IJHN; Vol.10 No.1, Juli 2023

E-ISSN 2355-3987
P-ISSN 2442-6636

Indonesian Journal of Human Nutrition

Diterbitkan oleh:

Universitas Brawijaya

Bekerjasama dengan

Persatuan Ahli Gizi Indonesia
(PERSAGI)

OPEN ACCESS

Indonesian Journal of Human Nutrition
P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

Carbohydrate and Fiber Intake on Fasting Blood Glucose Levels in Patients with Type 2 Diabetes Mellitus Following Brown-Rice Diet Intervention

Chyntia Cahyawardani [1*)], Etik Sulistyowati [2], EndangWidajati [2]

[1*)] Undergraduate Program in Applied Nutrition and Dietetics, Department of Nutrition, Malang Health Polytechnic

[2]Applied Nutrition and Dietetics Study Program, Department of Nutrition, Malang Health Polytechnic

*Correspondence Address: cinchyntia99@gmail.com

Accepted: August 2022 Reviewed: May 2023 Published: July 2023

ABSTRACT

Type 2 diabetes mellitus (T2DM) is a metabolic disorder characterized by hyperglycemia due to decreased insulin secretion by pancreatic beta cells and insulin resistance. Medical nutrition therapy is one of the pillars in the management of T2DM, in the form of a balanced diet. A good intake of carbohydrates and fiber can help regulate fasting blood glucose levels in diabetic patients. This study aims to determine the relationship between carbohydrate and fiber intake on fasting blood glucose levels in patients with T2DM following a brown-rice diet intervention. This study was pre-experimental without control variables and employed a non-random sample selection method. The research design was a one-shot case study, focusing on post-test results. The study included a sample size of 18 people aged 48–60 years. Data analysis involved the Shapiro-Wilk normality test and Spearman correlation test. The results showed that the majority of the respondents had normal carbohydrate intake (88.9%) and good fiber intake (100%). However, most respondents had uncontrolled fasting blood glucose levels (55.6%). There is no relationship between carbohydrate and fiber intake on fasting blood glucose levels following the intervention of a brown rice-based diet menu.

Keywords: T2DM, brown rice, carbohydrate intake, fiber intake, fasting blood glucose levels

INTRODUCTION

Diabetes mellitus is a chronic and progressive disease characterized by the body's inability to metabolize carbohydrates, fats, and proteins, leading to hyperglycemia or high blood glucose levels (1). According to The Indonesian Basic Health Research in 2013 and 2018, the national prevalence of diabetes mellitus among individuals aged 15 and older has been increasing from 6.9% to 10.95%. The highest prevalence rates of diabetes mellitus were observed in the age range of 55-64 years, as much as 6.3%, followed by the age range of 65-74 years, as much as 6%. In addition, the occurrence

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

of diabetes mellitus is more prevalent in women (1.8%) than in men (2).

Management of diabetes mellitus begins with adopting a healthy lifestyle, which includes medical nutrition therapy and physical activity, and pharmacological interventions involving oral and/or anti-hyperglycemic drug injections (3). The principle of dietary management in people with diabetes mellitus is known as the "3J Right Principles," emphasizing the right amount (*jumlah*) of energy and nutrients, selecting the right type (*jenis*) of food and/or food, and adhering to the right meal schedule (*jadwal*). People with diabetes mellitus can still eat the same menu as their family members, as the amount of energy and nutrients is more significant than the type of food (4).

Brown rice is an alternative food, which has effective preventive and therapeutic effects for diabetes mellitus. Brown rice is untreated whole grain obtained by removing the outermost layers of seed called husk (5). Brown rice retains its germ and bran layers, which are rich in fiber. Thus, carbohydrates in brown rice are digested more slowly in the digestive tract, leading to a gradual increase in blood glucose levels. According to research results, consuming 50 grams of brown rice per day can potentially reduce the incidence of diabetes by 13% (6).

Rice serves as a source of carbohydrates, contributing to energy besides fat and protein. The amount of carbohydrates consumed from main meals and snacks can affect blood glucose levels and insulin secretion. Consequently, the amount of carbohydrates consumed holds greater importance than the carbohydrate (7). The results of a study conducted by Ngaisyah (2015) showed a relationship between a high-carbohydrate diet and an increased risk of type 2 diabetes mellitus (T2DM). However, regularly consuming high-fiber foods such as brown rice can help reduce the risk of T2DM (8).

The fiber and mineral content in brown rice (22.04 g) are higher compared to those in white rice (20.58 g) (9). Dietary fiber offers many benefits for the management of T2DM. Due to its slow processing in the body, fiber will cause a feeling of fullness. Water-insoluble dietary fiber enhances the rate of absorption of nutrients in the gastrointestinal tract so that it can reduce carbohydrate absorption and increase insulin sensitivity (10). According to research conducted by Amanda and Bening (2019), there is a relationship between fiber consumption and fasting blood glucose levels in people with T2DM. The higher-fiber intake is associated with lower fasting blood glucose level (11).

Consumption of high-fiber foods is related to lower insulin response, thereby reducing the incidence of insulin resistance. Fasting blood glucose level is one way to establish the diagnosis of T2DM. It can provide an overall picture of glucose homeostasis and can effectively predict HbA1C levels (7). According to research conducted by Lee et al (2018), fasting blood glucose levels are particularly sensitive for predicting the risk of developing T2DM, especially in individuals older than 40 years old (12).

The purpose of this study was to analyze the relationship between carbohydrate and fiber intake on fasting blood glucose levels in T2DM patients following a brown rice-based diet intervention.

RESEARCH METHODS

Research Design

The type of research used in this study was pre-experimental research without control variables, and the samples were not randomly selected (13). This study used a one-shot case study design, where the researcher only conducted a one-time treatment believed to have an effect and then conducted a post-test (14).

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

Data Source

All data collected were primary data. The data were in the form of respondent characteristics (gender, age, type of work, BMI, disease), carbohydrate intake, fiber intake, and fasting blood glucose levels.

Brown Rice Diet

This study used a diet menu intervention based on brown rice with a frequency of three main meals and three side dishes. The type of DM diet given was adjusted to the respondent's daily energy needs, DM 1300, 1400, 1500, or 1600. The dietary intervention was given from Monday to Saturday for 12 weeks. The amount of brown rice consumed per day ranged from 200 to 270 grams, which contributes 86.2 to 116.4 grams of carbohydrates.

Research Target

The sampling method used in this study was purposive sampling, resulting in a total of 18 respondents who were outpatients with diabetes mellitus at Griya Bromo Malang Clinic. The inclusion criteria were female, aged between 48 and 60 years, nutritional status within the BMI range of 21.5-28.5 kg/m^2, Hb-A1c <8% with 1 or a combination of Anti-Diabetes Drugs (ADD), and were willing to be research respondents proven by signing the inform consent. The exclusion criteria were active smokers, having a history of gastrointestinal disorders requiring long-term medical therapy, having heart, kidney, and malignancy disorders.

Development of Data Collection Instruments and Techniques

Data on the characteristics of the respondents were taken using a questionnaire. Data on the nutritional status of patients were obtained from measuring height using a microtoa with an accuracy of 0.1 cm and body weight using Bioelectrical Impedance Analysis. The obtained data were then used to calculate the Body Mass Index (BMI). Then, BMI values were categorized into normal weight (18.5–22.9), overweight (23.0–24.9), or obesity I (25.0 – 29.9).

Food intake data during the intervention was collected using the method of food record three times a week for 12 weeks. The recording was done on two working days (Monday and Wednesday) and one day off (Saturday). Data on carbohydrate and fiber intake were obtained from brown rice-based food ingredients/diet menu consumed per day. Carbohydrate intake data were categorized into five levels: severe deficit (<70%), moderate deficit (70–79%), mild deficit (80–89%), normal (90–119%), and excess (>120%). Fiber intake is considered good when it is higher than 25 g per 1000 kcal and inadequate when below 25 g per 1000 kcal (4).

Data on fasting blood glucose (FBG) levels for each respondent were obtained from laboratory measurements one day after the dietary intervention was completed. FBG levels in respondents with T2DM can be categorized as controlled if below 126 mg/dL, and not controlled if higher or equal to 126 mg/dL (15).

Data Analysis Technique

The data obtained will be tested for the normality of the data using the Shapiro-Wilk test. The test was chosen because the sample size was less than 50. The results showed that the data on carbohydrate intake and fiber intake were not normally distributed at a significance level of $\alpha < 0.05$, while the fasting blood glucose data were normally distributed. Furthermore, a Spearman's correlation test was carried out with a confidence level of 95% ($\alpha = 0.05$) to determine the relationship between carbohydrate and fiber intake with fasting blood glucose levels.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

This research has received ethical approval issued by the Health Research Ethics Committee, Faculty of Medicine, Universitas Brawijaya, with license number 143/EC/KEPK/07/2016.

RESEARCH RESULT

Overview of Respondents

All respondents in this study were female within the age range of 40-60 years. Table 1 shows that most of the respondents (50%) belong to the early elderly group or the age range of 46-55 years. Most of the respondents are housewives (61.1%). Most of the respondents were in the Obesity I category. The majority of respondents had a history of other diseases besides T2DM. Most of the respondents had a history of hypertension, hypercholesterolemia, and even both diseases.

Tabel 1. Distribution of Respondents' General Description

Variable	Frequency	
	n	%
Age (Years)		
36 – 45	1	5.6
46 – 55	9	50.0
56 – 65	8	44.4
Profession		
Housewife	11	61.1
Tailor	2	11.1
Notary officer	1	5.6
Teacher	1	5.6
Headmaster	1	5.6
Posyandu cadres	1	5.6
Church officer	1	5.6
BMI Category		
Normal weight	4	22.2
Overweight	3	16.7
Obesity I	11	61.1
Disease History		
Hypercholesterolemia	4	22.2
Hypertension	4	22.2
Hypercholesterolemia & Hypertension	1	5.6
Hypercholesterolemia & gout	1	5.6
Asthma & gastritis	1	5.6
Spinal HNP	1	5.6
Nothing	6	33.3

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

Description of Respondents' Carbohydrate Intake

Tabel 2. Distribution of Respondents' Carbohydrate Adequacy Levels

Category	Frequency	
	n	%
Normal (90 – 119%)	16	88.9
Excess (> 120%)	2	11.1
Total	18	100

The average respondent's carbohydrate intake in this study ranged from 165 g to 320 g. Table 2 shows that most of the respondents had normal carbohydrate intake levels, 90-119%. As many as two people had carbohydrate intake that exceeded the recommended range (45-60%).

Description of Respondents' Fiber Intake

The recommended daily fiber intake for people with T2DM is 25 g/1000 kcal (4). The respondents' need for fiber in a day is equal to 31.5 g to 39.4 g. The fiber intake of all respondents (100%) was considered good as it exceeded the recommended needs.

Description of Respondents' Fasting Blood Glucose Levels

Tabel 3. Distribution of Respondents' Food Blood Glucose Levels

Category	Frequency	
	n	%
Controlled	8	44.4%
Uncontrolled	10	55.5%
Total	18	100

Table 3 shows that most of the respondents (55.5%) had uncontrolled FBG levels, ≥126 mg/dL. The statistical test results using the Spearman correlation test obtained a p-value of 0.501, which is greater than α=0.05 (0.501>0.05). It indicated no relationship between carbohydrate intake and FBG levels in people with T2DM. Statistical test results on fiber intake and FBG levels value obtained a p-value of 0.368, which is greater than α=0.05 (0.276>0.05), suggesting that there is no relationship between fiber intake and FBG levels in patients with T2DM. The results of the relationship test are presented in Tables 4 and 5.

Tabel 4. Correlation Carbohydrate intake and FBG Levels

Carbohydrate	FBG Levels				Total		p-value*
	Controlled		Uncontrolled				
	n	%	n	%	n	%	
Normal	8	50	8	50	16	100	
Excess	0	0	2	100	2	100	
Total	8	44.4	10	55.6	18	100	

*Statistic test

Tabel 5. Correlation Fiber Intake and FBG Levels

Fiber	FBG Levels				Total		p-value*
	Controlled		Uncontrolled				
	n	%	n	%	n	%	
Bad	0	0	0	0	0	0	
Good	8	44.4	10	55.6	18	100	
Total	8	44.4	10	55.6	18	100	

*Statistic test

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

DISCUSSION

Overview of Respondents

All respondents in this study were female. Since there is a monthly cycle syndrome (premenstrual syndrome) and post-menopause in women, this factor may contribute to the accumulation of fat in the body. Additionally, women who have experienced menopause tend to have decreased sensitivity to the hormone insulin (16).

Most of the respondents were in the early elderly group or the age range of 46-55 years. According to research conducted by Lathifah (2017), the majority of T2DM sufferers are over 58 years old (52%). An individual aged 45 years and above has a higher risk of suffering from diabetes mellitus and glucose intolerance due to generative factors, such as decreased body function for glucose metabolism (17).

In this study, most of the respondents were housewives. According to Isnaini & Ratnasari (2018), working as a housewife involves engaging in light physical activities, such as washing, cooking, cleaning the house, and several other similar activities. Regular physical activity has been shown to increase insulin production so that blood glucose levels will decrease (18).

Obesity in adults has a four-fold increased risk of developing T2DM compared to people with normal nutritional status (19). Obesity can contribute to metabolic disorders and insulin resistance, as insulin cannot work optimally in muscle, fat, and liver cells (20). In this study, most of the respondents were in the category of Obesity 1. It is in line with research conducted by Dafriani (2017) that respondents who have diabetes mellitus are more likely to be obese (21)

Some respondents had a history of diseases other than T2DM, such as hypertension and hypercholesterolemia. Individuals who suffer from T2DM are at risk of experiencing chronic complications. As many as 60% of diabetic patients also have hypertension and 28% of diabetic patients also have dyslipidemia. Diabetic patients often have high LDL cholesterol and triglyceride levels and low HDL cholesterol levels, which can result in insulin resistance (22)

Analysis of Carbohydrate Intake and Respondents' Fasting Blood Glucose Levels

T2DM sufferers need to be aware of the amount of carbohydrates consumed as most of the carbohydrates are converted into glucose in the body, mainly in the form of polysaccharides (4). The hormone insulin plays a crucial role in maintaining the balance of glucose levels in the blood (23). Statistical test results showed no relationship between carbohydrate intake and FBG levels in T2DM patients. These results are in line with a study conducted by Kurniasari (2014) that there was no relationship between carbohydrate intake and blood glucose levels in hospitalized T2DM patients, as the patients were given food containing carbohydrates according to their needs so that there is no excess carbohydrate intake (24). The result of Wati & Rodlah's research (2019) stated that carbohydrate intake is not related to blood glucose levels since carbohydrate intake is not an influencing factor in controlling the patient's blood glucose levels (25).

