.9% (2018) (Riskesdas, 2018).

Diabetes Mellitus causes the body to have an increase in blood glucose levels or hyperglycemia. Prolonged hyperglycemia in patients with Diabetes Mellitus leads to several complications, both macrovascular and microvascular. One of the frequently occurring microvascular complications is Diabetic Retinopathy that can cause injury in the retinal blood vessels, especially the sunlight-sensitive tissues. This condition causes visual impairment that potentially leads to blindness (Kemenkes RI, 2018).

Diabetic Retinopathy has a pretty high prevalence and it is at the fourth rank as the global cause of blindness after cataract, glaucoma, and macular degeneration (Soewondo et al., 2010). In 2010, of around 285 million people with Diabetes Mellitus globally, more than one-third have Diabetic Retinopathy symptoms, and one-third of them had vision-threatening Diabetic Retinopathy (Lee et al., 2015).

Based on the research data, the prevalence of patients with Diabetes Mellitus who suffered from Diabetic Retinopathy in Indonesia was 42.6%, indicating that around 24,600 people would be found suffering from Diabetic Retinopathy,

 Received 29-06-2021, Accepted 24-09-2021, Published online 30-01-2022

and around 10% of that number suffered from blindness (Kemenkes RI, 2018). The majority of age groups who suffered from this complication were 20–64 years (Suyono & Pandelaki, 2014). Most of the blindness due to Diabetic Retinopathy is a permanent condition, and it cannot be treated. Therefore, preventive action is a vital effort to reduce the occurrence of this disease.

The effort to prevent Diabetic Retinopathy is by controlling the oxidative stress due to an increase in blood glucose that happens for quite a long time (Kumawat et al., 2012). One of the ways to control oxidative stress in the body is by utilizing bioactive substances in certain food ingredients, such as curcumin (Panasea, 2014).

Curcumin is a polyphenol substance in the flavonoids group containing phenolic compounds. Hence, it functions as an antioxidant, anti-inflammatory agent, anti-mutagenic agent, anti-cancer, and anti-microbe (Hewlings & Douglas, 2017). Curcumin can prevent Diabetic Retinopathy by several mechanisms with the molecular target in the body (Zhang et al., 2013). The body needs antioxidant property to prevent cell damage by completing lacking electron tied by free radicals and inhibit the chain reactions that can cause oxidative stress.

This paper aimed at investigating some literature reviews using narrative synthesis in interpreting some recent empirical literature related to the effectiveness of curcumin against the prevention of Diabetic Retinopathy.

METHODS

This literature study searched for articles via electronic databases, such as *Google Scholar, Science Direct, Medline,* and *Research Gate*. The inclusion criteria of this literature review comprised the selected articles that were published, at least, in the last ten years, from 2011 to 2021,

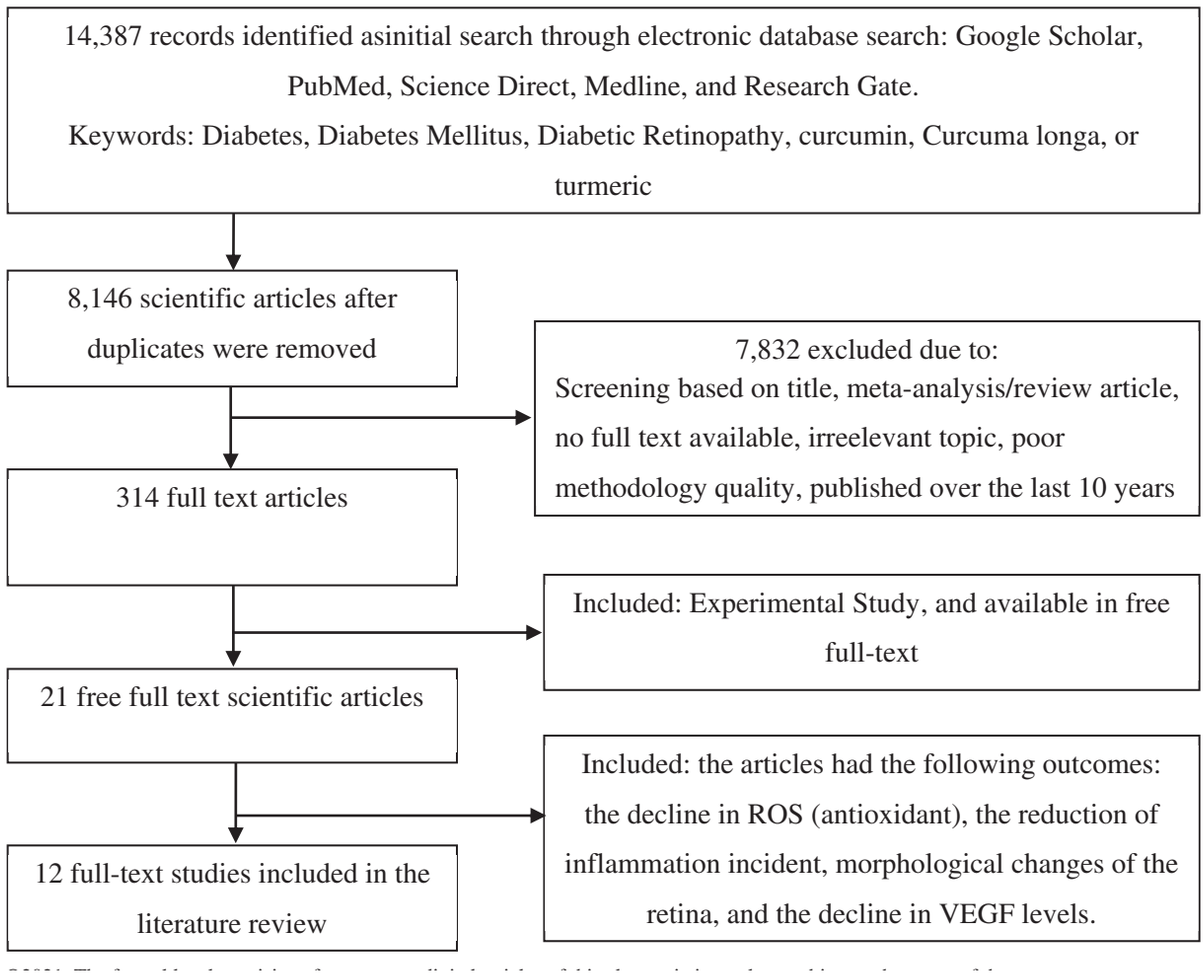


Figure 1. Diagram Flow of Excluded and Included Criteria for This Article

available in *free full-text*, and were experimental studies. The selected articles had the following measurement variables: the decline in ROS (Reactive Oxygen Species), the reduction of inflammation incident, morphological changes in the retina, and the decline in VEGF (Vascular Endothelial Growth Factor) levels. The search keywords were the variation and the combination of these following words: "Diabetes", "Diabetes Mellitus", "*Diabetic Retinopathy*", "curcumin", "*Curcuma longa*", or "*turmeric*".

Based on the search result, the writer found twenty-one scientific articles. After completing the identification process using the full-text method, twelve articles fulfilling the inclusion criteria for this literature review had been collected, the other nine articles did not meet the inclusion criteria. All articles were independently reviewed and coded by the writer. The extracted data consisted of research year, country of research site, research method, research duration, and the collected results.

Table 1. Review of Curcumin against the Prevention of Diabetic Retinopathy

No	Study	Method	Dosage	Duration (week/s)	Result	Reference
1	An experimental study using Wistar albino rats	Wistar albino rats were divided into three groups: the control, diabetic with normal diet, and diabetic treated with curcumin with a 1g/kg bodyweight dosage.	1 g/kg BW/day	16 weeks	Rats that were treated using curcumin had significantly lower blood glucose levels than the diabetic group (P<0.05), yet higher than normal (P<0.001). The HbA1C level in the rats treated using curcumin is significantly lower (P<0.05) than that of the diabetic group. The diameter of retinal blood vessels in the control group is lower than that of diabetic rats (p<0.05). The antioxidant parameter in the form of Retinal GSH, SOD, and CAT activity in the control group is similar to that of the normal rat group (p<0.05). The inflammation parameter showing the TNF-a level of the retina of the rats that are treated using curcumin is 2.5 times lower than the retina of diabetic rats that are not treated (P <0.05). The mean score of VEGF-treated rats is significantly lower than untreated ones (P <0.05). Curcumin prevents the thickening of Basement Membrane (BM) in the control group (p<0.05).	Gupta et al. (2011)

No	Study	Method	Dosage	Duration (week/s)	Result	Reference
2	An experimental study using male Sprague-Dawley (SD) rats	Rats are divided into four groups randomly: control group (rats are injected with citrate buffer), diabetic group (diabetic rats are induced with streptozotocin or STZ), DMSO group (STZ diabetic rats are given the mixture of DMSO (dimethyl sulfoxide) and normal saline intraperitoneally, once a day), and curcumin group (curcumin is given to diabetic-STZ rats intraperitoneally with a dosage of 80mg/kg, once a day).	80mg/kg BW/day	15 weeks	The MDA (malondialdehyde, indication of oxidative stress level) level of the retina compared to the control group significantly increases. In contrast, the GSH (glutathione) in the diabetic group and DMSO (dimethyl sulfoxide) group decreases (0.05 of each). No difference in GFAP (glial fibrillary acidic protein) or GS can be detected between the control groups and the curcumin groups (＞0.05).	Zuo et al. (2013)
3	An experimental study using male Sprague–Dawley (SD) rats	This experimental study was conducted using in vivo curcumin effects in the retina of rats streptozotocin (STZ)-induced diabetes and *in vitro* effects in muller cells stimulated by high glucose levels.	100 mg/kg BW/day	12 weeks	Curcumin reduces bleeding in the retinal vascular. Inflammation parameter in the form of VEGF, iNOS, ICAM_1 significantly decreases in the rats treated using curcumin	Li et al. (2016)

No	Study	Method	Dosage	Duration (week/s)	Result	Reference
4	An experimental study using male Wistar rats	Diabetic rats (blood glucose level ≥11.6 mmol/L) were randomly classified into three groups: diabetic rats without any treatment, diabetic rats treated using 100 mg/kg of curcumin, and diabetic rats treated using 200 mg/kg of curcumin. Curcumin was given orally every day for 16 weeks.	100 mg/kg BW of curcumin, and 200 mg/kg BW of curcumin	16 weeks	Giving curcumin keeps the thickness of the retina equal to that of normal rats ($p<0.01$). Giving curcumin with both dosages keeps the INL (Inner Nuclear Layer) in normal condition and decreases the thickness of BM (Basement Membrane). Giving curcumin decreases the SOD and T-AOC levels ($p<0.01$).	Yang et al. (2017)
5	An experimental study using mice	Mice are divided into four groups: diabetic group, diabetic treated using 25 µM curcumin, nondiabetic controls, and nondiabetic treated using 25 µM curcumin. Rats made to have Diabetes Mellitus using some methods: (1) Curcumin Treatment, (2) Determination of Reactive Oxygen Species (ROS), (3) DNMT Activity Quantification, and (4) Statistical Analysis using ANOVA, Student's t-test, and GraphPad version 6.0.	25 µM curcumin	8 weeks	Rats treated using curcumin can keep that stability of normal glucose level or acute/chronic condition using the treatment of 25 µM for 6 hours and trigger the decline in ROS in both acute and chronic conditions with a high blood glucose levels.	Maugery et al. (2018)

No	Study	Method	Dosage	Duration (week/s)	Result	Reference
6	An experimental study using retinal epithelial cells	The experimental study was conducted by treating the Retinal Pigment Epithelial Cell (RPEC) using 30 mmol/L of glucose considered a high-glucose group, the cell that was treated using 24.4 mmol/L of mannitol was determined as an equivalent osmolarity group.	10 µmol/L	-	Giving curcumin before the diabetic condition reaches a high blood glucose levels increases the viability (ability to survive) of RPECs. Giving curcumin decreases the inflammation indicators, such as TNF-α, IL-6, and IL1 B in RPECs. Giving curcumin decreases the ROS level in RPECs.	Ran et al. (2018)
7	An experimental study using male Sparague Dawley (SD) rats	The experimental study was conducted by giving curcumin or saline vehicle to the animal model every day for 12 weeks. Rats were randomly divided into three groups. The first group of rats were administered a 40mg dose of Alloxan/kg, then divided into Diabetic rats and Diabetic rats with curcumin at a dosage of 100mg/kg/day. At the same time, the third group of rats were administered only citrate buffer (0.1 mol/L,pH 4.5).	100mg/kg BW/day	12 weeks	Giving curcumin can keep the BM *(Basement Membrane)* in normal condition, Curcumin can keep the retinal vascular normality from bleeding and keep the thickness of blood vessels, Curcumin can decrease the VEGF level and iNOS-1 cytokine.	Pradhan et al. (2018)

No	Study	Method	Dosage	Duration (week/s)	Result	Reference
8	An experimental study using male New Zealand white rabbits	White rabbits were divided into 6 groups: the control group, untreated diabetes group, diabetes group with 1, 10, 20, and 100 μM concentrations of curcumin. This study was developed in the eyes of rabbits with high glucose levels.	1, 10, 20, and 100μM	-	Curcumin (10 mM) significantly decreases ($p < 0.01$) the ROS concentration and TNF- α discharge (inflammation indicators) in the retinal pigment epithelium and endothelial cells. The exact concentration of curcumin significantly ($p < 0.01$) protects retinal pericytes from the impact of high glucose. The highest concentration of curcumin(100μM) reached a statistically significant effect to decrease the ROS concentration.	Platania et al. (2018)
9	An experimental study using male Sprague-Dawley (SD) rats.	The experimental study was conducted in 60 mice by forming 4 groups: normal control group, osmolarity control group, high glucose group, curcumin-treated group (high glucose + curcumin). The curcumin-treated group was exposed to glucose with a concentration of 25 mmol/L for 72 hours, then, it was treated with 30 μmol/L of curcumin for 48 hours.	30 μmol/L	1 week	The ROS levels in the retinal vascular endothelial cells in the control group, osmotic control group, high glucose group, and curcumin-treated group are significantly different ($p \leq 0.001$). Compared to the high glucose group, the ROS content in the retinal vascular endothelial cells of the curcumin-treated group significantly decreases ($P < 0.001$). The NF-κB expression decreases significantly in the curcumin-treated group compared to the high glucose group ($p < 0.05$).	Huang et al. (2020)
10	An experimental study using male Sprague-Dawley (SD) albino rats	The experimental study was conducted in 48 albino Sprague-Dawley mice. There were three groups, namely the control group, diabetic group, and diabetic and curcumin-treated group. The treatment received diet powder completed with curcumin 0.5g/kg.	0.5g/kg BW/day	4 and 8 weeks	There was no significant improvement of the eye's retina in the treated diabetic group with curcumin duration treatment of four weeks ($p < 0.101$). The thickness of the eye's retina is improved in the treated diabetic mice with the curcumin treatment duration of weeks ($p < 0.046$). A significant decline in the retinal ganglion cells occurs in the diabetic mice compared to the control group. The improvement of the retinal ganglion cells significantly happens in the treated diabetic mice group with a duration of 8 weeks ($p < 0.033$).	Salem et al. (2012)

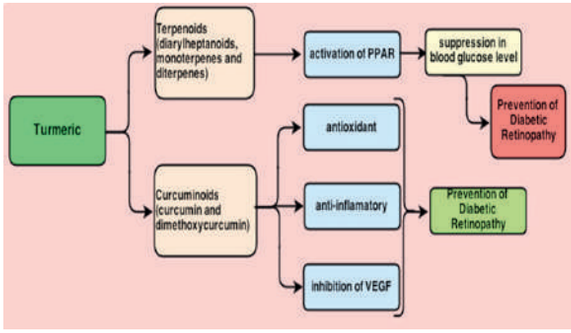
No	Study	Method	Dosage	Duration (week/s)	Result	Reference
11	An experimental study using male Wistar Strain (Wistar/NIN) rats	The experimental study was conducted on 29 mice classified into 4 groups: control group, diabetic group, SC diet-treated group, and RC diet-treated group. SC (Soluble Curcumin) diet contains 20% of curcumin from 20%-28% of turmeric extract. The RC (Regular Curcumin) diet contains 95% of curcumin.	SC (Soluble Curcumin) contains 20% of curcumin (0,01%). RC (Regular Curcumin) contains 95% of curcumin (0,01%).	12 weeks	Giving curcumin prevents morphological changes in the retina significantly. The SC (Soluble Curcumin) diet or curcumin solution is proven more effective than RC (Regular Curcumin) or curcumin powder. Giving RC formula did not effect VEGF expression Giving SC formula decreases the VEGF expression in the retina	Deshpande et al. (2015)
12	An experimental study using male Sprague-Dawley (SD) rats	The experimental study was conducted on 36 mice divided into three groups, the control group, diabetic mice group, and diabetic mice group treated with a curcumin diet. The dosage of the given curcumin was 100 mg/kg/ day orally.	100 mg/kg BW/day	12 weeks	The thinning of the retina can be significantly prevented in diabetic mice that are treated with a curcumin diet ($P < 0.01$) Curcumin significantly prevents the retinal nerves from losing in the diabetic mice group Compared to the diabetic mice group, the apoptosis in GCL (ganglion cell layer), INL (inner nuclear layer), and ONL (outer nuclear layer) are significantly inhibited in the diabetic mice that are treated using curcumin ($P <0.05$ for GCL, $P <0.01$ for INL and ONL).	Li et al. (2015)

RESULT AND DISCUSSION

All of the reviewed studies aimed to identify the effect of using curcumin in preventing Diabetic Retinopathy. The sample used rats as the laboratory animal in eleven studies and rabbits in one study using the experimental method. The duration of the studies was approximately one to sixteen weeks reported by the ten studies, while the two other studies did not report the research duration.

The analysis of twelve studies involved several measurement results, namely the decline in ROS level, decline in blood glucose levels, an improved morphology of the retina of the eyes, preventing inflammation, and a decline in VEGF level. Around five studies reported a significant result of giving curcumin extract against preventing Diabetic Retinopathy by decreasing the ROS level. Two studies reported a decrease in blood glucose levels with a significant result. Ten studies reported the measurement result in the retinal morphology improvement with a significant result. Besides, giving curcumin extract helps the anti-inflammation process in the retina of the eyes; four studies reported this with a significant result. Moreover, four studies reported that the bioactive substance of curcumin could decrease the VEGF level with a significant result.

Of twelve publications that had been analyzed, the best time needed for curcumin to give positive effects was sixteen weeks with a dosage of 100 mg/kg BW up to 1 g/kg BW daily. This dosage is in line with a study stating that giving curcumin 500 mg up to 1000 mg daily, as recommended



Source: Aldebashi (et al., 2013)

Figure 2. Curcumin and its constituents play a vital role in the management of Diabetic Retinopathy.

by medical experts, can prevent complications due to Diabetes Mellitus and metabolic disorders (Phillip, 2013). The bioactive substance of curcumin in solutions has a more effective potency than the regular curcumin or curcumin powder in preventing Diabetic Retinopathy (DR) (Deshpande et al., 2015).

The curcumin bioactive substance mainly contained in turmeric plays a role as a molecular target and has proven therapeutic potency in preventing Diabetic Retinopathy. The strength of curcumin involvement in controlling gene actions creates strong positive effects against the new therapeutic strategy of Diabetic Retinopathy with the following characteristics: no side effects, affordable, and easy to be accessed. The bioactive substance of curcumin can be made as a promising substance in controlling Diabetic Retinopathy (Aldebashi et al., 2013).

The Decrease in Blood Glucose Levels

The bioactive substance curcumin is able to lower blood glucose levels. Based on the review, There are two articles that have a significant result on reducing glucose levels. Curcumin acts as a hypoglycemic agent by increasing the activation of peroxisome proliferator-activated receptor (PPAR) (Aldebashi et al., 2013).

PPAR is a transcription factor bound to the nuclear membrane that plays a role in adipogenesis, glucose homeostasis, fat metabolism, and improves insulin sensitivity. PPAR activation on pancreatic β-cells will increase Insulin Receptor Substrate-2 (IRS-2) sensitivity. IRS-2 will activate the expression of pancreatic and duodenal homeobox-1 genes, which are transcription factors in the process of differentiation and maturation of pancreatic β-cells. The final effect obtained is a decrease in blood glucose levels (Jung et al., 2014).

The Decrease in Reactive Oxygen Species (ROS) levels

Based on the review in the table above, five studies showed a significant result ($P<0.05$) of giving curcumin extract towards the Diabetic Retinopathy prevention by decreasing the ROS levels. According to Huang et al. (2020), the mice with high blood glucose levels untreated using curcumin and those with high blood glucose levels treated using curcumin were significantly different ($p\leq0.001$).

Hyperglycemic conditions caused the increase in the ROS levels was due to Diabetes Mellitus. Based on several articles reviewed, the bioactive compound of curcumin had a significant result against the decline in the ROS levels. That can help decrease the risk of Diabetic Retinopathy since the increased ROS levels can activate poly-(ADP-ribose)-polymerase (PARP). Hence, it can inhibit glyceraldehyde phosphate dehydrogenase (GADPH). GADPH contributes to catalyzes the sixth step of glycolysis process. This condition can lead to the accumulation of glycolytic metabolism. It activates the Advanced Glycation End Products (AGE), Protein Kinase C (PKC), polyols, and hexosamines; the mechanism are supposed to play a role in microvascular damage and Diabetic Retinopathy. The activation of those mechanisms can worsen the Diabetic Retinopathy condition (Elvira & Ernes, 2019). The bioactive compound of curcumin acts as an antioxidant that can suppress ROS in the body to prevent the Diabetic Retinopathy condition from being worse in patients with diabetes mellitus.