Another factor related to blood glucose levels is age, where most of the respondents in this study were over 40 years old. Physiological changes usually

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

occur at the age of more than 40 years, one of which is the decreased ability of beta cells to produce insulin for glucose metabolism (17).

Table 4 shows eight people who had normal carbohydrate intake but had uncontrolled FBG levels. It could be caused by respondents' BMI classification as overweight and obese. Research by Sa'pang et al. (2018) stated that a higher BMI is associated with higher fasting blood glucose levels in patients with T2DM. A person with a BMI above the normal range has an increase in insulin resistance, which results in increased blood glucose levels (26).

The results of this study indicate that two people who consumed excessive carbohydrates had uncontrolled FBG levels. Excessive carbohydrate intake can trigger insulin resistance since the carbohydrates consumed will be broken down into a simple form, glucose, absorbed in the intestines, and enter the blood circulation. This excess carbohydrate intake will increase blood glucose levels (27). Moreover, the results of research conducted by Wulandari and Kurnianingsih (2018) stated a relationship between a high-carbohydrate diet and blood glucose levels, as intake of foods rich in carbohydrates can interfere with the stimulation of pancreatic beta cells in producing insulin (23).

T2DM sufferers who consume carbohydrates more than their daily needs can experience elevated blood glucose levels. Insulin hormone levels in people with DM are not enough to convert glucose into glucagon. According to research conducted by Sandra and Isnawati (2015), carbohydrate intake has a significant relationship with blood glucose levels. Every gram of excess carbohydrates can increase blood glucose levels by 2,750 mg/dl (28). Furthermore, the study results conducted by Juwita et al. (2020) showed a significant relationship between carbohydrate intake and blood glucose levels (29).

Analysis of Respondents' Fiber Intake and Fasting Blood Glucose Levels

Soluble dietary fiber can be fermented by bacteria in the large intestine, while only a small portion of insoluble fiber can be fermented. The content of soluble and insoluble dietary fiber in each food varies, thereby it is necessary to include a variety of foods that contain fiber in the diet plan (30). However, the statistical test results in Table 5 show that there is no relationship between fiber intake and FBG levels in people with T2DM. A study conducted by Jenkins et al. (2002) involving 23 respondents who followed a high-fiber diet for 12 weeks found no significant relationship between a high-fiber diet and a decrease in fasting blood glucose levels. This dietary intervention used high-fiber cereals and broken wheat bread, resulting in an average daily fiber intake of 37.3 g a day per respondent. Studies using longer duration are needed to observe changes from high-fiber diets (31).

Furthermore, the results of a study conducted by Karimi et al. (2015) found no significant decrease in fasting blood glucose after being given a high-fiber diet for eight weeks (32). The results of McRae's study (2018) stated that reducing fasting blood glucose levels could not reduce the incidence of T2DM in patients with adequate dietary fiber intake. Adequate fiber intake (25 grams per 1000 kcal) can reduce the occurrence of chronic microvascular and macrovascular complications in people with T2DM. However, long-term studies involving large populations are needed to analyze the relationship between fiber intake and blood glucose (33). According to Turner and Lupton (2011), there is no maximum limit to total fiber intake that the body can tolerate (34).

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

According to research conducted by Audina et al. (2018), lower fiber intake is associated with higher fasting blood glucose levels in T2DM sufferers (35). Fiber, especially soluble fiber, can help lower glucose levels by increasing food viscosity and slowing down the process of emptying and digestion in the stomach. This process results in decreased absorption of nutrients, including glucose, and creates a longer feeling of satiety so that food intake decreases. A decrease in glucose absorption and food intake lowers blood glucose levels. Undigested fiber will enter the large intestine and undergoes fermentation by bacteria. This process can increase insulin sensitivity and eventually lead to reduced blood glucose levels (36).

Research conducted by Audina et al. (2018) found a significant relationship between fiber intake and FBG levels of T2DM sufferers. Patients who consume fiber intake of more than 25 grams per day tend to experience reduced fasting blood glucose levels. Fiber intake can control fasting blood glucose levels and prevent complications (35). Furthermore, the results of a study conducted by Soviana and Maenasari (2019) showed a relationship between fiber intake and fasting blood glucose levels in T2DM patients at the Jasmine 2 Clinic in Surakarta. The average respondent's fiber intake is 14.33 grams per day, which is classified in the low category (37).

CONCLUSION

In conclusion, this study indicates that the majority (88.9%) of respondents had normal carbohydrate intake. All respondents (100%) had good fiber intake. There were ten people (55.6%) who had uncontrolled FBG levels (≥126 mg/dl) and eight people (44.4%) who had controlled FBG levels (<126 mg/dL). There is no relationship between carbohydrate and fiber intake on fasting blood glucose levels in T2DM patients following the intervention of a brown rice-based diet menu.

ACKNOWLEDGMENTS

The authors would like to thank Prof. Dian Handayani, SKM, M.Kes, PhD who has provided the opportunity to join the research team. The authors also thank Dr. Etik Sulistyowati, SST., S.Gz., M.Kes and Endang Widajati, SST., M.Kes., RD who have guided the completion of this research.

REFERENCES

1. Zamaa MS, Sainudin. Hubungan Kepatuhan Pengobatan Dengan Kadar Gula Darah Sewaktu Pada Pasien Diabetes Melitus Tipe II [Internet]. Vol. 1, Jambura Nurisng Journal. 2019. Available from: http://ejurnal.ung.ac.id/index.php/jnj%7C11
2. Kementerian Kesehatan Republik Indonesia. Hasil Utama Riskesdas. 2018 [cited 2020 Dec 3]; Available from: http://labdata.litbang.kemkes.go.id/images/download/laporan/RKD/2018/Laporan_Nasional_RKD2018_FINAL.pdf
3. PB Perkeni. Pedoman Pengelolaan dan Pencegahan Diabetes Melitus Tipe 2 Dewasa di Indonesia. 2015.
4. Supariasa ID., Handayani D. Asuhan Gizi Klinik. Jakarta: EGC; 2019.
5. Sirisoontaralak P, Nakornpanom NN, Koakietdumrongkul K, Panumaswiwath C. Development of Quick Cooking Germinated Brown Rice with Convenient Preparation and Containing Health Benefits. LWT - Food Sci Technol. 2015 Apr 1;61(1):138–44.
6. Rungkat F. Z. Beras Coklat Segar (Fresh Brown Rice) Anugrah Alam Untuk Kesehatan Anda. 2015; Available from: https://bpkn.go.id/uploads/document/ba5f2fc3907008189aaa2e07ea0

72c8c75ef26a6.pdf
7. Immawati FR, Wirawanni Y. Hubungan Konsumsi Karbohidrat, Konsumsi Total Energi, Konsumsi Serat, Beban Glikemik Dan Latihan Jasmani Dengan Kadar Glukosa Darah Pada Pasien Diabetes Mellitus Tipe 2. J Nutr Heal. 2014;2(3):1–27.
8. Ngaisyah RD. Hubungan Pola Makan dengan Tingkat Gula Darah Anggota DPRD Propinsi Kalimantan Timur. J Med Respati. 2015;10(2):35–47.
9. Sulistyowati E, Rudijanto A, Soeharto S, Handayani D. The Identification of Characteristic Macro- and Micronutrients and the Bioactive Components of Indonesian Local Brown Rice as a Functional Feed in Obesity Nutrition Therapy. Curr Nutr Food Sci. 2019 Apr 1;16(4):494–500.
10. Jung C-H, Choi KM. Impact of High-Carbohydrate Diet on Metabolic Parameters in Patients with Type 2 Diabetes. Nutrients [Internet]. 2017 Mar 24;9(4):322. Available from: http://www.mdpi.com/2072-6643/9/4/322
11. Amanda E, Bening S. Hubungan Asupan Zink, Magnesium, dan Serat dengan Kadar Gula Darah Puasa Pasien Diabetes Mellitus Tipe 2 di RS PKU Muhammadiyah Temanggung. J Gizi [Internet]. 2019 Nov 11;8(2):87–94. Available from: https://jurnal.unimus.ac.id/index.php/jgizi/article/view/4933
12. Lee J-W, Lim N-K, Park H-Y. The Product of Fasting Plasma Glucose and Triglycerides Improves Risk Prediction of Type 2 Diabetes in Middle-Aged Koreans. BMC Endocr Disord [Internet]. 2018 Dec 30;18(1):33. Available from: https://bmcendocrdisord.biomedcentral.com/articles/10.1186/s12902-018-0259-x
13. Sugiyono. Metode Penelitian Kombinasi (Mix Method). Bandung: Alfabeta; 2015.
14. Arikunto S. Prosedur Penelitian. Jakarta: Rineka Cipta; 2013.
15. PB Perkeni. Pedoman Pemantauan Glukosa Darah Mandiri. 2019. 28 halaman.
16. Sari N, Purnama A. Aktivitas Fisik dan Hubungannya dengan Kejadian Diabetes Melitus. Kesehatan. 2019;2(4):368–81.
17. Lathifah NL. Hubungan Durasi Penyakit dan Kadar Gula Darah Dengan Keluhan Subyektif Penderita Diabetes Melitus. J Berk Epidemiol [Internet]. 2017;5(2):231–9. Available from: https://e-journal.unair.ac.id/JBE/article/view/4781
18. Isnaini N, Ratnasari R. Faktor Risiko Mempengaruhi Kejadian Diabetes Mellitus Tipe Dua. J Kebidanan dan Keperawatan Aisyiyah. 2018;14(1):59–68.
19. Evi K, Bella Y. Faktor-Faktor yang Berhubungan dengan Kejadian Diabetes Mellitus Tipe 2. J Major. 2016;5(2):27–31.
20. Decroli E. Diabetes Melitus Tipe 2. Padang: Pusat Penerbitan Bagian Ilmu Penyakit Dalam; 2019.
21. Dafriani P. Hubungan Obesitas Dan Umur Dengan Kejadian DiabetesMellitus Tipe Ii. J Med Saintika [Internet]. 2017;8(2):17–24. Available from: http://syedzasaintika.ac.id/jurnal
22. Yuliani F, Oenzil F, Iryani D. Hubungan Berbagai Faktor Risiko Terhadap Kejadian Penyakit Jantung Koroner Pada Penderita Diabetes Melitus Tipe 2. J Kesehat Andalas [Internet]. 2014 Jan 1;3(1):37–40. Available from: http://jurnal.fk.unand.ac.id/index.p

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

hp/jka/article/view/22
23. Wulandari D, Kurnianingsih W. Pengaruh Usia, Stres, dan Diet Tinggi Karbohidrat Terhadap Kadar Glukosa Darah. INFOKES. 2018;8(1):16–25.
24. Kurniasari R. Hubungan Asupan Karbohidrat, Lemak, dan Serat dengan Kadar Glukosa Dan Trigliserida Darah pada Pasien DM Tipe II Rawat Inap di RSUP H. Adam Malik Medan. Wahana Inov [Internet]. 2014;3(1):1–5. Available from: http://penelitian.uisu.ac.id/wp-content/uploads/2017/05/Rita-Kurniasari-wahana-inovasi.pdf
25. Wati H, Rodliah. Asupan Makanan dan Kadar Gula Darah Pada Pasien Diabetes Mellitus Tipe II Di RS Jatinegara. Binawan Student J. 2019;1(1):15–21.
26. Sa'pang M, Puili D, Sitoayu L. Hubungan Indeks Massa Tubuh (IMT) dan Rasio Lingkar Pinggang Pinggul (RLPP) dengan Kadar Glukosa Darah Puasa Pada Penderita Diabetes Melitus Tipe II di Puskesmas Kebayoran Lama, Jakarta Selatan. Nutr Diaita. 2018;10(1):45–50.
27. Werdani AR, Triyanti T. Asupan Karbohidrat sebagai Faktor Dominan yang Berhubungan dengan Kadar Gula Darah Puasa. J Kesehat Masy Nas [Internet]. 2014 Aug 1;9(1):71–7. Available from: http://journal.fkm.ui.ac.id/kesmas/article/view/459
28. Sandra RA, Isnawati M. Asupan Energi, Asupan Karbohidrat dan Kadar Glukosa Darah Pasien Rawat Inap Diabetes Melitus Tipe 2 di RSUD Kota Salatiga. J Ris Gizi. 2015;3(1):26–31.
29. Juwita E, Susilowati S, Mauliku NE, Nugrahaeni DK. Faktor yang Berhubungan dengan Kadar Gula Darah Pada Penderita Diabetes Melitus Tipe 2 di Prolanis Puskesmas Kecamatan Cimahi Tengah. J Nutr Coll [Internet]. 2020 Jun 4;9(2):87–93. Available from: https://ejournal3.undip.ac.id/index.php/jnc/article/view/26119
30. Samaan RA. Dietary Fiber for the Prevention of Cardiovascular Disease. United States. United States: Academic Press; 2017.
31. Jenkins DJA, Kendall CWC, Augustin LSA, Martini MC, Axelsen M, Faulkner D, et al. Effect of Wheat Bran on Glycemic Control and Risk Factors for Cardiovascular Disease in Type 2 Diabetes. Diabetes Care [Internet]. 2002 Sep 1;25(9):1522–8. Available from: https://diabetesjournals.org/care/article/25/9/1522/21686/Effect-of-Wheat-Bran-on-Glycemic-Control-and-Risk
32. Karimi P, Farhangi MA, Sarmadi B, Gargari BP, Zare Javid A, Pouraghaei M, et al. The Therapeutic Potential of Resistant Starch in Modulation of Insulin Resistance, Endotoxemia, Oxidative Stress and Antioxidant Biomarkers in Women with Type 2 Diabetes: A Randomized Controlled Clinical Trial. Ann Nutr Metab [Internet]. 2016;68(2):85–93. Available from: https://www.karger.com/Article/FullText/441683
33. McRae MP. Dietary Fiber Intake and T2DM: An Umbrella Review of Meta-analyses. J Chiropr Med [Internet]. 2018 Mar;17(1):44–53. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1556370717300585
34. Turner ND, Lupton JR. Dietary Fiber. Adv Nutr [Internet]. 2011 Mar 1;2(2):151–2. Available from: https://academic.oup.com/advances/article/2/2/151/4644538

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

35. Audina M, Maigoda TC, W TW. Status Gizi, Aktivitas Fisik dan Asupan Serat Berhubungan dengan Kadar Gula Darah Puasa Penderita DM Tipe 2. J Ilmu dan Teknol Kesehat [Internet]. 2018 Oct 22;6(1):59–71. Available from: http://ejurnal.poltekkesjakarta3.ac.id/index.php/jitek/article/view/109
36. Sunarti. Serat Pangan dalam Penanganan Sindrom Metabolik. Yogyakarta: Gadjah Mada University Press; 2018.
37. Soviana E, Maenasari D. Asupan Serat, Beban Glikemik Dan Kadar Glukosa Darah Pada Pasien Diabetes Melitus Tipe 2. J Kesehat. 2019;12(1):19–29.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1

OPEN ACCESS

Indonesian Journal of Human Nutrition
P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

Association between Stunting in Children Under Five and Types of Food Sources

Nur Mufida Wulan Sari[1], Wilis Cahyaning Ayu[1], Trias Mahmudiono[1], Mahmudah[2], RR Soenarnatalina Melaniani[2]

[1]Nutrition Department, Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia
[2] Department of Biostatistics, Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia

Corresponding author: Nur Mufida Wulan Sari. E-mail: *nur.mufida.wulan-2021@fkm.unair.ac.id

Accepted: October 2022 Reviewed: October 2022 Published: July 2022

ABSTRACT

The prevalence of stunting in children under five years old has decreased from 25% in 2013 to 18% in 2019 in The Gambia. The consumption of certain food groups, as part of minimum dietary diversity, serves as a measure of the adequacy of nutrient density for children. This study aims to examine the association between stunted children under five years old and types of food sources, as well as wealth status. Secondary data from The Gambia Demographic and Health Survey 2019-2020 were analyzed, involving 2,533 out of 8,362 children. Logistic regression tests were performed with a 95% confidence interval. Staple foods were identified as the dominant food source for stunted toddlers ($p< 0.05$; OR = 1.78; 95% CI = 1.436-2.216) and considered a risk factor for stunting. Food intake from more than four food sources (OR = 0.6; 95% CI = 0.403-0.88), place of residence (OR = 0.72; 95% CI = 0.53-0.95), middle wealth status (OR = 0.47; 95% CI = 0.33-0.68), and wealthy household (OR = 0.74; 95% CI = 0.52-1.05) were significantly associated with a reduced likelihood of stunting and considered protective factors. The incidence of stunting is linked to the diversity of food sources given to toddlers. In providing care for stunted toddlers at the community level, stakeholders must consider food diversity, economic capacity, and type of residence.