Comparison of Retinal Morphology

According to a study by Salem et al. (2012), there was no significant retinal improvement in the diabetic-treated group by giving curcumin powder for four weeks ($p<0.101$); however, a significant retinal improvement occurred in the group treated using curcumin powder for eight weeks ($p<0.046$). A study by Deshpande et al. (2015) showed that there was a significant improvement in the retinal

morphology ($p<0.05$) with a research duration of twelve weeks. From the twelve studies reviewed, the improvement of retinal morphology showed a significant result with an average research duration of twelve weeks or more. Besides, giving the diet containing curcumin solution had more effective therapeutic potency than the powder curcumin for Diabetic Retinopathy (DR) prevention by preventing the morphological changes in the retina (Deshpande et al., 2015).

Around ten articles had a significant outcome against the morphological improvement of the retina of the eye. Patients with Diabetic Retinopathy will experience thickening or swelling in the retinal capillary basement membrane due to the endothelial cells' sorbitol accumulation. Retinal thickening is related to the characteristics of impermeable sorbitol or the inability to pass through the basement membrane resulting in the accumulation in the cell. Sorbitol accumulation can increase the osmotic stress that can result in morphological abnormalities, and it causes the occurrence of microaneurysms or capillary blockage (Septadina, 2015). The bioactive substance of curcumin can keep the typical morphology of the retina in the eyes by protecting the retinal vascular from bleeding and the thickness of blood vessels.

Besides, Diabetic Retinopathy causes nerve cell damage and loss in the retina or the occurrence of apoptosis (Li et al., 2016). Diabetic Retinopathy can cause an increase in NF-κB (transcription factor playing a role in cellular responses) that can cause apoptosis in the retina's nerve cells. Curcumin can decrease and inhibit the structuring of NF-κB significantly (Kowluru & Mamta, 2007). Hence, the bioactive substance of curcumin can keep the typical morphology of the retina of the eyes and its health.

Anti-inflammation

Based on Table 1, four studies reported that giving curcumin extract significantly ($P<0.05$) helped the anti-inflammation process. Based on the result of a study by Gupta et al. (2011), the inflammation parameter showed that the TNF-a level in the retina of the mice treated using curcumin was significantly different and 2.5 times lower than the diabetic retina that was not treated ($P <0.05$) within sixteen weeks.

Hyperglycemia due to Diabetes Mellitus is a pro-inflammation condition. Several paths of Diabetic Retinopathy structuring, such as polyols, AGE, PKC, and hexosamine, can cause a circulatory disorder, hypoxia, and inflammation in the retina. Hypoxia and inflammation in the retina occur due to microaneurysms or capillary blockage of the retina (Simorangkir, 2020). The bioactive substance of curcumin has an inflammatory agent, such as inhibiting cytokine production through a decline in Protein Kinase C (PKC) activation. Its ability inhibits cytokines because curcumin can inhibit the phosphorylation of phosphatidylserine that is phospholipids playing a role in the PKC activation process (Adrian, 2017).

The Decrease in VEGF Levels

Based on the review in the table above, three studies showed that the bioactive substance of curcumin could ($P<0.05$) significantly decrease the VEGF (Vascular Endothelial Growth Factor) levels. VEGF is a protein that helps the angiogenesis process or new blood vessel formation. According to a study by Pradhan et al. (2018), curcumin could significantly decrease the VEGF levels for twelve weeks. In the twelve studies reviewed, the average duration for giving curcumin with a significant result to decrease the VEGF levels was twelve weeks to sixteen weeks. Besides, the diet containing curcumin solution effectively decreases the VEGF levels than the diet containing curcumin powder (Deshpande et al., 2015).

Vascular Endothelial Growth Factor (VEGF) has a role in the process of structuring Diabetic Retinopathy. VEGF is the inflammation mediator that can be stimulated by the damage of vascular endothelial cells and tissue hypoxia due to microaneurysms or capillary blockage. VEGF can function in the angiogenesis process and stimulate endothelial cell growth to trigger neovascularization in the retinal capillaries (Adrian, 2017). The retinal blood vessels become weak due to the neovascularization process, so it is vulnerable to recurrent bleeding that can form fibrosis tissue. This process has a risk of vision degeneration. The bioactive substance of curcumin

has the anti-inflammatory characteristic that can suppress the VEGF level (Zhou et al., 2015). In the review result against 12 studies, the rats given curcumin intervention had a lower VEGF level than the diabetic rats without curcumin intervention. This condition can prevent the occurrence of Diabetic Retinopathy.

DISCUSSION

The review against twelve studies showed a significant result related to the intervention of curcumin bioactive substance toward the prevention of Diabetic Retinopathy. All articles used experimental study design since it is the best study design to know the effectiveness of a specific intervention. Curcumin has antioxidant activity, anti-inflammation, and inhibits the VEGF cellular signal modulation, and as a result, it can cause phenotype changes in Diabetic Retinopathy (Jeenger et al., 2015). The significant proof from several experimental studies showed the potency of curcumin in preventing the complications of Diabetes Mellitus.

The following study in the future implies that the researcher that uses an experimental study shall measure the research duration in each intervention applied. Besides, the researcher shall explain the primary ingredient of curcumin that is used. It is related to the effectiveness of curcumin on Diabetic Retinopathy. The result of this experimental study can be an alternative for further study; therefore, a clinical assessment of the bioactive substance of curcumin is required (Jeenger et al., 2015). The biological activity of curcumin is perfect for health; hence, further study can lead to the development of curcumin as herbal medicine orally related to the dosage for better effects in preventing Diabetic Retinopathy, a complication of diabetes mellitus.

A study is also required to be conducted on humans to ensure the potency of curcumin in preventing complications due to Diabetes Mellitus and the prevention of increased blood glucose levels. The study in the future shall discuss curcumin with the best effectiveness appropriate to the latest development of formulation, such as nanoparticles, encapsulations, emulsions, or tablets, in preventing complications due to Diabetes Mellitus (Zhang et al., 2013).

The strength of this literature review is that reviewing Scopus-indexed international journals with experimental study design or intervention; consequently, the effects of the treatment can be seen, namely, the effectiveness of curcumin bioactive substance against the prevention of Diabetic Retinopathy. Besides, the reviewed articles had been published, at least, in the last ten years. Meanwhile, the weakness of this paper is the limited references related to the effectiveness of curcumin in preventing Diabetic Retinopathy that fulfills the inclusion criteria.

CONCLUSION AND SUGGESTION

Based on the review result against twelve articles, most of the studies show that the intervention using curcumin bioactive compound is quite effective in preventing Diabetic Retinopathy. Curcumin is able to have a positive effects by controlling the oxidative stress, preventing inflammation, keeping the normal morphology of the retina, decreasing the blood glucose levels, and decreasing the VEGF levels. Curcumin can provide a significant result within 8-16 weeks with a dosage of 100mg-1g/kg/day.

A similar research development, especially in Indonesia, needs to be conducted to identify the benefits of the bioactive substance of curcumin against the prevention of Diabetic Retinopathy in a more specific way.

REFERENCES

Adrian, D. (2017). Pengaruh Anti-VEGF pada *Diabetic Retinopathy.* CDK-258, 44(1). Accessed from Cermin Dunia Kedokteran Journals

Aldebasi, Y.H., Salah, M.A., & Arshad, H.R. (2013). Therapeutic implications of curcumin in the prevention of Diabetic Retinopathy via modulation of antioxidant activity and genetic pathways (Review Article). Int J Physiol Pathophysiol Pharmacol, 5(4):194-202.

Deshpande, J., Shankarnarayanan, J., Bhanuprakash, R.G., Sreenivasa, R., & Vijaya, J. (2015). Soluble Curcumin in the Prevention of Diabetic Retinopathy via Modulation of Antioxidant Activity and Genetic Pathways – In Vivo Model. Advances in Ophthalmology & Visual System, 3(1): 00077.

Elvira & Ernes, E.S. (2019). Diabetic Retinopathy. CDK-274, 46(3). Accessed from Cermin Dunia Kedokteran Journals

Gupta, S.K., Binit, K., Tapas, C.N., Shyam, S.A., Renu, A., Puneet, A., Rohit, S., & Sushma S. (2011). Curcumin Prevents Experimental Diabetic Retinopathy in Rats Through Its Hypoglycemic, Antioxidant, and Anti-Inflammatory Mechanisms. Journal of Ocular Pharmacology and Therapeutics, 27(2):123-130. DOI: 10.1089/jop.2010.0123.

Hewlings, S.J., & Douglas S.K. (2017). Curcumin: A Review of Its' Effects on Human Health. Foods 2017; 6: 92. United States of America.

Huang, J., Quanyong, Y., Yao, C., Yi, L., Guoxu, X., Ji, Z., Tongtong, N., Yuhong, Y., Weijie, Z., Sicheng, Q., & Weifeng, L. (2020). Curcumin suppresses oxidative stress via regulation of ROS/NF-κB signaling pathway to protect retinal vascular endothelial cell in Diabetic Retinopathy. Endocrinology & Metabolism Ophthalmology. DOI:10.21203/rs.3.rs-27239/v1.

Jeenger, M.K., Shweta, S., Veera, G.Y., Naidu, Sistla, R., & Ashutosh, K. (2015). Curcumin: A Pleiotropic Phytonutrient in Diabetic Complications. *Nutrition* (2014), DOI: 10.1016/j.nut.2014.06.015.

Jung, K.Y., Kim, K.M., and Lim, S. (2014). Therapeutic Approaches for Preserving or Restoring Pancreatic β-Cell Function and Mass. Diabetes Metab J. 38: 426-36

Kementerian Kesehatan Republik Indonesia. (2018). Apa Itu Retinopati Diabetik?. Jakarta, Indonesia: Kemenkes RI. (Accessed on November 21, 2020)

Kementerian Kesehatan Republik Indonesia. (2018). Retinopati and Biochemistry. 2016;39:1196-1208. Diabetik: Pergeseran Paradigma Kebutaan pada Era Milenial. Jakarta, Indonesia: Kemenkes RI. (Accessed on November 21, 2020)

Kementerian Kesehatan Republik Indonesia. (2019). Hari Diabetes Sedunia Tahun 2018. Jakarta, Indonesia: Kemenkes RI. (Accessed on November 21, 2020)

Kowluru, R.A., & Mamta, K. (2007). Effects of curcumin onretinal oxidative stress and inflammation in diabetes. Nutr Metab (Lond), 4(8). DOI:10.1186/1743-7075-4-8

Kumawat, M., Singh, I., Singh, N., Singh, V., & Kharb, S. (2012). Lipid Peroxidation and Lipid Profile in Type II Diabetes Mellitus. Webmed Central Biochemistry. 2012; 3(3) :WMC003147. Rohtak India.

Lee, R., Tien, Y., & Charumathi, S. (2015). Epidemiology of Diabetic Retinopathy, Diabetic Macular Edema and Related Vision Loss. Eye and Vision Singapore: BioMed Central. 2015; 2:17. DOI 10.1186/s40662-015-0026-2.

Li, J., Peipei, W., Jia, Y., Zhen, C., & Songping, Y. (2016). Curcumin Attenuates Retinal Vascular Leakage by Inhibiting Calcium/CalmodulinDependent Protein Kinase II Activity in StreptozotocinInduced Diabetes. Journal of Cellular Physiology and Biochemistry, 2016;39:1196-1208. DOI: 10.1159/000447826.

Li, J., Peipei, W., Yanxia, Z., Zhen, C., Tianyan, S., Wensheng, L., & Songping, Y. (2015). Curcumin Inhibits Neuronal Loss in the Retina and Elevates Ca^{2+}/Calmodulin-Dependent Protein Kinase II Activity in Diabetic Rats. Journal of ocular pharmacology and therapeutics 31(9):555-62. DOI: 10.1089/jop.2015.0006.

Maugeri, A., Maria, G.M., Francesco, G., Manlio, V., Guido, B., Martina, B., & Antonella, A. (2018). Curcumin Modulates DNA Methyltransferase Functions in a Cellular Model of Diabetic Retinopathy. Journal of Oxydative Medicine and Cellular Longevity, 2018;1-12.

Panasea, A.F. (2014). Pengaruh Pemberian Ekstrak *Curcuma Longa L* terhadap Titer Interleukin-6 (IL-6) dan Gambaran Histologi Pankreas pada Tikus (*Rattus Norvegicus*) Model Diabetes Melitus Tipe 1. (Thesis, University of Brawijaya, Malang, Indonesia). Accessed from http:// repository.ub.ac.id/id/eprint/126912

Phillip J. (2013). Curcumin supplementation is shown to halt the progression of diabetes in prediabetics. Natural News. Truth Publishing International Ltd.

Platania, C.B.M., Annamaria, F., Francesca, L., Cateno, P., Federica, G., Giovanni, G., Gian, M.L., Salvatore, S., Filippo, D., & Claudio, B. (2018). Retinal Protective and Distribytion of Curcumin in Vitro and in Vivo. DOI: 10.3389/fphar.2018.00670.

Pradhan, D., Toffa, D., & Gitanjali, T. (2018). Pharmacognostic Evaluation of Curcumin on Diabetic Retinopathy in Alloxan-induced Diabetes through NFKB and Brn3a Related Mechanism. Pharmacogn J, 10(2): 324-332. DOI : 10.5530/pj.2018.2.56.

Ran, Z., Yueling, Z., Xiaoying, W., & Jingxue, M. (2019). Curcumin inhibits high glucose-induced inflammatory injury in human retinal pigment

epithelial cells through the ROS-PI3K/AKT/mTOR signaling pathway. Molecular Medicine Reports, 2018;19:1024-1031. DOI: 10. 3892/m m r. 2018.9749.

Riskesdas. (2018). Badan Penelitian dan Pengembangan Kesehatan Kementerian RI tahun 2018. Jakarta, Indonesia: (Accessed on November 21, 2020)

Salem, N.A., Gamal, M.A., Mohamed, E., & Amanuel, T.T. (2012). Effects of Curcumin on Early Retinal Neuro-Degenerative Changes in Diabetic Albino Rats. Journal of American Science, 8(1).

Septadina, I.S. (2015). Perubahan Anatomi Bola Mata pada Penderita Diabetes Mellitus. *MKS, Th. 47(2).*

Simorangkir, H.A. (2020). Mikroenkapsulasi Kombinasi Curcumin pada Kunyit (*Curcuma Longa*) dan Epigallocatechin-3-Gallate (EGCG) pada Daun Teh Hijau (*Camellia Sinensis*): Inovasi Terapi Pencegahan Diabetik Retinopati pada Penderita Diabetes Melitus Tipe 2. Scientific Medical Journal, 1(2). DOI: https://doi.org/10.32734/scripta.v1i2.1234

Soewondo, P., Sidartawan, S., Ketut, S., Agung, P., Djoko, W.S., & Askandar, T. (2010). The Diabcare Asia 2008 Study - Outcomes on Control and Complications of Type 2 Diabetic Patients in Indonesia. The DiabCare Asia 2008 study, 19(4): 235-244.

Suyono, E.A., & Pandelaki, K. (2014). Diabetes Melitus di Indonesia. In: Suyono E.A. Buku ajar ilmu penyakit dalam Jilid III. Edisi ke-6. Jakarta: Interna Publishing; 19101919.

World Health Organization. (2016). WHO Global Report on Diabetes. Switzerland: WHO

World Health Organization. (2016). Global Report on Diabetes Executive Summary. Switzerland: WHO

Yang, F., Jinqiang, Y., Feng, K., Mei, L., Dekun, L., Ke, T., Jiaojiao, L., Ying, W., Kaili, W., & Dai, L. (2018). Curcumin Alleviates Diabetic Retinopathy in Experimental Diabetic Rats. Ophtalmic Research, 60(1):43-54. DOI: 10.1159/000486574.

Zhang, D., Min, F., Si-Hua, G., & Jun-Li, L. (2013). Curcumin and Diabetes: A Systematic Review. Beijing, China: Evidence-Based Complementary and Alternative Medicine. Hindawi Publishing Vol 2013: 1-16.

Zhou, Y., Tiantian, Z., Xiaofei, W., Xiaowei, W., Yizhu, C., Lingyu, G., Junfeng, Z., & Changqian, W. (2015). Curcumin Modulates Macrophage Polarization Through the Inhibition of the Toll-Like Receptor 4 Expression and its Signaling Pathways. Cell Physiol Biochem, 36, 631-641. DOI: 10.1159/000430126.

Zuo, Z.F., Qiang, Z., & Xue-Zheng, L. (2013). Protective Effect of Curcumin on Retinal Muller Cell in Early Diabetic Rat. International Journal Opthalmol, 2013;6(4):422-424. DOI:10.3980/j.issn.2222-3959.2013.04.02.

FOOD-BASED AND NON-FOOD-BASED INTERVENTIONS TO IMPROVE DIETARY DIVERSITY: A LITERATURE REVIEW

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ABSTRACT

Dietary diversity is one of the diet quality. Poor dietary diversity is associated with malnutrition, stunting, poor gut health, pregnancy complications, and cognitive impairment. Overcoming the underlying and basic causes of poor dietary diversity is imperative through policymaking. This current literature review discussed about intervention policies to improve dietary diversity at the individual and population levels. Literature search was carried out in some databases, i.e., Pubmed/Medline, Google Scholar, and Google with key word search such as dietary diversity, improvement, programs, interventions, and policies. The synthesized articles included observational studies, experimental studies, and grey literature on Dietary diversity programs and interventions. Articles on biodiversity and microbial diversity were not included. Dietary diversity can outgrow by knowing the policy on food-based interventions which are closely related to the food system and non-food-based interventions to improve socio-economic aspect and knowledge. Food-based interventions include food production, food prices, agricultural diversification, market development, and food-based dietary guidelines. Meanwhile, non-food-based interventions involve a country's development and economic growth, social behavior change, communication strategy, cash transfer, and mass media campaigns. Interventions to improve dietary diversity must be carried out in multi-sectors, for example, by improving family welfare, knowledge and behavior change, and stable food access.

Keywords: Dietary diversity, policies, food-based intervention, and non-food-based intervention

INTRODUCTION

Dietary diversity, which represents a major part of dietary quality, is the amount of food consumed in a food group in a certain period (Arimond et al., 2011). Globally, two out of three children aged 6 to 23 months do not meet the minimum recommended dietary diversity and only consume at least five out of eight food groups in a day. Only Asia and upper-middle-income countries can provide the amount of fruit and vegetables according to FAO/WHO recommendations that mention a minimum food intake is 400 g/person/day. Less than 40% of children in seven of eleven subregions (i.e., Southern Africa, Eastern Asia, Northern Africa, Western Africa, Eastern Africa, Southern Africa, and Middle Africa) did not meet the minimum dietary diversity (Food and Agriculture Organization et al., 2020). Dietary diversity in low-income countries and rural areas is lower compared to middle-income countries and urban areas (Choudhury and Headey, 2017; Geng et al., 2018).

The number of food groups consumed is positively related to the adequate macronutrient and micronutrient density and nutritional status (Kennedy et al., 2011; Nithya and Bhavani, 2018). Stunting in under-five children is also known to occur partly due to poor dietary diversity, especially in children at the age of 6-11 months (Oldewage-Theron and Kruger, 2008; Roesler et al., 2019; Utami and Mubasyiroh, 2020). Other effects of poor dietary diversity are cognitive impairment (Otsuka et al., 2017; Yin et al., 2017; Zhang et al., 2020; Zheng et al., 2021) and poor gut health (Heiman and Greenway, 2016; Laitinen and Mokkala, 2019; Valdes et al., 2018). Meanwhile, an adequate intake of dietary diversity helps pregnant women reduce the occurrence of pre-eclampsia, anemia, low birth weight, and premature birth (Agrawal et al., 2015; Zerfu et

 Received 11-08-2021, Accepted 24-09-2021, Published online 30-01-2022

al., 2016). The high dietary diversity may prevent metabolic syndrome because it contributes to reduce low serum triglycerides, systolic blood pressure, and adiponectin serum (Farhangi and Jahangiry, 2018).

Household food diversity is useful to determine the level of resources available in a household. Due to the relevance of dietary diversity as a pillar of food security, several factors i.e., food availability, accessibility, utilization, and stability influence the adequacy of food diversity (Obayelu and Osho, 2020). Poor household and child dietary diversity is closely related to household socio-economic status, such as low education level, big household size, low household food expenditure, small house size, and poor hygiene and sanitation of toilet facilities and drinking water (Cordero-Ahiman et al., 2021; Obayelu and Osho, 2020; Powell et al., 2017).

A market has a great influence on the dietary diversity of the population (Ambikapathi et al., 2019; Masters et al., 2018). Households who contract with food markets more frequently are more likely to have diversified diets related to food purchase diversity (Matita et al., 2021). However, a drastic increase in food prices causes a decrease in purchasing power (Cordero-Ahiman et al., 2021; D'Souza and Jolliffe, 2016). Food availability as one of the pillars of food diversity is closely related to agriculture and agrobiodiversity. For instance, it has a relationship with the use of land varieties and landscape heterogeneity. Besides, food availability depends on home garden ownership, seasons, and geography (Custodio et al., 2019; Powell et al., 2017).

Preventions and interventions to improve dietary diversity at the individual and population levels should be carried out through cross-sectoral collaborative programs. Many strategies could improve dietary diversity, but there is no categorization of the policies yet. In this review, policies were reviewed based on two broad groups, namely food-based intervention (related to the food system) and non-food-based intervention (related to socio-economic aspects and knowledge). Therefore, it is necessary to improve dietary diversity at the individual and population levels.

METHODS

This current literature review synthesized several previous studies to gain more understanding about dietary diversity policies and interventions in a broader population. A non-systematic, explorative literature search was conducted in some electronic database platforms such as Google Scholar, Pubmed/Medline, and Google. The synthesized studies included observational studies (cross-sectional, case-control, and cohort), experimental studies, and grey literature which must contain relevant keywords such as dietary diversity or diversification which were searched alone or in combination with several keywords such as interventions, policies, and programs. Those keywords along with their synonyms were obtained using the Boolean search methods. All articles were free accessed full texts published in Indonesian and English. Articles which talked over other topics such as biodiversity, and microbial diversity were excluded.