Keywords: food source, stunting, wealth status, demographic and health survey

INTRODUCTION

Stunting is a condition where a child's height does not accord with the expected range of their age, typically measured with a standard deviation of less than -2 SD than the normal threshold based on the standards set by WHO. Stunting is the body's mechanism to make adjustments to prolonged periods of starvation (1). Long-term starvation can lead to chronic malnutrition regardless of age. Chronic malnutrition during the golden age has long-term consequences, such as low academic and immune abilities, as well as short-term consequences that affect brain growth and development (2). Therefore, optimal growth and development in children are

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.2

related to the quality of human resources, which is often associated with the Human Development Index. Following the year 2010, Gambia experienced a declined Gross National Index (GNI) with the sharpest declines in 2011 and 2014. However, starting in 2017 to 2019, the Gambia's GNI began to rise (3). This upward trend was consistent with a decrease in the prevalence of childhood stunting, from 25% in 2013 to 18% in 2019 (4,5). In 2019, around 14% of children aged 6 - 24 months were reported to receive food that met the minimum recommended diet (5). The Minimum Dietary Diversity is a measure that reflects the adequacy of micronutrient density, and it is achieved by consuming at least five food groups. Among these food groups, children are required to consume at least one type of animal-protein food, one type of fruit or vegetable, and staple foods such as whole grains, roots, and tubers (6). In the Demographic Health Survey Standard Recode Manual for DHS 2018 data, the eight food groups are breast milk; grains, roots, and tubers; legumes and beans; dairy products (milk, yogurt, and cheese); flesh foods (meat, fish, poultry, liver/organs); eggs; fruit and vegetables with Vitamin A content; and other fruit and vegetables (7). We investigated the association between the types of food sources with stunted children aged 6-59 months using The Gambia DHS 2019-2020 data. The findings of this study will provide insights for designing effective health policies and programs to reduce the burden of malnutrition.

METHODS

Research design

The study used secondary data from The Gambia Demographic and Health Survey 2019-2020. The survey obtained data through a questionnaire with a cross-sectional design approach.

Setting and samples

The sample inclusion criteria were children under five years old and above six months, with available height-for-age-z-score (HAZ) data and complete food intake records. A total of 2,533 children out of 8,362 toddlers were included in this study. Children aged less than six months and above five years and those with incomplete food intake records and HAZ data were excluded. The independent variables of the research were place of residence (urban, rural), wealth quintile (poorer, middle, and rich), and food groups. The wealth index in this variable was calculated from the household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities (7). The dependent variable was categorized as either stunting or not stunting.

Measurement and data collection

The measuring instrument in this study was a questionnaire to assess the consumption of food groups, such as staple food (grains, roots, and tubers), legumes (beans, legumes, and products), dairy products (milk, yogurt, cheese, and other dairy products), eggs, flesh foods (meat, fish, poultry, liver/organ, and meat products), fruit and vegetables[14]. Children were categorized as receiving a minimum dietary diversity if they consumed four or more types of food groups. The independent variables included were wealth status, which was categorized into three levels i.e., poor (from poor and the poorest), middle, and rich (from rich and the richest), and place of residence defined as dichotomous data, that were rural or urban.

Data analysis

The multivariate analysis employed to test the hypothesis was multiple logistics regression (binary) with a significance level of 95% ($\alpha = 0.05$) on one dependent variable (dichotomous) and

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.2

more than one independent variable (nominal data scale). In addition, the data were interpreted in the form of an odds ratio to determine the association size between variables.

Ethical considerations

Ethical permission was obtained from Universitas Airlangga, Indonesia. All respondents' identities were hidden and permission for using the dataset was obtained from ICF International.

RESULTS

The number of respondents who met the inclusion criteria was 2,533 children under the age of five. Most of the toddlers resided in rural areas (57%) with a higher prevalence of stunting (18.6%). Most children received staple food (54%), followed by flesh foods (31%). A small portion of children received dairy (2%), eggs (7%), vegetables (8%), legumes (12%), and fruits (16%). Few children received four or more food groups as their meals (9%). While 2,308 (91%) children did not get a diverse diet and consumed less than four kinds of food the day prior to the survey was conducted. In terms of wealth status, a significant portion of respondents came from poor households (58%) and stunted children (20%) (see Table 1).

Table 1. Characteristics of Respondents

No.	Characteristics	Stunting				N (%)	
		Yes (%)		No (%)			
1	Place of Residence						
	Urban	183	((16.7))	914	(83.3)	1097	(43)
	Rural	267	(18.6)	1169	(81.4)	1436	(57)
2	Giving children staple foods						
	No	164	(13.9)	1012	(86.1)	1176	(46)
	Yes	286	(21.1)	1071	(78.9)	1357	(54)
3	Giving children legumes						
	No	385	(17.2)	1849	(82.8)	2234	(88)
	Yes	65	(21.7)	234	(78.3)	299	(12)
4	Giving children vegetables						
	No	408	(17.9)	1914	(82.1)	2322	(92)
	Yes	42	(16.7)	169	(83.4)	211	(8)
5	Giving children fruit						
	No	381	(17.8)	1745	(82.2)	2126	(84)
	Yes	69	(17.6)	338	(82.4)	407	(16)
6	Giving children eggs						
	No	424	(17.9)	1941	(82.1)	2365	(93)
	Yes	26	(15.5)	142	(84.5)	168	(7)
7	Giving children flesh food						
	No	302	(17.3)	1439	(82.7)	1741	(69)
	Yes	148	(18.7)	644	(81.3)	792	(31)
8	Giving children dairy food						
	No	442	(17.7)	2050	(82.3)	2492	(98)
	Yes	8	(19.5)	33	(80.5)	41	(2)
9	Diversity of food (Four types or more)						
	No	418	(18.1)	1890	(81.9)	2308	(91)
	Yes	32	(14.5)	193	(85.5)	225	(9)
10	Wealth status						
	Poor	296	(20.0)	1182	(80)	1478	(58)
	Middle	80	(16.2)	414	(83.8)	494	(20)

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.2

Rich	74	(13.2)	487	(86.8)	561	(22)

This study found that staple food was dominantly given to stunted toddlers. The logistics regression analysis showed that providing staple food such as bread, noodles, and others made from grains, roots, and tubers was significantly associated with stunting ($p < 0.05$). This association was identified as a risk factor (OR 1.78; 95% CI 1.436-2.216). In contrast, providing more than four types of food sources (OR 0.6; 95% CI 0.403-0.88), having middle wealth status (OR 0.47; 95% CI 0.33-0.68), belonging to rich households (OR 0.74; 95% CI 0.52-1.05), and place of residence (OR 0.72; 95% CI 0.53-0.95) were significantly associated with stunting and determined as protective factors (Table 2). There were no significant associations found between stunting and consumption of legumes, vegetables, fruits, eggs, flesh foods, and dairy products.

Table 2 Association Between Stunting and Food Groups Intake

Variables	OR (95% CI)			p-values
	OR	Lower	Upper	
Place of Residence	0.715	0.532	0.957	*0.024
Giving children staple food	1.776	1.43	2.207	*0.000
Giving children legumes	1.318	0.937	1.853	0.112
Giving children vegetables	1.334	0.881	2.021	0.173
Giving children fruit	0.971	0.693	1.359	0.862
Giving children eggs	0.966	0.599	1.557	0.887
Giving children flesh food	0.837	0.638	1.097	0.197
Giving children dairy food	1.438	0.636	3.251	0.383
Diversity of food (Four groups or more)	0.582	0.39	0.869	0.008
Wealth status				
Middle	0.471	0.327	1.051	*<0.001
Rich	0.740	0.521	0.869	0.093

* logistic regression

DISCUSSION

Food grouping used in the DHS survey aligns with the 2010 WHO guidelines. This present study identified several factors associated with stunting and their contribution to dietary diversity. Consuming staple food only could increase the risk of stunting (OR 1.78 95% CI 1.436-2.216). Most children predominantly received staple food with less vegetables, eggs, fruits, dairy, and legumes; thus, putting them at higher risk of stunting. Previous studies in West Africa show that a larger proportion of staple foods in meals was associated with a greater likelihood of both stunting and wasting in Ugandan children, which was thought to be related to inadequate vitamin A, iron, and zinc in staple foods (8). Excessively consumption of staple food combined with limited intake of vegetables, fruit, animal sources, and nuts as a side dish may result in insufficient nutrition intake. Staple foods are often more affordable than other foods, especially animal sources foods, as shown in this study and the results of previous studies; thus, household wealth influences stunting (9,10). This study proved that

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.2

different levels of wealth status were linked to stunting. Middle-wealth status (OR 0.47; 95% CI 0.33-0.68) and rich households (OR 0.74; 95% CI = 5.18-1.05) had a lower risk of having stunted children. The results showed that families with middle-wealth status had a significant association with food diversity. Higher-income families are more likely to have access to a variety of food than those with the poorest wealth status, while the lowest wealth status is associated with insufficient minimum dietary diversity (11,12). Fulfillment of nutritional needs according to dietary guidelines is significantly related to food security and household income (13–15). Poverty-stricken communities with household food insecurity often change their food consumption patterns to cope with hunger, resulting in compromised nutrition (16). A higher family's economic capacity could prevent stunting in addition to accessing various food at least four or more types (17). Providing a variety of foods more than four types of food sources significantly lowers the risk of stunting (OR 0.6; 95% CI 0.403-0.88). This result accords with the other study that stunting was negatively associated with dietary diversity (OR 0.95, 95% CI 0.91-0.99, p=0.01) (18). It has been reported that household food insecurity was associated with stunting (15,19–21). Dietary diversity has also been associated with a lower likelihood of childhood stunting in Asian countries (OR 0.89; 95% CI 0.80-0.98) (22). In other words, dietary diversity has been proven as a protective factor leading to a low risk of stunting in children.

In addition to macronutrients, such as carbohydrates, proteins, and fats, micronutrients are also needed for optimal cell development, growth, and countless metabolic functions within the human body (23). Since vegetables, fruits, and nuts are sources of important nutrients, especially micronutrients, the composition of a toddler's daily diet needs to consider their inclusion in a child's feeding (6,24). The results of the study showed that children's respondents received vegetables, fruits, and nuts in limited amount (Table 1). Animal source foods, especially meat, play an important role in providing protein, easily absorbed zinc, and other essential minerals (iron, potassium, and selenium), amino acids, and vitamins (B2 (riboflavin), B3 (niacin), B6, and B12) (25,26). Consumption of animal-protein foods is significantly associated with a reduced risk of stunting (OR 0.69; 95% CI 0.54-0.89; p<0.01) (18). Consuming a variety of animal-sourced food is more beneficial than relying on one animal-sourced food (27). Despite being a crucial source of high-quality nutrients for children aged 6-23 months, the significance of animal-sourced foods is often overlooked by nearly 800 million people. For sustainable development, the animal-sourced needs of the poorest and most vulnerable people must be addressed to prevent stunting (27–29). This study found that no more than 40% of children in Gambia consumed animal-sourced foods, such as flesh food, dairy, and eggs. It appears that they consumed animal-sourced food in small amounts, resulting in prolonged malnutrition.

A recent study showed that stunting prevention in Sub-Sahara Africa has not been accompanied by improved equity in accessing minimum dietary diversity (p<0.01) and composite coverage index (p<0.001) persisted by wealth status and place of residence variables (30). Place of residence (rural/urban) has a simultaneous effect on preventing stunting, as it provides a geographical map of food sources. In this study, place of residence was associated with stunting in Gambia (p<0.05). Access to food, particularly in relation to housing, plays an important role in food security. It has been reported that West Africa is

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.2

vulnerable to variability and climate change that threatens food security (31). Weaknesses in food production systems due to extreme climate change, such as droughts and floods, can exacerbate food insecurity. In 2018, it has been suggested the adaptive response in addressing the impacts of climate change by improving regulations for restricting agriculture and livestock grazing activities, strengthening early-warning systems, crop diversification and rotation, and switching to drought-tolerant crop and animal species (32). Therefore, government support must be increased across all wealth quintiles to ensure that children receive a variety and adequate food intake across all regions.

The study was based on high-quality data regularly collected by an international expert group. In addition, the findings from nationally representative data are more feasible for policymakers to design appropriate intervention programs.

However, this study has some limitations. Included, data unavailability on each type of food sources amount consumed may be limited, and data may suffer bias in recalled information.
Since dietary diversity is significantly associated with stunting, types of food and the affordability of family to food sources must be considered in efforts to nutrition improvement. Incomplete data on staple food such as grains, roots, and tubers and intake of food sources could be further investigated in future studies.

CONCLUSION

Providing at least four types or more of food sources has a significant effect on stunting prevention. The types of food given to toddlers are closely related to the incidence of stunting. Therefore, when caring for stunted toddlers at the community level, stakeholders need to pay attention to food diversity, family's economic capacity, and place of residence.