RESULTS AND DISCUSSION

Dietary Diversity Improvement Interventions

Nutrition interventions at the community level can be carried out using two approaches: food-based and non-food-based nutrition interventions. Food-based interventions have something to do with the food system aimed to improve food production and availability, supply, processing, conservation, commercialization, as well as food access and consumption (Morón, 2006). Meanwhile, non-food-based interventions aim to improve dietary diversity through supporting factors, e.g., socio-economic aspects and knowledge.

These two interventions indicated a multisectoral approach on nutrition interventions could address the underlying causes and basic causes of malnutrition. To comply with quality diets, a diverse diet ensures that each individual has access to food as an adequate source of macro and micronutrients. Nair et al. (2016) found that successful dietary diversity strategies can tackle hidden hunger by integrating the interventions with bioavailability, such as food synergy on

food accessibility, affordability, and lifestyle modification.

Food-based Intervention Strategy

Food Production and Supply Management

Interventions to improve population food diversity can be applied through improved food security (Chiang and Capiña, 2018). Food production and supply management can meet the population needs with sufficient food quantity. Supply management not only includes producers and suppliers but also deals with logistics flows, transporters, warehouses, retailers, and consumers (van der Vorst et al., 2007). Increased food production likely lead to local food availability. Higher production generally means lower food prices and access to greater quantities of food in markets (Dorward, 2014).

Increased crop diversity alone may not be sufficient to ensure more food diversities (Dillon et al., 2015). Better market access in peri-urban and rural areas in smallholder households in Kenya and Tanzania generally result in lower food production diversity, but higher food diversity. Such access can expand opportunities for product sales and purchase of diversified food items (Kissoly et al., 2020). In Indonesia, the control of food production, which reflects the food sufficiency of the population, is carried out by taking into account the level of food availability in an area, either originating from domestic production, reserves/ stocks, or imports (Food Security Agency, 2018). An increase in food availability and control of food stocks leads to improved desirable dietary pattern scores in Indonesia, ranging from 86.2 in 2016 to 92.5 in 2019 (Food Security Agency, 2021).

Homestead food production programs in four Asian countries (Bangladesh, Cambodia, Nepal, and the Philippines) could increase dietary diversification. Moreover, it could result in more frequent vegetable consumption in children by 1.6 times higher through home gardening, animal husbandry, and nutrition education (Talukder et al., 2010).

Agricultural diversity

Agricultural diversity is "the variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries" (Dulloo, 2019). Agriculture increases food diversity through diversification of food production by considering the seasons (Habtemariam et al., 2021). Strong agricultural biodiversity can support healthy diets through easy access to diverse crop availability and better soil quality (Chiang and Capiña, 2018). Other interventions related to agricultural production and diversification include subsidies and assistance to distribution, tax deduction, technology, and government-funded farm research. These policies need to be carefully designed and implemented to avoid unintended consequences (Food and Agriculture Organization of the United Nations, 2019).

Agroecological control can improve diversity through swelling small-scale production of micronutrient-rich foods for personal or local consumption and higher commercial production of micronutrient-rich foods (Thompson et al., 2014). Agroecology is the simultaneous application of ecological and social concepts and principles for food and agricultural system design and management (Nannipieri et al., 2002). Such control can also preserve micronutrient levels of commonly eaten foods through reduced postharvest loss and selected breed plants (Thompson et al., 2014).

Indonesia has applied agroecology in its agricultural diversity policy. For example, the country has established a food self-sufficient area program by involving community representatives from selected villages to enforce independent communities through a labor-intensive and stunting reduction in regions prone to food deficiency (Food and Agriculture Organization of the United Nations, 2019).

Food-based Dietary Guidelines

Food-based dietary guidelines (FBDGs) are valuable tools for nutrition policy and public health strategies to promote healthy eating with various food groups and physical activities. These guidelines aim to increase public awareness of evidence-based healthy eating and lifestyle habits, which are tailored to the eating habits of the target population. More than 100 countries around the world have developed food-based

dietary guidelines that recommend a variety of foods based on dietary patterns and culture. Some of the holistic approaches often used are the healthy eating pyramid or food pyramid and my plate (Food and Agriculture Organization of the United Nations, 2021). FBGDs are also the basis for assessing the dietary diversity of the population (Verger et al., 2019).

Interdisciplinary experts, including policymakers, legislators, nutrition and other health professionals, have developed dietary guidelines in agriculture, education, consumer science, non-government organizations, communications, as well as private sectors such as food and health industries, as well as media (World Health Organization, 1998). Before being distributed to the target population, the guidelines will be tested to ensure practicability and comprehensiveness. The target population of the FBDGs should include the general population, infants, children, adults, pregnant and lactating mothers, and elderly. Certain dietary preference groups i.e., vegetarians and people with diseases e.g., cardiovascular disorders and diabetes require special diets (World Health Organization, 2011).

Food Price Controls

High food price volatility (significant and frequent changes in the direction and magnitude of food prices) harms food security and lead to reduced purchasing power (Kalkuhl et al., 2016). Price control is a government regulation in limiting the price of goods and services in the market. Food price management policies carried out by 81 countries in Asia, Africa, Latin America, and the Caribbean during the food price volatility period include 1) domestic market-based measures (released stock at the subsidized price and suspension/reduced VAT (Value Added Tax)) and other taxes, and price control or restrict private trade); 2) trade policy measures (reduction of tariffs and customs fees on imports and restricted or banned exports); 3) safety nets such as cash or food transfer; 4) increased disposable income; 5) non-market based production support (production support programs and fertilizers and seeds programs; and 6) market-based interventions (Rapallo, 2011).

Food price subsidies help the community access food. For example, India provides food subsidies on staple food commodities such as rice, millet, pulses, and vegetables which then have significantly improved food consumption (Malaiarasan et al., 2021). However, subsidizing low-nutrient staple foods (cereals, oil, and sugar) can encourage unbalanced diets and higher risk of malnutrition and health problems among the population (Food and Agriculture Organization of the United Nations, 2019).

Market Development

Food diversity in the market can be the potential mitigation to increase dietary diversity. The rapid growth of supermarkets competing with small retailers in low-income countries could encourage the consumption of cheap but less nutritious processed foods (Swinburn et al., 2019). Besides, modern markets can also provide fresh food at any time despite higher prices of goods that suit their target market. Such modern markets are easier to access than traditional markets due to the weakened purchasing power of their customers because the fuel price increases (Schipmann and Qaim, 2011; Suryadarma, 2007).

The power asymmetry of the food system needs to be addressed through policies that empower small and medium-sized farmers, local and regional markets, and short food chains. Small and medium-sized farmers and local and regional markets mostly maintain the diversity of food, e.g., vegetables, fruits, and grains that are used as the basis of traditional cuisines and diets (Swinburn et al., 2019).

Some market development interventions can be carried out in new development industries such as emerging private pharmaceuticals, food processing, and retail firms. Moreover, entrepreneurship and trade that cut long distribution chains can lower the food price (Dupouy and Gurinovic, 2020). In Indonesia, Toko Tani program becomes the government's effort to cut the food supply chain from 8-9 parties to only 3-4 parties (Food Security Agency, 2019). To achieve good food chains, infrastructure has a vital role in market access. Poor access to roads, railways, and other basic transportation will limit market access despite

the adequate purchasing power (Thompson et al., 2014).

Non-Food Based Intervention Strategy

Country's Economic Development

Choudhury and Headey (2017) conducted a cross-country analysis related to what drives the diversification of national food supplies. Food diversification scores are closely related to the level of country's development in general, consumption per capita, and economic growth. However, in some instances, such as in rural Indonesian areas, despite economic development, the average dietary diversity of the population declined. It may occur likely due to market access (physically and economically) and perception of a healthy diet (Mehraban and Ickowitz, 2021).

Other economic development factors that influence food diversification scores are the transition of population structure (younger to older), urbanization, and increased dependence on the food trade. Research showed that high levels of population density are negatively associated with food diversification scores (Choudhury and Headey, 2017). The relationship between food diversification and urbanization could occur due to increasing reliance on food trade. In some cases, urbanization does not affect increasing food diversification due to low incomes and the transition of food choices to high sugar food and instant food (Pandey et al., 2020).

Social Behavior Changes and Communication

Social behavior changes and communication (SBCC) become one of the public health interventions that significantly improve health status. It is a systematic approach of interactive, theory-based, and research-driven communication strategies to change individual behaviors and social norms (USAID Wildlife Asia, 2020).

SBCC in the field of nutrition have widely been performed to increase the community's dietary diversity. The approach includes school feeding programs, general food assistance, and other nutrition-sensitive programs. It is also broadcasted to various channels such as community radio shows, television programs, caregiver support groups, and policy-level working groups (World Food Programme, 2020).

Education has strong and significant effects on household dietary diversity and child nutrition (Chegere and Stage, 2020). Educational and social marketing activities are critically aimed at increasing the consumption of micronutrient-rich food (Thompson et al., 2014). Community-based nutrition education with a participatory approach for caregivers can increase children's dietary diversity even in areas with food insecurity (Kuchenbecker et al., 2017). Another example of participatory community approach is that community health workers (CHW) through small neighborhood units (SNU) likely improve dietary diversity and child nutrition practices by and caregiver attitudes towards recommended feeding (Hitachi et al., 2020).

The Farmer Nutrition School (FNS) program for mothers and children in the first 1,000 days in Bangladesh demonstrated a significant increase in food diversity consumption because of education and consultation related to nutrition, water, sanitation, and hygiene (WASH), and agriculture (Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING), 2017). Apart from crop and livestock diversity, purchasing power, infrastructure, supply, and price stability, well-run food system for dietary diversity could improve cultural norms. Cultural norms will affect food allocation and dietary diversity at household and community levels (Thompson et al., 2014).

Cash and Voucher Programs

Direct cash transfers can impact nutrition status through nutrition-sensitive channels such as improved food diversity and food consumption for all household members. Cash transfers are one of the social protection interventions aimed at increasing and stabilizing household income (Food and Agriculture Organization of the United Nations, 2020).

Both conditional and unconditional transfers could improve the diversity of food recipients (Grellety et al., 2017; Grijalva-Eternod et al., 2018; Harris-Fry et al., 2018; Irenso and Atomsa, 2018; Potts et al., 2019; Cahyadi et al., 2018; Martins and Monteiro, 2016). Conditional cash transfers

are available when the beneficiary must meet certain conditions. Meanwhile, unconditional cash transfers are available anytime for the beneficiary that must be at below the poverty standard (World Bank, 2018).

In contrast to cash transfers, voucher schemes allow beneficiaries to exchange paper or electronic cards for goods and services at pre-selected stores. Meanwhile, food transfers are almost the same as cash transfers but provide food exchange (Food and Agriculture Organization of the United Nations, 2016). Both interventions have a positive effect on food diversity. In Ethiopia, the provision of cash transfers resulted in better household dietary diversity than those who received food only due to an ongoing increase in food prices (Baye et al., 2014). While in Northern Ecuador, vouchers gave the most significant effect on increasing dietary diversity compared to cash transfers and food transfers. Vouchers give households the ability to consume a variety of food on a longer period and to buy cheaper food (Hidrobo et al., 2014).

Mass Media Campaign

Mass media campaign for behavior change related to healthy eating behavior is a method to provide education to large populations. Positive behavior changes occurred due to this mass campaign (Korda and Itani, 2013; Wakefield et al., 2010). Mass media communications in India p could increase the intake of vitamin A-rich foods among preschool children by fourfold. It was then followed by improved knowledge, attitudes, and practices on vitamin A food consumption among mothers of preschool children (Nayak et al., 2001). Several mass media platforms that can serve as campaign platforms include television, radio, newspaper, magazines, posters, leaflets, and internet media (website, emails, podcasts, and blogs). Another highly developed method is internet communication using social media, such as Tiktok, Youtube, Twitter, Facebook, and Instagram (Haslam et al., 2019; Korda and Itani, 2013; Maryon-Davis, 2012; Saei et al., 2021; Santarossa and Woodruff, 2018; Zhu et al., 2020).

Health promotion must uplift health information to the public, social marketing (engaging and motivating people to adopt a healthy lifestyle), and media advocacy (raising awareness of health topics to change policies in facilitating health promotion) (Maryon-Davis, 2012).

Food-based and non-food-based interventions are interconnected to improve dietary diversity. For example, poor management of food production and supply can affect food availability such as food price inflation, which reduces the community purchasing power. The provision of nutrition education and cash transfers will not be sufficient to overcome this problem because the community has inadequate access to food. Therefore, the government should carry out all interventions involving the community and multisectoral participation to achieve dietary diversity.

Above all, none of the existing research compares the effectiveness of all programs to improve dietary diversity. None examines the success of the food-based dietary guidelines program alone to improve dietary diversity.

CONCLUSION

Intervention and policy to increase individual and population dietary diversity are closely related to understanding of problems and their causes. Intervention policies are categorized as food-based interventions and non-food-based interventions. Food-based interventions take parts in handling of the food system, such as food production and supply management, agriculture diversity, food-based guidelines, food price controls, and market development. Non-food-based interventions can be done by improving economic aspect, social and behavior change communication, cash transfer, and mass media campaigns.

These interventions are expected to address the basic causes of malnutrition because of insufficient food diversity consumption at individual and population levels. There is no single policy that can replace other policies in improving dietary diversity. Therefore, it is imperative that all policies, both food-based and non-food-based interventions, must be simultaneously implemented to improve dietary diversity.

ACKNOWLEDGMENT

We would like to thank the Faculty of Public Health, Universitas Airlangga and Nutrition

Study Program, the State University of Medan for supporting the research.

REFERENCES

Agrawal, S., Fledderjohann, J., Vellakkal, S., & Stuckler, D. (2015). Adequately diversified dietary intake and iron and folic acid supplementation during pregnancy is associated with reduced occurrence of symptoms suggestive of pre-eclampsia or eclampsia in Indian women. PLoS ONE 10, e0119120. doi:10.1371/journal.pone.0119120

Ambikapathi, R., Gunaratna, N.S., Madzorera, I., Passarelli, S., Canavan, C.R., Noor, R.A., & Fawzi, W.W. (2019). Market food diversity mitigates the effect of environment on women's dietary diversity in the Agriculture to Nutrition (ATONU) study, Ethiopia. Public Health Nutr. 22, 2110–2119. https://doi.org/10.1017/S136898001900051X

Arimond, M., Wiesmann, D., Becquey, E., Carriquiry, A., Daniels, M., Deitchler, M., & Torheim, L.E., (2011). Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets in Resource-Poor Areas: Summary of Results from Five Sites 97.

Baye, K., Retta, N., & Abuye, C., (2014). Comparison of the effects of conditional food and cash transfers of the ethiopian productive safety net program on household food security and dietary diversity in the face of rising food prices: ways forward for a more nutrition-sensitive program. Food Nutr. Bull. 35, 289–295. doi:10.1177/156482651403500301

Cahyadi, N., Rema, H., Benjamin, A., Prima, O., R. A., Satriawan, E., & S. Ekki, (2018). Cumulative Impacts of Conditional Cash Transfer Programs: Experimental Evidence from indonesia.

Chegere, M.J., Stage, J., (2020). Agricultural production diversity, dietary diversity and nutritional status: Panel data evidence from Tanzania. World Dev. 129, 104856. doi:10.1016/j.worlddev.2019.104856

Chiang, S.-N., & Capiña, X.G., (2018). Adding Diversity as a New Dimension in the Food Security Framework. Southeast Asian Reg. Cent. Grad. Study Res. Agric. SEARCA 12.

Choudhury, S., & Headey, D., (2017). What drives diversification of national food supplies? A cross-country analysis. Glob. Food Secur. 15, 85–93. doi:10.1016/j.gfs.2017.05.005

Cordero-Ahiman, O.V., Vanegas, J.L., Franco-Crespo, C., Beltrán-Romero, P., Quinde-& Lituma, M.E., (2021). Factors that determine the dietary diversity score in rural households: The Case of the Paute River Basin of Azuay Province, Ecuador. Int. J. Environ. Res. Public. Health 18, 2059. doi: 10.3390/ijerph18042059

Custodio, E., Herrador, Z., Nkunzimana, T., Węziak-Białowolska, D., Perez-Hoyos, A., & Kayitakire, F., (2019). Children's dietary diversity and related factors in Rwanda and Burundi: A multilevel analysis using 2010 Demographic and Health Surveys. PLOS ONE 14, e0223237. doi:https://doi.org/10.1371/journal.pone.0223237

Dillon, A., McGee, K., & Oseni, G., (2015). Agricultural Production, Dietary Diversity and Climate Variability. J. Dev. Stud. 51, 976–995. doi:10.1080/00220388.2015.1018902

Dorward, A., (2014). How can agricultural interventions contribute in improving nutrition health and achieving the MDGs in Least-Developed Countries? Nestlé Nutr. Inst. Workshop Ser. 78, 93–109. doi:10.1159/000354946

Dulloo, M.E., (2019). Maintaining Diversity of Plant Genetic Resources as a Basis for Food Security, in: Ferranti, P., Berry, E.M., Anderson, J.R. (Eds.), Encyclopedia of Food Security and Sustainability. Elsevier, Oxford, pp. 54–63. doi: 10.1016/B978-0-08-100596-5.22208-7

Dupouy, E., & Gurinovic, M. (2020). Sustainable food systems for healthy diets in Europe and Central Asia: Introduction to the special issue. Food Policy 101952. doi: 10.1016/j.foodpol.2020.101952

D'Souza, A., & Jolliffe, D. (2016). Coping with Food Price Shocks in Afghanistan, in: Kalkuhl, M., von Braun, J., Torero, M. (Eds.), Food Price Volatility and Its Implications for Food Security and Policy. Springer International Publishing, Cham, pp. 543–581. doi:10.1007/978-3-319-28201-5_21

Farhangi, M.A., & Jahangiry, L. (2018). Dietary diversity score is associated with cardiovascular risk factors and serum adiponectin concentrations in patients with metabolic syndrome. BMC Cardiovasc. Disord. 18, 68. doi: 10.1186/s12872-018-0807-3

Food Security Agency (2018). Annual Report of the Food Security Agency.

Food Security Agency, (2019). Food Security Development Policies and Programs in 2020.

Food Security Agency, (2021). Food Security Agency Performance Report 2020.

Food and Agriculture Organization of the United Nations, (2016). Cash and voucher programmes.

Food and Agriculture Organization of the United Nations, (2019). The State of Food Security and Nutrition in the World 2019: Safeguarding against economic slowdowns and downturns. Food & Agriculture Org.

Food and Agriculture Organization of the United Nations, (2020). Nutrition and cash-based interventions. FAO. doi: 10.4060/ca9143en

Food and Agriculture Organization of the United Nations, (2021). Food-based Dietary Guidelines [WWW Document]. Food Agric. Organ. U. N. Retrieved from http://www.fao.org/nutrition/education/food-dietary-guidelines/home/en/ (accessed 7.21.21).

Food and Agriculture Organization, IFAD, UNICEF, WFP, (2020). The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. FAO.

Geng, S., Ma, J., Liu, S., & Zhang, J. (2018). Lack of Dietary Diversity Contributes to the Gaps in Micronutri- ent Status and Physical Development between Urban and Rural Infants. Iran J Public Health 47, 9.

Grellety, E., Babakazo, P., Bangana, A., Mwamba, G., Lezama, I., Zagre, N.M., & Ategbo, E.-A., (2017). Effects of unconditional cash transfers on the outcome of treatment for severe acute malnutrition (SAM): a cluster-randomised trial in the Democratic Republic of the Congo. BMC Med. 15, 87. doi: 10.1186/s12916-017-0848-y

Grijalva-Eternod, C.S., Jelle, M., Haghparast-Bidgoli, H., Colbourn, T., Golden, K., & Seal, A.J., (2018). A cash-based intervention and the risk of acute malnutrition in children aged 6-59 months living in internally displaced persons camps in Mogadishu, Somalia: A non-randomised cluster trial. PLoS Med. 15, e1002684. doi: 10.1371/journal.pmed.1002684

Habtemariam, L.T., Gornott, C., Hoffmann, H., & Sieber, S., (2021). Farm Production Diversity and Household Dietary Diversity: Panel Data Evidence From Rural Households in Tanzania. Front. Sustain. Food Syst. 0. doi: 10.3389/fsufs.2021.612341

Harris-Fry, H.A., Paudel, P., Harrisson, T., Shrestha, N., Jha, S., Beard, B.J., & Saville, N.M., (2018). Participatory women's groups with cash transfers can increase dietary diversity and micronutrient adequacy during pregnancy, whereas women's groups with food transfers can increase equity in intrahousehold energy allocation. J. Nutr. 148, 1472–1483. doi: 10.1093/jn/nxy109

Haslam, K., Doucette, H., Hachey, S., MacCallum, T., Zwicker, D., Smith-Brilliant, M., & Gilbert, R., (2019). YouTube videos as health decision aids for the public: An integrative review. Can. J. Dent. Hyg. CJDH J. Can. Hyg. Dent. JCHD 53, 53–66.

Heiman, M.L., Greenway, F.L., 2016. A healthy gastrointestinal microbiome is dependent on dietary diversity. Mol. Metab. 5, 317–320. doi: 10.1016/j.molmet.2016.02.005

Hidrobo, M., Hoddinott, J., Peterman, A., Margolies, A., & Moreira, V., (2014). Cash, food, or vouchers? Evidence from a randomized experiment in northern Ecuador. J. Dev. Econ. 107, 144–156. doi:/10.1016/j.jdeveco.2013.11.009

Hitachi, M., Wanjihia, V., Nyandieka, L., Francesca, C., Wekesa, N., Changoma, J., & Kaneko, S. (2020). Improvement of dietary diversity and attitude toward recommended feeding through novel community based nutritional education program in Coastal Kenya—An Intervention Study. Int. J. Environ. Res. Public. Health 17, 7269. doi: 10.3390/ijerph17197269

Irenso, A.A., & Atomsa, G.E., (2018). Implications of Ethiopian Productive Safety Net Programme on household dietary diversity and women's body mass index: a cross-sectional study. Food Nutr. Res. 62. doi: 10.29219/fnr.v62.1574

Kalkuhl, M., von Braun, J., & Torero, M., (2016). Volatile and Extreme Food Prices, Food Security, and Policy: An Overview, in: Kalkuhl, M., von Braun, J., Torero, M. (Eds.), Food Price Volatility and Its Implications for Food Security and Policy. Springer International Publishing, Cham, pp. 3–31. doi: 10.1007/978-3-319-28201-5_1

Kennedy, G., Ballard, T., & Dop, M.-C. (2011). Guidelines for measuring household and individual dietary diversity. FAO, Rome.