ACKNOWLEDGMENTS

We would like to acknowledge all participants who made this study possible. We confirmed that all of our research members participated sufficiently in conceptualizing, designing, analyzing, writing, and revising the manuscript. Furthermore, we stated that the materials used in this study or similar materials have never been submitted to or published in any other publication.

AUTHOR CONTRIBUTION

Study design: NM, MM, RN
Data analysis: NM, WA, TM
Manuscript writing and revisions for important content: NM, TM, WA, MM, RN.

CONFLICT OF INTEREST

There are no conflicts of interest associated with this publication. This study received no specific grant from any funding agency, commercial, or not-for-profit organizations.

1. Kundan I, Nair R, Kulkarni S, Deshpande A, Jotkar R, Phadke M. Assessment, outcomes and implications of multiple anthropometric deficits in children. BMJ Nutr Prev Heal. 2021;4(1).
2. Soliman A, De Sanctis V, Alaaraj N, Ahmed S, Alyafei F, Hamed N, et al. Early and long-term consequences of nutritional stunting: From childhood to adulthood. Acta Biomed. 2021;92(1).
3. World Bank. World Bank Country and Lending Groups. World Bank Country and Lending Groups. 2020.
4. Gambia Bureau of Statistics (GBoS), ICF. The Gambia Demography and Heath Survey 2013. GBoS ICF. 2014;(April):2014–5.
5. Gambia Bureau of Statistics

(GBoS), ICF. The Gambia Demographic and Health Survey 2019-2020. GBoS ICF. 2021;56(4).
6. WHO. Indicators for assessing infant and young child feeding practices: Part 1 Definitions. World Health Organization. 2008.
7. ICF. Demographic and Health Surveys Standard Recode Manual for DHS 7. Usaid [Internet]. 2018;145. Available from: https://dhsprogram.com/pubs/pdf/DHSG4/Recode7_DHS_10Sep2018_DHSG4.pdf
8. Amaral MM, Herrin WE, Gulere GB. Using the Uganda National Panel Survey to analyze the effect of staple food consumption on undernourishment in Ugandan children. BMC Public Health. 2017;18(1).
9. Ettyang GAK, Sawe CJ. Factors associated with stunting in children under age 2 in the Cambodia and Kenya 2014 Demographic and Health Surveys. DHS Work Pap. 2016;(126).
10. Mutisya M, Kandala NB, Ngware MW, Kabiru CW. Household food (in)security and nutritional status of urban poor children aged 6 to 23 months in Kenya Global health. BMC Public Health. 2015;15(1).
11. Dafursa K, Gebremedhin S. Dietary Diversity among Children Aged 6-23 Months in Aleta Wondo District, Southern Ethiopia. J Nutr Metab. 2019;2019.
12. Victor R, Baines SK, Agho KE, Dibley MJ. Factors associated with inappropriate complementary feeding practices among children aged 6-23 months in Tanzania. Matern Child Nutr. 2014;10(4).
13. Wilcox S, Sharpe PA, Liese AD, Dunn CG, Hutto B. Socioeconomic factors associated with diet quality and meeting dietary guidelines in disadvantaged neighborhoods in the Southeast United States. Ethn Heal. 2020;25(8).
14. Berra WG. Household Food Insecurity Predicts Childhood Undernutrition: A Cross-Sectional Study in West Oromia (Ethiopia). J Environ Public Health. 2020;2020.
15. Belayneh M, Loha E, Lindtjørn B. Seasonal Variation of Household Food Insecurity and Household Dietary Diversity on Wasting and Stunting among Young Children in A Drought Prone Area in South Ethiopia: A Cohort Study. Ecol Food Nutr. 2020;
16. Oldewage-Theron WH, Dicks EG, Napier CE. Poverty, household food insecurity and nutrition: Coping strategies in an informal settlement in the Vaal Triangle, South Africa. Public Health. 2006;120(9).
17. Sekartaji R, Suza DE, Fauziningtyas R, Almutairi WM, Susanti IA, Astutik E, et al. Dietary diversity and associated factors among children aged 6–23 months in Indonesia. J Pediatr Nurs. 2021;56.
18. Darapheak C, Takano T, Kizuki M, Nakamura K, Seino K. Consumption of animal source foods and dietary diversity reduce stunting in children in Cambodia. Int Arch Med. 2013;6(1).
19. Sreeramareddy CT, Ramakrishnareddy N, Subramaniam M. Association between household food access insecurity and nutritional status indicators among children aged <5 years in Nepal: Results from a national, cross-sectional household survey. Vol. 18, Public Health Nutrition. 2015.
20. Agho KE, Mukabutera C, Mukazi M, Ntambara M, Mbugua I, Dowling M, et al. Moderate and severe household food insecurity

predicts stunting and severe stunting among Rwanda children aged 6–59 months residing in Gicumbi district. Matern Child Nutr. 2019;15(3).
21. Gassara G, Chen J. Household food insecurity, dietary diversity, and stunting in sub-saharan africa: A systematic review. Nutrients. 2021;13(12).
22. Mahmudiono T, Sumarmi S, Rosenkranz RR. Household dietary diversity and child stunting in East Java, Indonesia. Asia Pac J Clin Nutr. 2017;26(2).
23. Ofoedu CE, Iwouno JO, Ofoedu EO, Ogueke CC, Igwe VS, Agunwah IM, et al. Revisiting food-sourced vitamins for consumer diet and health needs: a perspective review, from vitamin classification, metabolic functions, absorption, utilization, to balancing nutritional requirements. Vol. 9, PeerJ. 2021.
24. WHO; MIYCF. Essential Nutrition Actions IMPROVING MATERNAL, NEWBORN, INFANT AND YOUNG CHILD HEALTH AND NUTRITION [Internet]. WHO Library Cataloguing. The WHO Document Production Services, Geneva, Switzerland; 2013. 144 p. Available from: (www.who.int)
25. Papier K, Tong TY, Appleby PN, Bradbury KE, Fensom GK, Knuppel A, et al. Comparison of major protein-source foods and other food groups in meat-eaters and non-meat-eaters in the epic-oxford cohort. Vol. 11, Nutrients. 2019.
26. Bradbury KE, Tong TYN, Key TJ. Dietary intake of high-protein foods and other major foods in meat-eaters, poultry-eaters, fish-eaters, vegetarians, and vegans in UK biobank. Nutrients. 2017;9(12).
27. Headey D, Hirvonen K, Hoddinott J. Animal sourced foods and child stunting. Am J Agric Econ. 2018;100(5).
28. Adesogan AT, Havelaar AH, McKune SL, Eilittä M, Dahl GE. Animal source foods: Sustainability problem or malnutrition and sustainability solution? Perspective matters. Vol. 25, Global Food Security. Elsevier B.V.; 2020.
29. Zaharia S, Ghosh S, Shrestha R, Manohar S, Thorne-Lyman AL, Bashaasha B, et al. Sustained intake of animal-sourced foods is associated with less stunting in young children. Nat Food. 2021 Apr 1;2(4):246–54.
30. Baye K, Laillou A, Chitweke S. Socio-economic inequalities in child stunting reduction in sub-Saharan Africa. Nutrients. 2020;12(1).
31. Obayelu OA, Adepoju AO, Idowu T. Factors influencing farmers ' choices of adaptation to climate change in Ekiti State , Nigeria. J Agric Environ Int Dev - JAEID. 2014;108(1).
32. Amuzu J, Jallow BP, Kabo-Bah AT, Yaffa S. The climate change vulnerability and risk management matrix for the coastal zone of The Gambia. Hydrology. 2018;5(1).

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.2

OPEN ACCESS

Indonesian Journal of Human Nutrition
P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

Telemedicine for Monitoring Nutritional Intake in Malnourished Community-Dwelling Elderly: A Scoping Review of Clinical Trials

Bryanna Infinita L. Saputro[1], Muhammad Ilham Dhiya Rakasiwi [1*)], Astrid Maariam Khairani Siregar[1]

[1*)] Faculty of Medicine, University of Indonesia, Jakarta, Indonesia

* Corresponding author: Muhammad Ilham Dhiya Rakasiwi. E-mail: m.ilhamdhiya@gmail.com

Received: July 2022 Reviewed: October 2022 Published: July 2023

ABSTRACT

Malnutrition is a part of the geriatric giant and a major concern among community-dwelling elderly individuals. Improper intervention of this problem can have detrimental effects on the elderly. Monitoring nutritional intake plays a vital role in managing malnutrition. Telemedicine has been widely applied for managing chronic diseases and gained prominence during the COVID-19 pandemic as a remote health monitoring method. This scoping review aims to identify the advantages and limitations of implementing telemedicine for addressing malnutrition in community-dwelling elderly. This study reviewed the literature obtained through a systematic search of PubMed and Science Direct databases, supplemented by manual searches based on specific inclusion criteria. Two randomized controlled trials (RCTs) assessing the application of telemedicine for malnutrition were identified. The forms of telemedicine used were telecare and set-top boxes on television. The interventions included nutritional monitoring and specific interventions for each patient. However, high patient dropout rates indicated low patient compliance. Nevertheless, the application of telemedicine demonstrated improved patient compliance with nutritional intake guidelines. Limitations of telemedicine implementation included low motivation, technological constraints, and physiological constraints. Telemedicine may be used as a tool for monitoring nutritional intake among malnourished geriatric populations

Keywords: elderly, malnutrition, telemedicine

ABSTRAK

Malnutrisi merupakan bagian dari geriatric giant dan masalah utama pada pasien lansia di komunitas. Penanganan yang tidak adekuat menimbulkan dampak buruk. Pemantauan asupan gizi menjadi penting dilakukan dalam menangani kasus malnutrisi. Telemedisin telah banyak diterapkan pada penanganan kasus penyakit kronik. Pada masa pandemi, telemedisin menjadi metode pemantauan kesehatan yang banyak digunakan. Untuk mengidentifikasi kelebihan dan keterbatasan dari penerapan telemedisin pada kasus malnutrisi di populasi yang memiliki keterbatasan mobilitas seperti lansia. Studi ini meninjau literatur yang diperoleh dari pencarian sistematis dari database Pubmed dan ScienceDirect. Artikel pendukung diperoleh dari pencarian manual dengan kriteria

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.3

inklusi tertentu.Terdapat 2 studi randomized controlled trial (RCT) yang menilai penerapan telemedisin untuk malnutrisi. Bentuk telemedisin yang digunakan berupa ala telecare dan set top box pada televisi. Intervensi berupa pemantauan asupan gizi dan intervensi spesifik untuk setiap pasien. Angka dropout pasien tinggi menandakan kepatuhan pasien yang rendah. Penerapan telemedisin meningkatkan kepatuhan pasien pada pedoman asupan gizi. Keterbatasan penerapan telemedisin berupa motivasi rendah, kendala teknologi dan kendala fisiologis. Telemedisin berpotensi sebagai alat pemantau asupan gizi pada populasi lansia yang mengalami malnutrisi.

Kata Kunci: *lansia, malnutrisi, telemedisin*

INTRODUCTION

Malnutrition refers to an imbalanced nutritional intake, either excessive intake (obesity) or insufficient intake (underweight or wasting). Malnutrition is common, but some groups are more vulnerable, such as people with low socioeconomic status, the elderly, those with acute or chronic illnesses, and pregnant women.[1] In elderly patients, malnutrition is one of the geriatric giants that necessitates comprehensive treatment. Failure to address malnutrition can lead to decreased immune function, increased risk of infection, muscle and bone weakness, decreased quality of life, and increased morbidity and mortality (Figure 1).[2–7]

Generally, the term "geriatric patients" refers to elderly patients. They are associated with a higher degree of weakness and are more likely to have chronic diseases.[8] Various factors predispose elderly patients to higher risks of malnutrition. Decreased food intake can be due to decreased ability to smell and taste, difficulty in chewing or swallowing, impaired nutrient absorption, cognitive decline, psychological conditions such as loneliness and depression, and the side effects of drugs.[8] This decrease in food intake can also be influenced by external factors such as difficulty in food preparation, food quality, and dining atmosphere.[8] In addition, certain socio-demographic factors such as gender (female patients), marital status (unmarried patients), living alone, low education level, unemployment, and lifestyles (smoking and alcohol consumption) have been associated with a higher risk of malnutrition.[9]

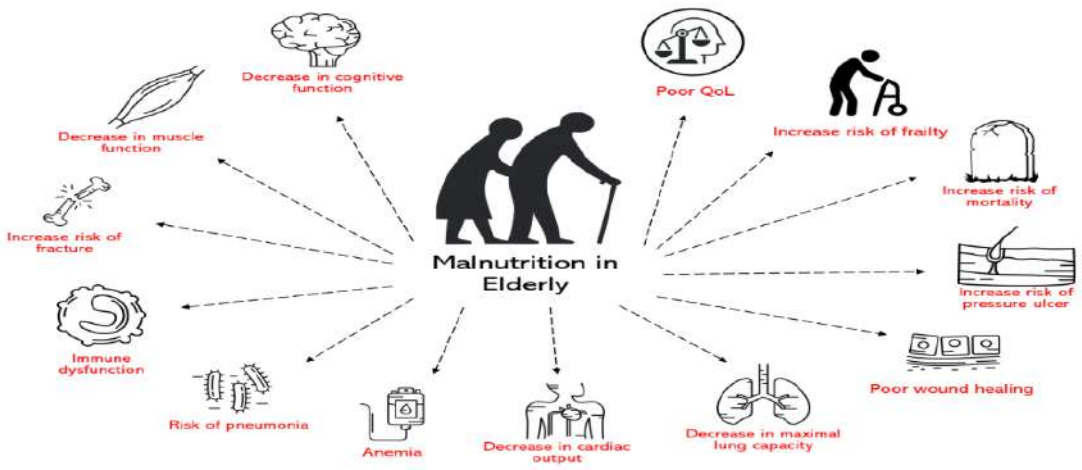


Figure 1. Effect of Malnutrition on the Elderly Population [2–4]

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.3

The prevalence of malnutrition among elderly patients reaches 50%, but it varies significantly depending on the demographic factors, the conditions of healthcare settings, and the screening tools used to assess nutritional status.[8] Another study states a relatively low prevalence of malnutrition in the elderly (6-11%), but higher rates are observed among the elderly receiving treatment in hospitals or care centers (32-64%). In Europe and Asia, the prevalence of malnutrition in the elderly varies from 12% to 84%.[7] Various studies on malnutrition in the elderly population in Indonesia show that 1 out of 2 elderly people is undernourished or overweight.[9] When considering the residential background, malnutrition prevalence is quite low (1-15%) in the elderly living at home in European and North American populations compared to aged care facilities (25-60%) or in hospitals (35-65 %).[10] A study conducted by Kaiser et al. regarding malnutrition conditions in various residential backgrounds in Mataram, West Nusa Tenggara, Indonesia found 30 - 90% of malnutrition cases or at risk of malnutrition among the elderly living in hospitals, nursing homes, communities, and rehabilitation centers.[11] In addition, a study in Iran showed that the prevalence of malnutrition was 9.2% among elderly patients living at home and 21.6% in nursing homes.[7] Despite the abundance of available data and the dangers of malnutrition in the elderly, addressing this problem has not yet been established as a necessity in elderly care.[7]

Therefore, to detect risks and prevent malnutrition in the elderly, it is important to carry out nutritional screening and monitoring.[12] The process of providing nutritional care to the elderly follows a systematic approach. Through nutritional treatment, healthcare workers are expected to detect the risk of malnutrition and conduct personalized management for the patient. Nutritional treatment consists of (1) nutritional screening and risk detection using validated screening tools, (2) nutritional assessment by assessing phenotypic criteria (weight loss, low body mass index, and decreased muscle mass) and etiological factors (decreased food intake or the presence of certain diseases which could cause eating difficulties), (3) making a diagnosis based on meeting at least one phenotypic and etiological criterion, and (4) determining of case severity based on the phenotypic criteria. The process of nutritional care requires assistance from both healthcare workers and the patient's caregiver.[12]

In recent years, home telemonitoring has been extensively studied and has shown promising results.[13] Telemedicine technology has been applied in the field of nutrition to monitor the nutritional intake of elderly patients at home.[14] This literature review aims to identify the advantages and limitations of utilizing telemedicine for the treatment of malnutrition in elderly patients in the community.

METHOD

A literature review was made by means of a detailed and systematic literature review (PRISMA Guideline) on the topic of the potential of telemedicine for monitoring the nutritional intake of malnourished community-dwelling elderly.[15] The main article used for this literature review was obtained from the search results conducted on PubMed and ScienceDirect international journal databases. Additional supporting articles were obtained from manual searches performed by the authors (BI, MI, AM). The inclusion criteria for the main article literature search included fully accessible articles, studies employing clinical trial or pilot study designs, articles written in English, and publications within the period of 2011-2021 (Figure 2).

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.3

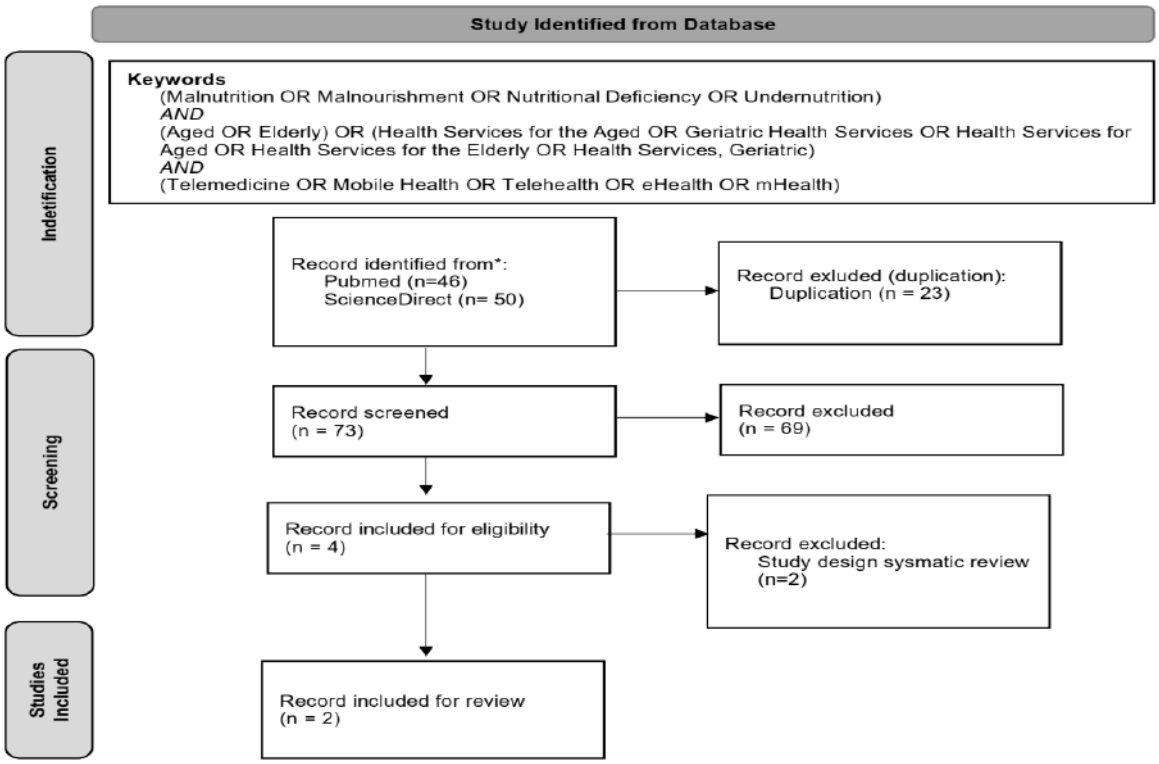


Figure 2. Literature Selection Flow

RESULT

Two randomized controlled trials (RCTs) were identified and met the search criteria. The studies conducted by Kraft et al. and Van Doorn-Van Atten et al. investigated the use of telemedicine for monitoring the nutritional status of elderly patients living in communities who were at risk of malnutrition.[16,17]

DISCUSSION

Telemedicine Application

Telemedicine varies across the literature reviewed. The study by Kraft M *et al.* used a monitoring system consisting of telecare scales and monitors developed by Vitaphone GmbH, Mannheim, Germany. Participants were required to measure their weight every day and answer questions from the telecare monitor. The system did not only display the questions on the screen but also read the questions aloud. Prior to the start of the study period, participants were taught how to use the monitor. This system would provide a real-time message to the healthcare workers if participants experienced weight loss, discontinuation of oral supplement consumption, deterioration in physical condition, or any other conditions that required participants to contact the healthcare workers. Healthcare workers would then provide intervention in accordance with the situation.[16]

In contrast, another study by Van Doorn-Van Atten *et al.* used a different form of telemedicine. Participants received a set-top box that would add channels to the television owned by each participant. This television channel contained food menus, messages about nutrition, results of nutritional status measurements, and advice on food intake and physical activity. The telemedicine included both uniform messages for all participants as well as

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.3

specifically tailored messages depending on each patient's condition. Whenever an alarming condition was detected, the healthcare providers would receive notifications and proceed with providing intervention to the patient. In addition, patients were required to measure their weight and count the number of steps taken per month. They were provided with a standardized weighing scale and instructions to measure the weight correctly. Questionnaires such as the Dutch Healthy Diet Food Frequency Questionnaire (DHD-FFQ), Simplified Nutritional Appetite Questionnaire (SNAQ), and Mini Nutritional Assessment Short Form (MNA-SF) were also completed by participants at the beginning of the intervention and again after two months.[17] The different forms of telemedicine utilized in these studies highlight the flexibility of technology, allowing for adaptation to the specific needs and cultural context of different populations.

Effectivity

The effectiveness of telemedicine can be evaluated based on the participants' compliance with carrying out technology-based monitoring. The study by Kraft M *et al.* showed a decrease in the number of participants, with only one participant remaining for the final assessment out of the initial 13 participants in the intervention group. Eight participants discontinued prematurely, resulting in a higher attrition rate compared to the control group, which had four participants remaining out of the initial 13. The main reasons for discontinuation among the five participants who initially participated but dropped out were declining physical and psychological health requiring treatment (two participants), difficulties in using the technology (one participant), and feeling burdened by the study (one participant). Consequently, only one participant completed the study.[16] This finding was similar to the study by Van Doorn-Van Atten *et al.* with an initial sample of 20 elderly participants, nine participants stopped participating due to mental and psychological health decline and difficulties in using the telemedicine technology applied in the study.[16,17]

The main similarity between the two studies is that they used relatively complex technology. In the second study, the use of telemedicine took advantage of the participants' existing television devices, which was expected to increase participants' understanding of accessing telemedicine. However, almost half of the participants still discontinued their participation. This number was smaller than the study by Kraft M *et al.*, which used special technology and saw a majority of participants discontinuing.[16,17]

When evaluating the effectiveness of telemedicine in improving the nutritional status of participants, it is important to consider the following aspects. The two main sources of this literature review were pilot studies with the same objective, to see the potential role of telemedicine in addressing malnutrition in elderly patients. Nonetheless, a study by Van Doorn-Van Atten *et al.* found a significant increase in participant adherence to nutritional intake according to guidelines, particularly in terms of consumption of fish, fiber, protein, and vitamin D. However, these findings still require further research with a larger sample size.[17] On the other hand, the study by Kraft M *et al.* obtained results that were not significantly different between the intervention and control groups. Although still inconclusive, telemedicine still shows some potential in its applicability and benefits.[16,17]

Advantage and Limitation

The application of telemedicine offers a number of advantages (Figure 3). First, it eliminates the need for patients to

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.3

come to healthcare facilities. This is beneficial especially for elderly patients in the community and the presence of movement restrictions due to the pandemic (at the time of writing this study). The application of telemedicine and remote consultation in cases of chronic illness or patients with malnutrition can reduce medical costs while still providing affordable healthcare services.[16,18,19] Secondly, telemedicine facilitates routine monitoring, allowing patients to monitor their health status (in this case, nutritional condition) without the direct presence of a healthcare worker. This type of routine monitoring has been implemented in the management of heart failure.[20]

However, several limitations were identified from this literature analysis. One limitation is the need for patients to familiarize themselves with the technology used. This is challenging, especially for elderly patients with low digital literacy.[16,17] Another study has also shown that elderly patients were not ready to fully engage in video conference-based telemedicine.[21] Low motivation of the patient and/or caregiver also proves to be a limitation. Low motivation arises from the notion that nutritional supplements are not important or that patients and caretakers feel that the patients are in good health, and the difficulty of elderly patients to receive information regarding their nutritional problems.[16,22,23] In the study by Kraft *et al*. and Van Doorn-Van Atten *et al.* some physiological barriers were reported, including (1) limitations in consuming the recommended foods, (2) discomfort in taking supplements, which prompted patients to discontinue monitoring, and logistical problems such as the unavailability of supplements.[14,16,17]

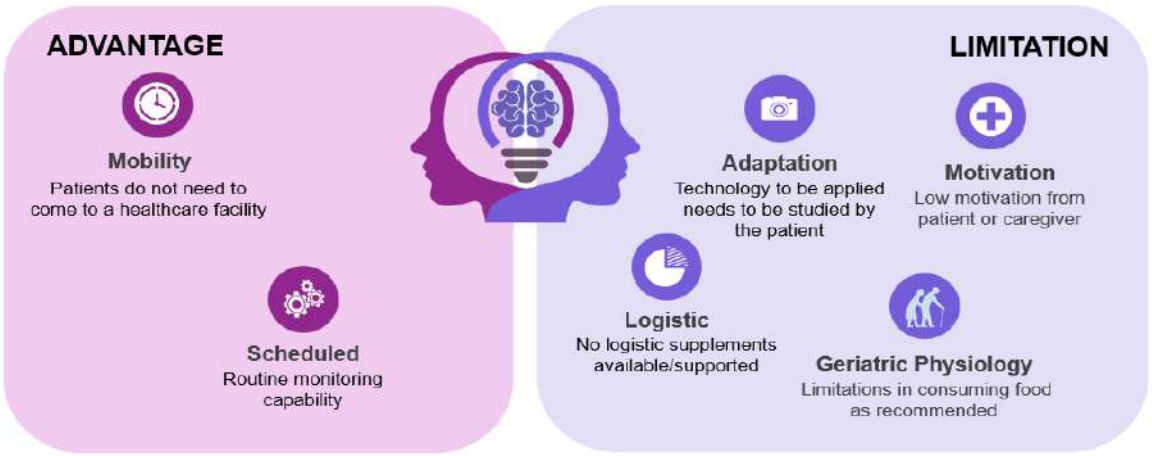


Figure 3. Strengths and Limitations of the Application of Telemedicine Identified from the Literature [16–20]

CONCLUSION

Malnutrition remains a major problem faced by elderly patients, and monitoring their nutritional intake is one crucial step to improving nutritional status. This literature review highlighted two RCT studies that showed the potential of telemedicine to monitor the nutritional intake of elderly patients in the community. Telemedicine offers advantages, including reducing the need for high mobility and facilitating routine monitoring of nutritional

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.3

status. Meanwhile, the challenges identified were low patient motivation, limited knowledge and ability to adapt to technology, physiological constraints, and logistical constraints. Considering the benefits of telemedicine, the development of telemedicine that can overcome these challenges should be addressed.

REFERENCES

1. Kabashneh S, Alkassis S, Shanah L, Ali H. A Complete Guide to Identify and Manage Malnutrition in Hospitalized Patients. Cureus. 2020 Jun 7;12(6).
2. Sinclair AJ, Morley JE, Vellas B. Pathy's Principles and Practice of Geriatric Medicine. 5th ed. Oxford: Wiley-Blackwell; 2012.
3. Rasheed S, Woods RT. Malnutrition and quality of life in older people: a systematic review and meta-analysis. Ageing Res Rev. 2013 Mar;12(2):561–6.
4. Verlaan S, Ligthart-Melis GC, Wijers SLJ, Cederholm T, Maier AB, de van der Schueren MAE. High Prevalence of Physical Frailty Among Community-Dwelling Malnourished Older Adults-A Systematic Review and Meta-Analysis. J Am Med Dir Assoc. 2017 May 1;18(5):374–82.
5. Kiesswetter E, Colombo MG, Meisinger C, Peters A, Thorand B, Holle R, et al. Malnutrition and related risk factors in older adults from different health-care settings: an enable study. Public Health Nutr. 2020 Feb 1;23(3):446–56.
6. Wong MMH, So WKW, Choi KC, Cheung R, Chan HYL, Sit JWH, et al. Malnutrition risks and their associated factors among home-living older Chinese adults in Hong Kong: hidden problems in an affluent Chinese community. BMC Geriatr. 2019 May 23;19(1).
7. Bakhtiari A, Pourali M, Omidvar S. Nutrition assessment and geriatric associated conditions among community dwelling Iranian elderly people. BMC Geriatr. 2020 Aug 6;20(1):1–10.
8. Volkert D, Beck AM, Cederholm T, Cereda E, Cruz-Jentoft A, Goisser S, et al. Management of Malnutrition in Older Patients—Current Approaches, Evidence and Open Questions. J Clin Med. 2019 Jul 1;8(7):974.
9. Irawati D, Ekawanti A, Josafat A. Nutritional profile in Indonesian elderly subpopulation. JKKI J Kedokt dan Kesehat Indones. 2020 Aug 31;11(2):121–9.
10. Moreira NCF, Krausch-Hofmann S, Matthys C, Vereecken C, Vanhauwaert E, Declercq A, et al. Risk Factors for Malnutrition in Older Adults: A Systematic Review of the Literature Based on Longitudinal Data. Adv Nutr. 2016 May 1;7(3):507–22.
11. Kaiser MJ, Bauer JM, Rämsch C, Uter W, Guigoz Y, Cederholm T, et al. Frequency of malnutrition in older adults: a multinational perspective using the mini nutritional assessment. J Am Geriatr Soc. 2010;58(9):1734–8.
12. Holst M, Beck AM. Nutritional Assessment, Diagnosis, and Treatment in Geriatrics. In: Santy-Tomlinson J, Falaschi P, Hertz K, editors. Perspectives in Nursing Management and Care for Older Adults. Berlin: Springer; 2001.
13. Paré G, Jaana M, Sicotte C. Systematic Review of Home Telemonitoring for Chronic Diseases: The Evidence Base. J Am Med Inform Assoc. 2007 May;14(3):269.
14. Aure CF, Kluge A, Moen A. Older Adults' Engagement in Technology-Mediated Self-Monitoring of Diet: A Mixed-Method Study. J Nurs Scholarsh. 2021 Jan 1;53(1):25–34.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.3

15. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMC. 2021;372:n71.
16. Kraft M, Van Den Berg N, Kraft K, Schmekel S, Gärtner S, Krüger J, et al. Development of a telemedical monitoring concept for the care of malnourished geriatric home-dwelling patients: a pilot study. Maturitas. 2012 Jun;72(2):126–31.
17. Van Doorn-Van Atten MN, Haveman-Nies A, Heery D, De Vries JHM, De Groot LCPGM. Feasibility and Effectiveness of Nutritional Telemonitoring for Home Care Clients: A Pilot Study. Gerontologist. 2019 Jan 9;59(1):158–66.
18. Annaswamy TM, Verduzco-Gutierrez M, Frieden L. Telemedicine barriers and challenges for persons with disabilities: COVID-19 and beyond. Disabil Health J. 2020 Oct 1;13(4).
19. Richardson E, Aissat D, Williams GA, Fahy N. Keeping what works: remote consultations during the COVID-19 pandemic. Eurohealth (Lond). 2020;26(2):73–6.
20. Volterrani M, Sposato B. Remote monitoring and telemedicine. Eur Hear J Suppl. 2019 Dec 1;21(Suppl M):M54–6.
21. Lopez AM, Lam K, Thota R. Barriers and Facilitators to Telemedicine: Can You Hear Me Now? Am Soc Clin Oncol Educ B. 2021 Jun;41(41):25–36.
22. Hage E, Roo JP, Van Offenbeek MAG, Boonstra A. Implementation factors and their effect on e-Health service adoption in rural communities: A systematic literature review. BMC Health Serv Res. 2013 Jan 12;13(1):1–16.
23. Beelen J, Vasse E, Ziylan C, Janssen N, De Roos NM, De Groot LCPGM. Undernutrition: Who cares? Perspectives of dietitians and older adults on undernutrition. BMC Nutr. 2017 Dec 22;3(1):1–9.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.3

OPEN ACCESS

Indonesian Journal of Human Nutrition
P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

Sensory Evaluation and Fiber Content Analysis of Analog Rice with Moringa Leaf Flour Substitution

Ika Wahyuningsih[1], Arif Sabta Aji[1,2,*], Veriani Aprilia[1], Satrijo Saloko[3], Dina Seftina[1], Vivi Meiliza Majid[1]

[1] Undergraduate Program in Nutrition, Faculty of Health Sciences, Alma Ata University.
[2] Postgraduate Program in Public Health, Faculty of Health Sciences, Alma Ata University.
[3] Food Science and Technology Study Program, Faculty of Food Technology and Agroindustry, University of Mataram.

Corresponding author: Arif Sabta Aji. Email: sabtaaji@almaata.ac.id

Accepted: August 2022 Reviewed: October 2022 Published: July 2023

ABSTRACT

Analog rice, also known as artificial rice, is a rice substitute made from a combination of local flour, including sorghum flour, mocaf flour, and glucomannan. Incorporating Moringa leaves into analog rice flour offers potential health benefits due to its anti-diabetic and antihyperglycemic effects, which lowers blood sugar levels and HbA1C levels in individuals with Diabetes Mellitus. This study aims to develop analog rice using a combination of sorghum, mocaf, and glucomannan flour and to determine its sensory properties and fiber content. This study employed an experimental design, with Moringa leaf flour substitutions divided into P1 (0%), P2 (2%), P3 (4%), P4 (6%), P5 (8%), and P6 (10%), using a Completely Randomized Design (CRD). Sensory evaluation was done using the hedonic test, involving 25 trained panelists who assessed taste, aroma, color, and texture. Fiber content was analyzed using the enzymatic gravimetric test. Data were analyzed using a one-way ANOVA test, followed by Duncan's test if $p<0.005$. The results showed a significant effect of Moringa leaf flour substitution on sensory evaluation and fiber content ($p<0.001$ for all comparisons). Based on sensory evaluation, panelists preferred analog rice P2 (2%). The fiber content of analog rice with Moringa leaf flour substitution ranged from 11.16 to 13.65% for insoluble dietary fiber, 0.60 to 0.99% for soluble dietary fiber, and 11.80 to 14.62% for total dietary fiber. Moringa leaf flour substitution had a significant difference in sensory evaluation and fiber content of analog rice. The highest preference level was found in P2 (2%) analog rice, while the highest total fiber content was found in P5 (8%) analog rice.

Keywords: analog rice, sensory evaluation, dietary fiber, Moringa leaf flour

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

INTRODUCTION

Diabetes Mellitus (DM) is a chronic disease caused by a metabolic disorder that leads to elevated blood sugar levels exceeding normal limits. This disease can also be a major cause of other chronic diseases, such as heart disease, blindness, and kidney failure (1). The International Diabetes Federation (IDF) stated that 463 million people have diabetes mellitus at the age of 20-79 years, with projections indicating a further increase to 578 million and 700 million by 2030 and 2045, respectively. Meanwhile, Indonesia ranks 7th among the top 10 countries with the highest sufferers, affecting approximately 10.7 million people (2).

The Indonesia Basic Health Research (RISKESDAS) report a 2% prevalence of diabetes mellitus at the age of 15 years and above based on medical diagnoses, while an 8.5% prevalence was based on blood sugar examination. Therefore, immediate action to control diabetes mellitus must be taken to prevent further increases in the number of sufferers, one of which is through dietary management (3).

Dietary management for patients with diabetes mellitus in Indonesia involves adjustments in the type of foods, amount, and meal timing (known as 3J, *Jenis, Jumlah, Jadwal*) (1). The recommended type of foods chosen mainly consists of low glycemic index foods, which can raise blood sugar levels slowly. The low or high glycemic index in food is mainly determined by dietary fiber, amylose, amylopectin, fat, protein content, and food processing method (4) Rice, as a carbohydrate source, is a staple food mainly consumed in many countries worldwide. However, rice also has a high glycemic index (54-97) and contains a low amount of insoluble dietary fiber (3.64%) (5). Therefore, there is a growing need for alternative food options that enables people with Diabetes to still consume rice without concern about elevated blood sugar levels.

Analog rice, or artificial rice, is produced by combining locally sourced flour and has almost the same carbohydrate content as that of regular rice (6). Therefore, the selection of raw materials used in the manufacturing process will greatly determine the nutritional value and characteristics of the analog rice. In this study, the raw materials used were sorghum and mocaf (modified cassava flour), which were substituted with Moringa and glucomannan. Most respondents expressed a preference for analog rice derived from sorghum and mocaf, with a 30%:50% ratio (7). The pleasant taste of mocaf makes the ratio of mocaf composition higher than that of sorghum.

Sorghum is a functional food and is known to offer various benefits. According to Suarni, sorghum contains iron, fiber, oligosaccharides, and β-glucan, which are non-starch polysaccharide (NSP) carbohydrate components (8). In addition, sorghum also contains tannins and phytic acid. Tannins exhibit stronger antioxidant properties compared to vitamins E and C. Sorghum has 11.53% dietary fiber and 1.44 mg total phenolic compound (9). Phenolic compounds are antioxidants and have a role in α-amylase and α-glycosidase enzyme inhibition, potentially beneficial in managing hyperglycemia and diabetes-related complications (10). The glycemic index value of sorghum rice is 47.38 and is included in the low category (<55) (11).

Mocaf is flour made from cassava that undergoes a fermentation process (12). A study reported that the nutritional content and caloric value of mocaf rice are higher than those of regular white rice, with 212.53 kcal/100gr, 2.09% protein, and 46.45% carbohydrates (13).

In addition, Moringa leaves are widely cultivated in Indonesia, and their

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

leaf extract is known to have antidiabetic and antihyperglycemic effects. A study has shown that Moringa leaf extract is also able to reduce blood sugar levels and HbA1C levels, which are parameters for the success of diabetes therapy (14). Consumption of boiled Moringa leaves water is known to lower blood glucose levels in people with diabetes mellitus (15). In addition, Moringa leaves that have been dried and ground into powder form (flour) have an increased concentration of nutrient content (16).

Furthermore, glucomannan, a type of dietary fiber found in *porang* tubers, is known to slow down the gastric emptying rate, restrain the absorption of glucose and lipids, and prolong the feeling of fullness (17). Glucomannan derived from *porang* tubers can be a nutraceutical component for type II diabetes management (18).

Therefore, this research aims to conduct sensory evaluations (taste, aroma, color, texture) and fiber content analysis of analog rice deriving from locally sourced ingredients that are sorghum, mocaf, and porang glucomannan extract substituted with Moringa leaf extract, which has a low glycemic index and rich in antioxidant. It is expected that this analog rice can serve as an alternative functional food for food diversification.

METHODS

The study utilized an experimental research design employing a single-factor Completely Randomized Design (CRD). Five treatment formulations and one control were used to perform sensory evaluation (taste, aroma, color, and texture) and dietary fiber content analysis in analog rice. The ratios of composite flour and Moringa flour are shown in Table 1. Composite flour ingredients consisting of sorghum flour, mocaf, and glucomannan extract from *porang* tuber were then substituted with Moringa leaf flour in each treatment group with varying amounts, ranging from 0 to 10 g.

Table 1. Analog Rice Composition

	Sorghum Flour (g)	Mocaf Flour (g)	Moringa Leaf Flour (g)	Glucomanan Powder (g)
P1(0%)	90	10	0	0.1
P2 (2%)	88	10	2	0.1
P3 (4%)	86	10	4	0.1
P4 (6%)	84	10	6	0.1
P5 (8%)	82	10	8	0.1
P6 (10%)	80	10	10	0.1

In the analysis of dietary fiber, the number of replications was calculated. This study consisted of six experimental groups, requiring two replications for each group (19). The sensory evaluation analysis was performed by involving trained panelists. The panelists in this study were students of the Undergraduate Program in Nutrition, Faculty of Health Sciences, Alma Ata University, classes of 2018 and 2019 (both regular and transfer students). The panelists had received theory in the sensory evaluation practicum test in the Food Nutrition Science Block or Advanced Culinary Course. Before performing the sensory evaluation, the panelists signed the consent form to participate in the research, and their identities were kept confidential. This research has received ethical approval from the Ethical Commission of Alma Ata University (KE/AA/IX/10622/EC/2021).

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

The population in this study was the 25 trained panelists. The number of panelists was determined based on the maximum requirements of people with good enough sensitivity (20). Selected panelists were those who met the predetermined inclusion and exclusion criteria. The inclusion criteria for selecting the panelists were as follows: male or female with a minimum age of 18 years, in good health, had received sensory evaluation test theory, and were willing to participate by signing the consent form to become a panelist. On the other hand, the exclusion criteria were individuals who experienced sickness, withdrew from the sensory evaluation test, and have not/never received sensory evaluation test theory.

The sensory evaluation data were analyzed using the hedonic test method, employing a preference scale consisting of the following levels: a) score 1: dislike very much; b) score 2: dislike slightly; c) score 3: neutral/like; d) score 4: like slightly; e) score 5: like very much (21). In addition, the dietary fiber test includes measuring total dietary fiber, soluble fiber, and insoluble dietary fiber using a gravimetric enzymatic method (22). The statistical analysis performed in this study was one-way ANOVA with a 95% confidence level (α = 0,05). Therefore, a p-value of less than 0.05 was considered a significant difference. If there were a significant difference, the data would be analyzed further using Duncan's test to determine which treatment group has the real difference.

RESULTS

Preference level for the color of analog rice substituted with Moringa leaf flour

Table 2 shows that there was no significant difference between P1 and P2 (notation d). This means the panelists gave no different taste ratings between analog rice with 2% Moringa leaves addition and without the addition. P2, with the addition of 2 g of Moringa leaves, has an average score of 3.32 (neutral/like). Likewise, P3 with the addition of 4 g of Moringa leaves has an average score of 3.04 (neutral/like), P4 with the addition of 6 g of Moringa leaves has an average score of 2.84 (neutral/like), and P5 with the addition of 8 g of Moringa leaves has an average score of 2.72 (neutral/like). However, P6, with the addition of 10 g of Moringa leaves, was less preferred by respondents, with an average score of 2.36 (dislike slightly).

This result may be due to the analog rice without the addition of Moringa leaf flour having a lighter color (white bone) than the analog rice added with Moringa leaf flour. Therefore, the addition of more Moringa leaf extract makes the analog rice have a darker green color which lowered the panelist's level of preference.

Statistical test results showed that the moringa leaf flour substitution in analog rice has significantly different results in the preference level for the rice color ($p<0.001$). The results of the significance test found that P6 was significantly different from P1, P2, P3, P4, and P5. However, P1 was not significantly different from P2 in color.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

Substituted with moringa leaf flour (P1: 0%)

Substituted with moringa leaf flour (P4: 6%)

Substituted with moringa leaf flour (P2: 2%)

Substituted with moringa leaf flour (P5: 8%)

Substituted with moringa leaf flour (P3: 4%)

Substituted with moringa leaf flour (P6: 10%)

Figure 1. Analog rice products with Moringa leaf flour substitution

Preference level for the aroma of analog rice substituted with Moringa leaf flour

The sensory evaluation test results in Table 2 show the preference level of panelists for analog rice for aroma at different Moringa leaf flour substitution levels. At P1, P2, and P3, the aroma was rated as neutral/like with subsequent average scores of 3.06, 2.90, and 2.82, respectively. Whereas, at P4, P5, and P6, with the addition of 6 g, 8 g, and 10 g of Moringa leaves, the average scores declined to 2.42, 2.48, and 2.48, respectively. The panelist's feedback indicated "dislike slightly" for the aroma as more Moringa flour was added to the analog rice. This decline in preference could be attributed to the increased concentration of the aroma from Moringa leaf flour. The statistical analysis revealed a substantial impact of substituting Moringa leaf flour on the aroma preference of analog rice ($p<0.001$). Specifically, there were significant differences between P1 and P4, P5, and P6. However, no significant difference was observed between P1 and P2, as well as between P1 and P3 concerning aroma preference.