Kissoly, L.D., Karki, S.K., & Grote, U. (2020). Diversity in Farm Production and Household Diets: Comparing Evidence From Smallholders in Kenya and Tanzania. Front. Sustain. Food Syst. 4. https://doi.org/10.3389/fsufs.2020.00077

Korda, H., & Itani, Z. (2013). Harnessing Social Media for Health Promotion and Behavior Change. Health Promot. Pract. 14, 15–23. doi: 10.1177/1524839911405850

Kuchenbecker, J., Reinbott, A., Mtimuni, B., Krawinkel, M.B., & Jordan, I. (2017). Nutrition education improves dietary diversity of children 6-23 months at community-level: Results from a cluster randomized controlled trial in Malawi. doi: PLOS ONE 12, e0175216. https://doi.org/10.1371/journal.pone.0175216

Laitinen, K., & Mokkala, K. (2019). Overall dietary quality relates to gut microbiota diversity and abundance. Int. J. Mol. Sci. 20, 1835. doi:10.3390/ijms20081835

Malaiarasan, U., Paramasivam, R., & Felix, K.T., (2021). Does Food Price Subsidy Affect Dietary Diversity? Evidence from South India. Margin J. Appl. Econ. Res. 15, 268–290. doi: 10.1177/0973801021990397

Martins, A.P.B., & Monteiro, C.A. (2016). Impact of the Bolsa Família program on food availability of low-income Brazilian families: a quasi experimental study. BMC Public Health 16, 827. doi: 10.1186/s12889-016-3486-y

Maryon-Davis, A. (2012). Using the Mass Media to Promote Health. InnovAiT 5, 767–773. doi: 10.1093/innovait/ins191

Masters, W., Bai, Y., Herforth, A., Sarpong, D., Mishili, F., Kinabo, J.,… Coates, J., (2018). Measuring the Affordability of Nutritious Diets in Africa: Price Indexes for Diet Diversity and the Cost of Nutrient Adequacy. Am. J. Agric. Econ. 100, 1285–1301. doi: https://doi.org/10.1093/ajae/aay059

Matita, M., Chirwa, E.W., Johnston, D., Mazalale, J., Smith, R., & Walls, H., (2021). Does household participation in food markets increase dietary diversity? Evidence from rural Malawi. Glob. Food Secur. 28, 100486. doi: 10.1016/j.gfs.2020.100486

Mehraban, N., & Ickowitz, A. (2021). Dietary diversity of rural Indonesian households declines over time with agricultural production diversity even as incomes rise. Glob. Food Secur. 28, 100502. doi:10.1016/j.gfs.2021.100502

Morón, C., (2006). Food-based nutrition interventions at community level. Br. J. Nutr. 96 Suppl 1, S20-22. doi: https://doi.org/10.1079/bjn20061693

Nair, M.K., Augustine, L.F., & Konapur, A., (2016). Food-Based Interventions to Modify Diet Quality and Diversity to Address Multiple Micronutrient Deficiency. Front. Public Health 3. doi: 10.3389/fpubh.2015.00277

Nannipieri, P., Kandeler, E., & Ruggiero, P., (2002). Enzyme activities and microbiological and biochemical processes in soil. Enzym. Environ. Act. Ecol. Appl. 1–33.

Nayak, M.U., Vazir, S., Vijayaraghavan, K., & Chandralekha, K. (2001). Nutrition Communication Using Social-Marketing Techniques to Combat Vitamin A Deficiency: Results of Summative Evaluation. Food Nutr. Bull. 22, 454–465. doi: 10.1177/156482650102200419

Nithya, D.J., & Bhavani, R.V. (2018). Dietary Diversity and Its Relationship with Nutritional Status among Adolescents and Adults in Rural India. J. Biosoc. Sci. 50, 397–413. doi: 10.1017/S0021932017000463

Obayelu, O.A., & Osho, F.R., (2020). How diverse are the diets of low-income urban households in Nigeria? J. Agric. Food Res. 2, 100018. doi: 10.1016/j.jafr.2019.100018

Oldewage-Theron, W.H., & Kruger, R., (2008). Food Variety and Dietary Diversity as Indicators of the Dietary Adequacy and Health Status of an Elderly Population in Sharpeville, South Africa. J. Nutr. Elder. 27, 101–133. doi: 10.1080/01639360802060140

Otsuka, R., Nishita, Y., Tange, C., Tomida, M., Kato, Y., Nakamoto, M., … Shimokata, H., (2017). Dietary diversity decreases the risk of cognitive decline among Japanese older adults. Geriatr. Gerontol. Int. 17, 937–944. https://doi.org/10.1111/ggi.12817

Pandey, B., Reba, M., Joshi, P.K., Seto, K.C., (2020). Urbanization and food consumption in India. Sci. Rep. 10, 17241. doi: 10.1038/s41598-020-73313-8

Potts, K.S., Mulugeta, A., & Bazzano, A.N., (2019). Animal Source Food Consumption in Young Children from Four Regions of Ethiopia: Association with Religion, Livelihood, and Participation in the Productive Safety Net Program. Nutrients 11. doi: 10.3390/nu11020354

Powell, B., Bezner Kerr, R., Young, S.L., & Johns, T. (2017). The determinants of dietary diversity and nutrition: ethnonutrition knowledge of local people in the East Usambara Mountains, Tanzania. J. Ethnobiol. Ethnomedicine 13, 23. doi:10.1186/s13002-017-0150-2

Rapallo, R., (2011). Food Price Volatility and the Right to Food.

Roesler, A.L., Smithers, L.G., Wangpakapattanawong, P., Moore, V., (2019). Stunting, dietary diversity and household food insecurity among children under 5 years

in ethnic communities of northern Thailand. J. Public Health 41, 772–780. doi: 10.1093/pubmed/fdy201

Saei, M.H., Valadi, S., Karimi, K.,& Khammarnia, M. (2021). The role of mass media communication in public health: The impact of Islamic Republic of Iran broadcasting health channel on health literacy and health behaviors. Med. J. Islam. Repub. Iran 35, 54. doi:10.47176/mjiri.35.54

Santarossa, S., & Woodruff, S.J., (2018). #LancerHealth: Using Twitter and Instagram as a tool in a campus wide health promotion initiative. J. Public Health Res. doi:10.4081/jphr.2018.1166

Schipmann, C., & Qaim, M. (2011). Modern Food Retailers and Traditional Markets in Developing Countries: Comparing Quality, Prices, and Competition Strategies in Thailand. Appl. Econ. Perspect. Policy 33, 345–362.

Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING), (2017). Bangladesh: Farmer Nutrition School Cohort Study. Sustainability of Improved Practices Following Graduation — Technical Brief. 12.

Suryadarma, D. (Ed.), (2007). Impact of supermarkets on traditional markets and retailers in Indonesia's urban centers: research report, SMERU research report. SMERU Research Institute, Jakarta.

Swinburn, B.A., Kraak, V.I., Allender, S., Atkins, V.J., Baker, P.I., Bogard, J.R., … Dietz, W.H., (2019). The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report. The Lancet 393, 791–846. https://doi.org/10.1016/S0140-6736(18)32822-8

Talukder, A., Haselow, N.J., Osei, A.K., Villate, E., Reario, D., Kroeun, H., … Quinn, V., (2010). Homestead food production model contributes to improved household food security and nutrition status of young children and women in poor populations. Field Actions Sci. Rep. J. Field Actions.

Thompson, B., Amoroso, L., C.A.B. International, Food and Agriculture Organization of the United Nations, (2014). Improving diets and nutrition: food-based approaches. CABI ; Food and Agriculture Organization of the United Nations, Wallingford, Oxfordshire : Rome, Italy.

USAID Wildlife Asia, (2020). Social and Behavior Change Communication (SBCC) Demand Reduction Guidebook.

Utami, N.H., Mubasyiroh, R., (2020). Keragaman Makanan dan Hubungannya dengan Status Gizi Balita: Analisis Survei Konsumsi Makanan Individu (SKMI). GIZI Indones. 43, 37. doi: 10.36457/gizindo.v43i1.467

Valdes, A.M., Walter, J., Segal, E., Spector, T.D., 2018. Role of the gut microbiota in nutrition and health. BMJ 361, k2179. doi: 10.1136/bmj.k2179

Verger, E.O., Ballard, T.J., Dop, M.C., Martin-& Prevel, Y., (2019). Systematic review of use and interpretation of dietary diversity indicators in nutrition-sensitive agriculture literature. Glob. Food Secur. 20, 156–169. doi: 10.1016/j.gfs.2019.02.004

WFP, (2020). Nutrition in Numbers: Beyond the Annual Perfomance Report 2019 Series. An overview of WFP nutrition programming in 2019.

Wakefield, M.A., Loken, B., & Hornik, R.C., (2010). Use of mass media campaigns to change health behaviour. Lancet 376, 1261–1271. doi: 10.1016/S0140-6736(10)60809-4

World Bank, (2018). The State of Social Safety Nets.

World Health Organization, (1998). Preparation and use of food-based dietary guidelines: report of a Joint FAO/WHO Consultation, WHO Technical Report Series. WHO, Geneva.

World Health Organization, (2011). Regional Consultation on Food-Based Dietary Guidelines for countries in the Asia Region: A Report.

Yin, Z., Fei, Z., Qiu, C., Brasher, M.S., Kraus, V.B., Zhao, W., .. Zeng, Y. (2017). Dietary Diversity and Cognitive Function among Elderly People: A Population-Based Study. J. Nutr. Health Aging 21, 1089–1094. doi: 10.1007/s12603-017-0912-5

Zerfu, T.A., Umeta, M., & Baye, K., (2016). Dietary diversity during pregnancy is associated with reduced risk of maternal anemia, preterm delivery, and low birth weight in a prospective cohort study in rural Ethiopia. Am. J. Clin. Nutr. 103, 1482–1488. doi: 10.3945/ajcn.115.116798

Zhang, J., Zhao, A., Wu, W., Yang, C., Ren, Z., Wang, M., … Zhang, Y., (2020). Dietary Diversity Is Associated With Memory Status in Chinese Adults: A Prospective Study. Front. Aging Neurosci. 0. https://doi.org/10.3389/fnagi.2020.580760

Zheng, J., Zhou, R., Li, F., Chen, L., Wu, K., Huang, J., … Wu, X. (2021). Association between dietary diversity and cognitive impairment among the oldest-old: Findings from a nationwide cohort study. Clin. Nutr. 40, 1452–1462. doi: 10.1016/j.clnu.2021.02.041

Zhu, C., Xu, X., Zhang, W., Chen, J., & Evans, R., (2020). How Health Communication via Tik Tok Makes a Difference: A Content Analysis of Tik Tok Accounts Run by Chinese Provincial Health Committees. Int. J. Environ. Res. Public. Health 17, 192. doi: 10.3390/ijerph17010192

van der Vorst, J., da Silva, C., Trienekens, J., Rural Infrastructure and Agro-Industries Division, (2007). Agro-industrial supply chain management: concepts and applications, Agricultural management, marketing and finance occasional paper. FAO, Rome, Italy.