Preference level for the taste of analog rice substituted with Moringa leaf flour

As shown in Table 2, the sensory evaluation test results indicate that panelists displayed a preference for analog rice taste at P1 compared to the other treatment groups, with an average score of 3.62. Treatments P2, P3, and P4, which involved the addition of 2 g, 4 g, and 6 g of Moringa leaves, respectively, received average scores within the "neutral/like" category, with values of 3.02, 2.94, and 2.64, respectively. However, panelists exhibited "slight dislike" for analog rice at

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

P5 and P6, where 8 g and 10 g of Moringa leaves were added, with average scores of 2.30 and 2.18, respectively.

The data suggests that as more Moringa leaf flour was added to the analog rice, the panelists' acceptance of the product decreased. This might be attributed to the increasing bitterness in the rice taste resulting from the higher levels of Moringa leaf flour.

The statistical test results showed a significant difference in the panelists' preference for analog rice taste for each treatment group substituting with Moringa leaves ($p<0,001$). P1 was significantly different from the other five treatment groups.

Preference level for the texture of analog rice substituted with Moringa leaf flour

The results of the sensory evaluation test in Table 2 show that the panelists preferred the analog rice texture at P1, P2, P3, and P4, which included in the "neutral/like" category with an average score of 3.46, 3.24, 3.06 and 2.62, respectively. This was because the analog rice in P1, P2, and P3 had a chewier consistency. However, for P5 and P6, the panelists did not like the texture of the analog rice because it was hard and brittle, referred to as "*nasi pera*" in Indonesian. The average scores for these treatments were 2.42 and 2.48, respectively.

The statistical test results showed a significant difference in the panelists' preference for analog rice texture for each treatment group substituting with Moringa leaves ($p=0,001$). P1 did not differ from P2 and P3 but was significantly different from P4, P5, and P6 concerning texture preference.

Preference level for the overall characteristics of analog rice substituted with Moringa leaf flour

The sensory evaluation test results in Table 2 show that the panelists' preference level for the overall characteristics of analog rice substituted with Moringa leaf flour was "neutral/like." The treatment group P1 obtained the highest average score (3.50) due to its desirable overall characteristics, which included a sticky, chewy texture, and a pleasant taste. Similarly, P2, P3, P4, and P5 were included in the "neutral/like" category with an average score of 3.14, 3.12, 2.72, and 2.52, respectively. However, the panelists showed a slight dislike for the analog rice on P6, with an average score of 2.42, because it was slightly hard and brittle and tasted slightly bitter. These characteristics could be attributed to the higher substitution level of Moringa flour (10%) in P6.

The statistical test results showed a significant difference in the panelists' preference level for the overall characteristics of analog rice with Moringa leaf flour substitution ($P< 0.001$). The results of the significance test found that P1 was significantly different from P2, P3, P4, P5, dan P6.

Dietary Fiber

The results of the one-way ANOVA test for soluble dietary fiber content, as shown in Table 3, demonstrated a highly significant effect ($p<0.001$) resulting from the addition of Moringa leaf flour to analog rice made from sorghum flour, mocaf, and glucomannan.

The lowest average soluble dietary fiber content value in analog rice was in the group without moringa flour (P1) substitution at 0.64%. In contrast, the highest average value (0.97%) was obtained in the P5 group with Moringa leaf flour substitution. These results were followed by Duncan's test, which obtained significant differences between P3 and P1, P2, P4, P5, and P6.

Insoluble Dietary Fiber

The results of the one-way

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

ANOVA test for insoluble dietary fiber in Table 3 showed $p<0.001$, which means that H0 was rejected. Therefore, the addition of Moringa leaf flour had a significant impact on the insoluble dietary fiber content of analog rice made from sorghum flour, mocaf, and glucomannan.

The lowest average value of insoluble dietary fiber content in analog rice was found in the group without moringa flour (P1) substitution (11.18%). On the other hand, the highest average value (13.63%) was obtained in the P5 group with Moringa leaf flour substitution. These results were followed by Duncan's test, which showed significant differences in all treatment groups P1, P2, P3, P4, P5, and P6.

Total Dietary Fiber

Table 4 shows a significant difference resulting from the addition of Moringa leaf flour to the total dietary fiber content of analog rice made from sorghum flour, mocaf, and glucomannan

The group without Moringa leaf flour substitution (P1) exhibited the lowest average total dietary fiber content in analog rice, measuring 11.82%. In contrast, the highest average value was observed in the group with Moringa leaf flour substitution (P5), at 14.61%. Duncan's test further confirmed significant differences among all treatment groups (P1, P2, P3, P4, P5, and P6) in terms of total dietary fiber content.

Table 2. Sensory Evaluation Test of Analog Rice

	Color	Aroma	Taste	Texture	Overall Characteristic
P1	3.52±0.83^{d}	3.06±0.89^{c}	3.62±0.90^{d}	3.46±0.81^{b}	3.50±0.73^{c}
P2	3.32±0.76^{cd}	2.90±0.99^{bc}	3.02±0.915^{c}	3.24±1.00^{b}	3.14±0.80^{b}
P3	3.04±0.85^{bc}	2.82±1.04^{abc}	2.94±1.03^{c}	3.06±1.14^{b}	3.12±0.94^{b}
P4	2.84±0.89^{b}	2.42±0.97^{a}	2.64±1.10^{bc}	2.62±0.98^{a}	2.72±0.88^{a}
P5	2.72±0.90^{b}	2.48±0.95^{ab}	2.30±0.95^{ab}	2.42±1.05^{a}	2.52±0.93^{a}
P6	2.36±1.04^{a}	2.48±1.09^{ab}	2.18±1.13^{a}	2.48±0.95^{a}	2.42±1.03^{a}
	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

Note: Different letters in the notation column indicate significant differences between treatment groups P < 0.05, while the same letters indicate no notation differences in the treatment level P < 0.05 in the one-way ANOVA test followed by Duncan's test. The value of each sensory evaluation score in the table shows that score 1 = dislike very much, 2 = dislike slightly, 3 = neutral/like, 4 = like slightly, 5 = like very much.

Table 3. Dietary and Insoluble Fiber Contents of Analog Rice

	Dietary Fiber	P *Value*	Insoluble Fiber	P Value
P1 (0%)	0.64±0.0563564^{a}		11.18±0.0212839^{a}	
P2 (2%)	0.71±0.0014849^{a}		12.52±0.0670337^{c}	
P3 (4%)	0.82±0.0339411^{b}		13.14±0.0217789^{d}	
P4 (6%)	0.90±0.0034648^{c}		13.52±0.0653367^{e}	
P5 (8%)	0.97±0.0265165^{c}		13.63±0.0149907^{f}	
P6 (10%)	0.70±0.0200111^{a}		12.25±0.0021213^{b}	

Note: Different letters in the notation column indicate significant differences between treatment groups P < 0.05, while the same letters indicate no notation differences in the treatment level P < 0.05 in the one-way ANOVA test followed by Duncan's test.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

Tabel 4. Total Dietary Fiber Content of Analog Rice

	Total Dietary Fiber	P *Value*
P1 (0%)	11.82±0.0350018[a]	
P2 (2%)	13.24±0.0685186[c]	
P3 (4%)	13.96±0.0556493[d]	
P4 (6%)	14.43±0.0688722 [e]	
P5 (8%)	14.61±0.0114551[f]	
P6 (10%)	12.96±0.0178191[b]	

Note: Different letters in the notation column indicate significant differences between treatment groups P < 0.05, while the same letters indicate no notation differences in the treatment level P < 0.05 in the one-way ANOVA test followed by Duncan's test.

DISCUSSION

Color Sensory Evaluation Test of Analog Rice

Moringa leaf flour substitution in analog rice has significant differences in the level of color preference (p<0.001). Particularly, treatment group P6 showed a distinct difference from the other treatment groups.

Analog rice (P1) without Moringa leaf flour exhibited a white bone color, which aligns with the traditional appearance of rice. Conversely, the inclusion of Moringa leaf flour in the formula imparted a green color to the analog rice, with the intensity of green increasing as more Moringa leaf flour was added. This vibrant green hue is attributed to the chlorophyll content present in Moringa leaves. Chlorophyll is a green pigment found in chloroplasts along with carotenes and xanthophylls (23). Color plays a crucial role in sensory evaluation tests, reflecting freshness and ripeness. An even and uniform color can be indicative of the quality of mixing or processing methods. For individuals with Diabetes mellitus who adhere to strict diet control, an appealing color can enhance food choices. In this study, the color of analog rice was paid close attention, and a sensory evaluation test using hedonic scales was conducted to assess color preferences (24).

A study found that analog rice with the 10% substitution of Moringa leaf extract has 2.723% greater chlorophyll content than analog rice with the addition of 5% broccoli extract (1.260%)(25). This is because the total chlorophyll content in Moringa leaves was higher (12.68 g/L) than that in broccoli (6.21 mg/L). Furthermore, factors such as pH, pigment sources, and processing methods can influence the total chlorophyll content in leaves, along with sunlight exposure and leaf age.

This study was in line with a study that found that panelists preferred wet noodles without the addition of Moringa leaf flour compared to noodles added with Moringa leaf flour with various concentrations (26). Additionally, an increase in Moringa leaf flour addition negatively impacted the general acceptance of sponge cake (27).

Aroma Sensory Evaluation Test of Analog Rice

Substitution of moringa leaf flour in analog rice has a significant difference in the level of preference for aroma (p<0.001). A test of difference showed that treatment 1 was significantly different from P4, P5, and P6 but not significantly different from P2 and P3.

Analog rice with Moringa leaf flour substitution offers rice with a

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

specific aroma of Moringa. The intensity of this characteristic aroma increases with higher amounts of Moringa leaves added to the analog rice. This is attributed to the drying process of Moringa leaves at 50°C, which activates phenolic compounds responsible for the distinct Moringa aroma (28).

In this study, the panelists disliked the analog rice aroma substituted with moringa leaf flour, compared to analog rice with fresh Moringa leaf and brown algae (*Sargassum* sp). This is due to the lower intensity of the Moringa leaf. Aroma plays a crucial role in consumer food preferences as it stems from the olfactory sensing process. The presence of volatile compounds in food products contributes to their distinctive aromas, significantly influencing consumer preferences and related to the sense of smell (29).

In addition, Moringa also contains lipoxidase enzymes found in the leaves. These enzymes hydrolyze or break down fats into compounds that can cause unpleasant odors, particularly in the hexanal and hexanol groups. As a result, an increase in Moringa leaf flour added to the product can lead to a stronger unpleasant smell (30). However, the aroma can be reduced by blanching, picking, washing, and storing the Moringa leaves at room temperature (30^{o}C to 32^{o}C) (31).

Taste Sensory Evaluation Test of Analog Rice

Substituting Moringa leaf flour in analog rice resulted in a significant difference in the preference level for taste ($P< 0.001$). A test of difference showed that P1 significantly differed from the other five treatment groups. In the sensory evaluation test with the level of taste preference, 13.98% of the panelists expressed a liking for the taste of P1 analog rice.

Products substituted with Moringa leaves have a slightly bitter taste, and this bitterness increases with higher levels of Moringa leaf flour added (32). This is because Moringa leaves contain tannins which produce a bitter taste (33). Additionally, tannins are astringent compounds with a bitter taste due to the presence of polyphenolic groups, which can bind and precipitate or shrink the protein components. This polyphenol group also gives a dry and puckering sensation in the mouth (34). However, the bitter taste in Moringa leaves will disappear if it is regularly harvested for consumption (35).

Texture Sensory Evaluation Test of Analog Rice

Substitution of moringa leaf flour on analog rice has a significant difference in the level of preference for texture ($P<0.001$). A difference test showed that P1, P2, and P3 significantly differ from P4, P5, dan P6.

The texture of analog rice can be influenced by the levels of amylose and amylopectin present in the rice ingredients. As explained in a previous study (25), high amylose levels could make the rice texture harder and more brittle, while higher levels of amylopectin can result in a nicer and stickier texture. In addition, the fat content also affects the texture of the analog rice. Fats or oils can weaken the dough, reduce the hardness of the extruded product, and increase the plasticity of the product. This finding aligns with a previous study, which indicated that the panelists expressed a dislike for the texture of analog rice when combined with moringa leaf flour and Sargassum sp (28).

Dietary Soluble Fiber Test

Moringa leaf flour substitution on analog rice made from sorghum flour,

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

mocaf, and glucomannan, had a significant difference (P<0.001) in the soluble dietary fiber content. Duncan's test further revealed a significant difference between P3 and P1, P2, P4, P5, and P6.

The decrease in soluble dietary fiber content observed in P6 can be attributed to the cooking process, where heating causes the fiber component to dissolve in the water, resulting in the hydrolysis of water-insoluble protopectin compounds into pectinate (pectin). This phenomenon leads to a reduction in soluble dietary fiber levels (36).

Soluble dietary fiber is a dietary fiber that is fermented in the large intestine, which can increase the concentration of good bacterial metabolites such as short-chain fatty acids (SCFA). These SCFAs provide a fecal bulking effect, enhancing bowel movements by increasing intestinal transit time (37). Water-soluble dietary fiber also has viscosity properties that can delay the absorption of glucose and lipids, which can positively impact postprandial metabolism (38).

In addition to its role in delaying digestion in the small intestine, water-soluble dietary fiber contributes to a prolonged feeling of fullness, slowing down blood glucose release, reducing the amount of insulin required to transfer glucose into cells, and limiting its conversion into energy (39). According to a study by Hernawan dan Meylani (2016), white rice has the lowest fiber content; both organic white rice (0.5746% w/w) and non-organic white rice (0.4021% w/w). These results indicate that the chemical characteristics of rice (fiber content) differ from one variety to another. The general properties of water-soluble dietary fiber compounds include large polymeric molecules, complex structures, lots of hydroxyl groups, and large water-binding capacities.

A large number of polar free hydroxyl groups and the multiple matrix structure provide great opportunities for water binding through hydrogen bonds. The water-binding property of dietary fiber is important in retaining water in the stomach, increasing the viscosity of food in the small intestine, and influencing nutrition and body metabolism. These reactions include an increase in stool mass, a decrease in plasma cholesterol levels, and a decrease in the glycemic response to food. Soluble dietary fiber is widely used in water-based foods, such as soups, drinks, and puddings, while insoluble dietary fiber is widely used in solid foods (41).