Media Gizi Indonesia

(National Nutrition Journal)

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III. WRITING SYSTEM

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Introduction
Methods
Results and Discussion
Conclusion and Suggestion
References

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Title is written as clear, concise, informative, and understandable as possible. The maximum length of the title consists of 20 words. The author's name and identity (affiliation, city), are included

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Abstracts are written in English in Bahasa Indonesia and in Times New Roman 11 pt, single-spaced. Abstracts consist of no more than 250 words length, written in 1 (one) paragraph. Keywords are written below the abstract, consist of 3-5 specific words that are consistently used in the manuscript. Avoid using quotations and the use of abbreviations in writing abstracts.

Abstracts contain brief information regarding the background of the study, objectives of the study, brief summary of the methods (research design, subject selection, methods of data analysis), results, and discussion (use the most specific data in answering the objectives of the study, along with the signification results of statistical test, if any), conclusion as well as the significance/urgency of obtained conclusion..

c. Manuscript

The core section of a manuscript consists of subtitles: introduction, methods, results and discussions, and conclusion and suggestions.

Introduction

The introduction part comprises the background of the study, research intention, research questions, previous studies and the objectives of the study.

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The methods section consists of the steps completed by the author in doing the research, elaborated completely, yet concisely, begins from research design (including the sampling methods, if any), samples, materials, & tools used, working methods, techniques of data collection, and data analysis.

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Results of the study provide clear and concise results that are in line with the objectives of the study. The results can be complemented with tables and figures to help explaining the results.

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Discussions explains research results, concisely, and clearly. Using relevant arguments to the research topic and answering the research questions. Employ references (other research results or theories) to support the explanation of research. If there is abbreviation, use the standardized

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Conclusion

Conclusion elucidates important matters discussed in the result and analysis briefly, concisely, clearly, and answers research questions. Conclusion can be completed with suggestions (if necessary).

Acknowledgement (if necessary)

Acknowledgement given to person/institution who have important roles in conducting a research (for example, funders) and/or writing scientific manuscripts and includes explanations whether the research is part of a series of research in thesis/dissertation.

References

Writing references refers to the APA Referencing Guide 6th edition. [*Publication Manual of the American Psychological Association*. (6th ed.). (2010). Washington, D.C.: American Psychological Association]. References are arranged systematically and sorted alphabetically according to author's name. Generally, writing references is as follows:

Author, A.A., Author, B.B, & Author, C.C. (year of publication). *Title of publication: sub title*. (Edition [if not the first edition]). City of publication: Publisher.

A minimum of 80% of the literature used comes from 'up to date' sources (published no more than 10 years before scientific papers submitted to MGI). Unpublished sources, such as manuscripts or personal communication cannot be used as references for the writing.

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Smith, et al (2017) or (Smith et al*.,* 2017)

EXAMPLES OF REFERENCES WRITING

a. **References from books**

- Contento, I. R. (2011). Nutrition education (2nd ed.). Sadburry, Massachusetts: Jones and Bartlett Publishers.
- Mahan, L. K., & Raymond, J. L. (2017). *Krause's food & the nutrition care process*. Canada: Elsevier Health Sciences.

b. **Books or reports composed by organizations, associations, or government agencies**

Kementerian Kesehatan. (2013). *Hasil Riset Kesehatan Dasar 2013.* Jakarta: Badan Penelitian dan Pengembangan Kesehatan, Kementerian Kesehatan RI.

c. **Book chapters on a book that has editors**

Brown, J.E. (2011). Nutrition through the life cycle (4th Ed.). Janet Sugarman Isaacs, *Infant Nutrition* (pp. 223–225). Belmont, CA, USA: Wadsworth.

d. **Conference manuscript – online**
Bochner, S. (1996). Mentoring in higher education: Issues to be addressed in developing a mentoring program. Paper presented at the Australian Association for Research in Education Conference, Singapore. Retrieved from http://www.aare.edu.au/96pap/bochs96018.txt

e. **Manuscripts from a journal**
El-Gilany, A. H., & Elkhawaga, G. (2012). Socioeconomic determinants of eating pattern of adolescent students in Mansoura, Egypt. *The Pan African Medical Journal*, 13, 22. https://doi.org/10.4314/pamj.v13i1.

McDonald, C. M., McLean, J., Kroeun, H., Talukder, A., Lynd, L. D., & Green, T. J. (2015). Correlates of household food insecurity and low dietary diversity in rural Cambodia. *Asia Pacific Journal of Clinical Nutrition*, 24(4), 720–730. https://doi.org/10.6133/apjcn.2015.24.4.14

Diana, R., Sumarmi, S., Nindya, T. S., Rifqi, M. A., Widya, S., & Rhitmayanti, E. (2017). *Household Income and Unbalanced Diet Among Urban Adolescent Girls. Proceedings ofthe 4th Annual Meeting ofthe Indonesian Health Economics Association (INAHEA 2017)*.

f. **Thesis/Dissertation – printed version**
Hilgendorf, M. (2018). *Assessing malnutrition in liver disease patients being evaluated for transplant using the nutrition focused physical exam* (Unpublished master's thesis). University of Kentucky, Lexington, Kentucky.

Diana, R. (2014). *Pengaruh pemanfaatan pekarangan dan penyuluhan terhadap konsumsi sayur dan asupan gizi rumah tangga dan balita.* Institut Pertanian Bogor.

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Hilgendorf, M. (2018). *Assessing malnutrition in liver disease patients being evaluated for transplant using the nutrition focused physical exam* (Master's thesis, University of Kentucky, Lexington, Kentucky). Retrieved from https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1065&context=foodsci_etds

h. **Web page (if referenced are a few pages on the same web page, use the homepage page)**
SStatistic Bureau of East Java. (2018). Number and Percentage of Poor, P1, P2 and Poverty Line By Regency / Municipality, in 2017. Retrieved November 22, 2018, from https://jatim.bps.go.id/statictable/2018/01/15/733/jumlah-dan-persentase-penduduk-miskin-p1-p2-dan-garis-kemiskinan-menurut-kabupaten-kota-tahun-2017.html

Example of tables:

Table 1. Characteristics of Patients in Malnutrition and Non-Malnutrition Groups

Karakteristik	Malnutrition (n=70)		Non-Malnutrition (n=233)		Total (n=303)	X^2	*p value*
	n	%	n	%			
Sex							
Male	38	54,3	117	52,5	155	0,070	0,790
Female	32	45,7	106	47,5	138		
Age							
<55 years old	48	68,6	151	67,7	199	0,890	0,180
≥55 years old	22	31,4	72	32,3	94		
Education							
Low	24	34,3	51	22,9	75	10,153	0,063
Middle	33	47,1	151	67,7	184		
High	13	18,6	21	9,4	33		

Table 2. Average of Nutrition Intake in Malnutrition and Non-Malnutrition Groups

Nutrition Intake	Malnutrition (Mean ± SD)	Non-Malnutrition (Mean ± SD)	t	*p value*
Calories	1328,1± 215,3	1482,9± 327,4	2,04	0,032
Protein	43,2±13,1	48,7±17,3	2,47	0,010

Example of a figure:

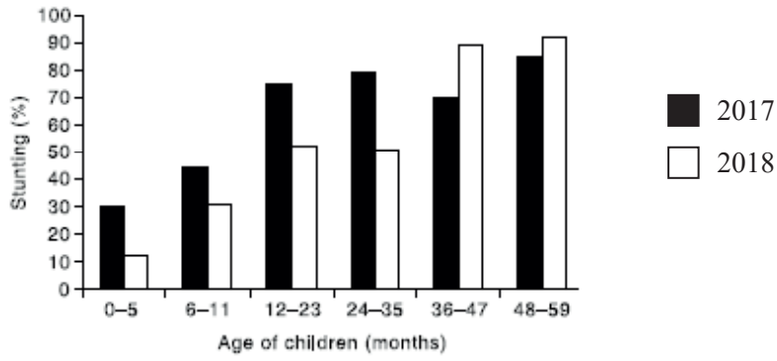

Figure 1. Changes in Stunting Prevalence (%) in Toddlers in Kalimantan

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(National Nutrition Journal)

p-ISSN 1693-7228
e-ISSN 2540-8410

Vol. 17 | No. 1 | Page 1 – 105 | January 2022

p-ISSN 1693 7228
e-ISSN 2540 8410

Media Gizi Indonesia
(National Nutrition Journal)

Volume 17 Number 1, January - April 2022

Cover Designer : Agnessia Nanda Arimbi, S.Pd

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Media Gizi Indonesia (MGI) has been published since 2004 is a scientific journal that provides articles regarding the results of research and the development of nutrition including community nutrition, clinical nutrition, institutional nutrition, food service management, food technology, current issues on food and nutrition. This journal is published once every 3 months: January, May, and September

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INTRODUCTION TO THE EDITOR

Media Gizi Indonesia (MGI) is a scientific journal published regularly every 3 months that provides articles regarding the research and the development of nutrition knowledge including community nutrition, clinical nutrition, institutional nutrition, food service management, food technology, and current issues on food and nutrition. Media Gizi Indonesia tries to always present a variety of scientific articles in the scope of Nutrition and Health.

This volume provides both original research and literature review in the field of nutrition. The literature review are related to body images in adolescents, the function of chlorogenic acid in coffee and obesity, and vitamin D status in thalassemia patient. Meanwhile, original research varies from child nutrition, adolescent health, and elderly nutrition. To date, child and adolescent nutrition has become more attention because a good nutritional status in that period will manifest a better quality of life during adults and elderly period. For that, this current edition of MGI presents several best researches related to child and adolescent nutrition in relation to stunting, preschool children development, and dietary intervention. Besides presenting studies related to child and adolescent nutrition, the current edition of MGI also shows research in food product development for elderly and nutrition related elderly quality of life. More interestingly, this edition also publishes studies related to nutrition education during the covid pandemic in the hope that it can be useful for the wider community.

We do hope MGI scientific journals can leverage the development of a writing culture and communicative scientific studies as well as attract readers and writers to participate in MGI for future issues. Media Gizi Indonesia will maintain its role in providing current, relevant, and topical issues in food and nutrition. Hopefully, the works displayed by MGI can provide benefits and enrich the readers' knowledge.

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Volume 17 Number 1 January–April 2022

p-ISSN 1693 7228
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Media Gizi Indonesia
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Table of Contents