Insoluble Dietary Fiber Test

Moringa leaf flour substitution on analog rice had a significant difference (p<0.001) in the insoluble dietary fiber content. Subsequent Duncan's test demonstrated significant differences among all treatment groups, including P1, P2, P3, P4, P5, and P6.
Insoluble dietary fiber consists of cellulose, hemicellulose, and lignin. The interaction of insoluble dietary fiber with the heating process causes damage to the gel structure of pectin and hemicellulose, leading to a decrease in fiber content observed in P6. Among dietary fibers, insoluble dietary fiber cannot be adequately fermented by bacteria in the large intestine. Instead, it acts as a laxative, promoting an increase in fecal mass and bile acid excretion, while also reducing intestinal transit time (37)

Total Dietary Fiber Test

Moringa leaf flour substitution in analog rice resulted in a significant difference (p<0.001) in the total dietary fiber content. This result was followed by Duncan's test, which showed

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

significant differences in all treatment groups P1, P2, P3, P4, P5, and P6.

Each treatment group in this study exhibited a distinct total dietary fiber content value. A study by Augustyn et al. (2017) found that the higher the addition of moringa leaf flour, the higher the fiber content. However, P6, with the addition of 10% moringa leaf flour, the highest among other treatments, experienced a decrease in fiber content. This decrease can be attributed to insufficient attention to the heating temperature during the cooking process for P6, which caused a decline in the total dietary fiber content. Total dietary fiber is calculated as the sum of insoluble and soluble dietary fiber. Based on the observations and analysis results, the interaction between the heating method and temperature has a significantly different effect on the total dietary fiber content (43).

In addition, the decrease in fiber content in P6 is due to soluble dietary fiber as part of insoluble and total dietary fiber. During the cooking process, heating causes the fiber component to dissolve in the water, leading to the hydrolysis of water-insoluble protopectin compounds into pectinate (pectin), which further dissolves in water and reduces the soluble dietary fiber levels (36). Insoluble dietary fiber consists of cellulose, hemicellulose, and lignin. The interaction of insoluble dietary fiber with the heating process causes damage to the gel structure of pectin and hemicellulose, contributing to the overall fiber content decrease in P6 (36).

Dietary fiber causes some alterations in hormone levels in the digestive tract, influencing nutrient absorption, and regulating insulin secretion. Dietary fiber helps increase insulin sensitivity and stabilizes blood glucose levels, thereby protecting against complications due to Diabetes. Moreover, dietary fiber can help prevent or reduce the risk of degenerative diseases like coronary heart disease, diabetes, and cancer. Therefore, analog rice, with Moringa leaf flour substitution, formulated from sorghum flour, mocaf, and glucomannan, can serve as a valuable food source of dietary fiber (44).

CONCLUSION

Analog rice with substitution of Moringa leaf flour mixed with sorghum flour, mocaf, and glucomannan extract from porang tuber, showed significant differences in preference level among panelists, encompassing color, aroma, taste, and texture. As the proportion of Moringa leaf flour increased, the overall preference level decreased. The most preferred analog rice variant was P2 (2%). Substitution of moringa leaf flour in analog rice led to significant differences in total dietary fiber, soluble dietary fiber, and insoluble dietary fiber content; P5 (8%) demonstrated the highest total dietary fiber content among all variants.

REFERENCES

1. Kemenkes RI. Infodatin-2020-Diabetes-Melitus.pdf. 2020.
2. International Diabetes Federation (IDF). IDF DIABETES ATLAS NONTH EDITION 2019. 2020.
3. Kemenkes RI. Hasil Riset Kesehatan Dasar Tahun 2018. Kementrian Kesehatan RI. 2019;53(9):1689–99.
4. Arif A Bin, Budiyanto A, Hoerudin D, Penelitian BB, Pengembangan D, Pertanian P. Glicemic Index of Foods and Its Affecting Factors. Jurnal Litbang Pertanian. 2013;32(3):91–9.
5. Widowati S, Astawan M. Penurunan Indeks Glikemik berbagai Varietas Beras Melalui Proses Pratanak.

Jurnal Penelitian Pascapanen Pertanian. 2018;6(1):1–9.
6. Darmanto Y, Riyadi PH, Susanti S. Beras Analog Super. 1st ed. Semarang: Undip Press; 2017.
7. Mahfuzhah N, Ridwansyah, Lubis Z. KARAKTERISTIK KIMIA BERAS ANALOG BERBAHAN BAKU TEPUNG KOMPOSIT DARI JAGUNG, SAGU, SORGUM, DAN UBI KAYU. 2018;6(4):734–40.
8. Suarni. Potensi Sorgum sebagai Bahan Pangan Fungsional. Iptek Tanaman Pangan. 2012;7(1):58–66.
9. Yousif A, Nhepera D, Johnson S. Influence of sorghum flour addition on flat bread in vitro starch digestibility, antioxidant capacity and consumer acceptability. Food Chemistry. 2012 Sep;134(2):880–7.
10. Ademiluyi AO, Oboh G. Soybean phenolic-rich extracts inhibit key-enzymes linked to type 2 diabetes (α-amylase and α-glucosidase) and hypertension (angiotensin I converting enzyme) in vitro. Experimental and Toxicologic Pathology. 2013 Mar;65(3):305–9.
11. Ambarwati A. Penentuan Indeks Glikemik Biji Sorgum yang Dioalah dengan Cara Ditanak pada Hewan Coba Kelinci (Oryctolagus Cuniculus). Fakultas Farmasi , Universitas Airlangga. 2013;
12. Subagio A, Windrati WS. Pengaruh Komposisi MOCAF (Modified Cassava Flour) dan Tepung Beras pada Karakteristik Beras Cerdas. Pangan. 2012;21(1):29–38.
13. Loebis E, Junaidi L, Susanti I. Karakterisasi Mutu Dan Nilai Gizi Nasi Mocaf Dari Beras Analog - (Characterization of Quality and Nutrition Value of Cooked Rice Mocaf From Rice Analog). Biopropal Industri. 2017;8(1):33–46.
14. Alethea T, Ramadhian MR. Efek Antidiabetik pada Daun Kelor. Jurnal Majority. 2015;Vol 4(No 9):Hal 118-122.
15. Fatmawati A, Sucianingsih D, Kurniawati R, Abdurrahman M. Microscopic Identification and Determination of Total Flavonoid Content of Moringa Leaves Extract and Ethyl Acetate Fraction (Moringa oleifera L.). Indonesian Journal of Pharmaceutical Science and Technology. 2021;1(0):66–74.
16. Syamra A. Pemberian Rebusan Daun Kelor Terhadap Penurunan Kadar Glukosa Darah Pada Pasien Penderita Diabetes Mellitus (DM). Media Laboran. 2018;8(Dm):51.
17. Aini. Makalah Kelor (Moringa Oliefera). Fakultas Kesehatan Masyarakat, Universitas Sumatera Utara. 2015;
18. Nabilla D, Aji A, Nufaisah A, Saputri W, Aprilia V, Rahayu H, et al. Pengembangan Biskuit "Prozi" Tinggi Protein dan Kaya Zat Besi untuk Ibu Hamil sebagai Upaya Pencegahan Stunting: Prozi Biscuit Development. Amerta Nutrition. 2022 Dec 23;6:79–84.
19. Sunarti. Serat Pangan dalam Penanganan Sindrom Metabolik. 1st ed. yogyakarta: Gadjah Mada University Press; 2017.
20. Susanti N. SUPLEMENTASI TEPUNG PORANG (Amorphophallus muelleri Blume) SEBAGAI Nutraceutical DALAM MANAJEMEN DIABETES MELLITUS TIPE 2. el–Hayah. 2014 Sep;5(1):9.
21. Siska Ariftiyana, Veriani Aprilia, Lieyan Nurfikasari, Dwi Muriyati, Agus Prastowo, Yulinda Kurniasari, et al. Porang (Amorphophallus oncophyllus) Flour Macerated with Strobilanthes crispus Reduced the Blood Glucose Levels of Streptozotocin-Induced Diabetic

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

Rats | Open Access Macedonian Journal of Medical Sciences. 2023 Jul 23 [cited 2023 Jul 27]; Available from: https://oamjms.eu/index.php/mjms/article/view/9505
22. Notoatmojo. Metodologi Penelitian Kesehatan. Jakarta: Rineka Cipta; 2010.
23. Kartika, Bambang, Hastuti P, Supartono W. Pedoman Uji Inderawi Bahan Pangan. yogyakarta: Pusat Antar Universitas Pangan dan Gizi Universitas Gadjah Mada; 1998.
24. Pimentel TC, Gomes da Cruz A, Deliza R. Sensory Evaluation: Sensory Rating and Scoring Methods. In: Caballero B, Finglas PM, Toldrá F, editors. Encyclopedia of Food and Health [Internet]. Oxford: Academic Press; 2016 [cited 2023 Jun 4]. p. 744–9. Available from: https://www.sciencedirect.com/science/article/pii/B9780123849472006176
25. Cunniff P. Official methods of analysis of AOAC international. 16th ed. Washington, DC: Association of Official Analytical Chemists; 1995. 2 p.
26. Nisizawa K. Seaweeds Kaiso. Japan Seaweed Association, editor. Tokyo: USA Marine Biological Institute; 2002. 106 p.
27. Negara JK, Sio AK, Rifkhan R, Arifin M, Oktaviana AY, Wihansah RRS, et al. Aspek mikrobiologis, serta Sensori (Rasa, Warna,Tekstur, Aroma) Pada Dua Bentuk Penyajian Keju yang Berbeda. Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan. 2016;4(2):286–90.
28. Damat D, Tain A, Winarsih S, Siskawardhani DD, Rastikasari A. Teknologi Proses Pembuatan Beras Analog Fungsional. 2020. 93 p.
29. Zakaria, Nursalim, Tamrin A. Pengaruh Penambahan Tepung Daun Kelor Terhadap Daya Terima dan Kadar Protein Mie Basah. Media Gizi Pangan Tepung Daun Kelor. 2016;21(1):73–8.
30. Sari FI. Pengaruh Penambahan Tepung Daun Kelor (Moringa oleifera) dalam Pembuatan Bolu Kukus Menggunakan Tepung Terigu dan Tepung Pisang Kepok Putih [Internet] [Thesis]. Universitas Sumatera Utara; 2019 [cited 2023 Jun 5]. Available from: https://repositori.usu.ac.id/handle/123456789/16248
31. Komalasari H, Saloko S, Sulastri Y. PENGARUH PENGGUNAAN DAUN KELOR DAN PENAMBAHAN Sargassum sp. TERHADAP SIFAT FISIKOKIMIA DAN SENSORIS BERAS ANALOG. Universitas Mataram. 2017;
32. Deman J. Principle of Food Chemustry (Terjemahan) Kimia Makanan. 2nd ed. Padmawinata K, editor. Bandung: ITB Press; 1989. 50–214 p.
33. Ilona, A D, Ismawati R. Pengaruh penambahan ekstrak daun kelor (Moringa oleifera) dan waktu inkubasi terhadap sifat organoleptik yoghurt. Jurnal Tata Boga. 2015;4(3):151–9.
34. Khasanah V, Astuti P. Pengaruh Penambahan Ekstrak Dau Kelor (Moringa Oleifera) Terhadap Kualitas Inderawi Dan Kandungan Protein Mie Basah Substitusi Tepung Mocaf. Jurnal Kompetensi Teknik. 2019;11(2):15–21.
35. Gultom NS. Pengaruh Perbandingan Tepung Mocaf dengan Tepung Terigu dan Penambahan Tepung Daun Kelor Terhadap Mutu Cup Cake. 2019;
36. Cahyaningati O. PENGARUH PENAMBAHAN TEPUNG DAUN

KELOR (Moringa oleifera Lamk) TERHADAP KADAR β-KAROTEN DAN ORGANOLEPTIK BAKSO IKAN PATIN (Pangasius pangasius). JFMR-Journal of Fisheries and Marine Research. 2020;4(3):345–51.
37. Ismarani. POTENSI SENYAWA TANNIN DALAM MENUNJANG PRODUKSI RAMAH LINGKUNGAN Ismarani Abstract menjadi hydrolyzable tannin dan condensed tannins (proanthocyanidins). Jurnal Agribisnis dan Pengembangan Wilayah. 2012;3(2):46–55.
38. Aminah S, Ramdhan T, Yanis M. Kandungan Nut risi dan Sifat Fungsional Tanam an Kelor (M oringa oleifera). Buletin Pertanian Perkotaan. 2015;5(30):35–44.
39. Agustin AT, Zaini MA, Handito D. Pengaruh Metode Dan Suhu Blanching Terhadap Persenyawaan Serat Batang Pisang Sebagai Bahan Baku Pembuatan Ares. Pro Food. 2020;6(1):609–22.
40. Angelina C, Swasti YR, Pranata FS. PENINGKATAN NILAI GIZI PRODUK PANGAN DENGAN PENAMBAHAN BUBUK DAUN KELOR (Moringa oleifera): REVIEW. Jurnal Agroteknologi. 2021;15(01):79.
41. Deehan EC, Duar RM, Armet AM, Perez-Muñoz ME, Jin M, Walter J. Modulation of the Gastrointestinal Microbiome with Nondigestible Fermentable Carbohydrates To Improve Human Health. Britton RA, Cani PD, editors. Microbiology Spectrum. 2017 Sep;5(5).
42. Ioniță-Mîndrican CB, Ziani K, Mititelu M, Oprea E, Neacșu SM, Moroșan E, et al. Therapeutic Benefits and Dietary Restrictions of Fiber Intake: A State of the Art Review. Nutrients. 2022 Jun 26;14(13):2641.
43. Hernawan E, Meylani V. Analisis Karakteristik Fisiokimia Beras Putih, Beras Merah dan Beras Hitam (Oryza sativa L., Oryza nivara dan Oryza sativa L. indica). Jurnal Kesehatan Bakti Tunas Husada: Jurnal Ilmu-ilmu Keperawatan, Analis Kesehatan dan Farmasi. 2016;15(1):79.
44. Kumolontang N, Edam M. Kandungan Serat Pangan dan Tingkat Kesukaan Beras Analog Berbahan Tepung Talas dan Tepung Kelapa The Level of Accepetance and Fiber Conten of Rice Analogue Made from Taro and Coconut Flour Mixture Nova Kumolontang , Mariati Edam. Jurnal Penelitian Teknologi Industri. 2020;12(1):11–8.
45. Augustyn GH, Tuhumury HCD, Dahoklory M. Pengaruh Penambahan Tepung Daun Kelor (Moringa oleifera) Terhadap Karakteristik Organoleptik dan Kimia Biskuit Mocaf (Modified Cassava Flour). AGRITEKNO, Jurnal Teknologi Pertanian. 2017;6(2):52–8.
46. Susilowati E. Kajian Aktivitas Antioksidan, Serat Pangan, dan Kadar Amilosa pada Nasi yang Disubtitusi dengan Ubi Jalar (Ipomoea batatas L.) sebagai Bahan Makanan Pokok. Universitas Sebelas Maret. 2010. 22 p.
47. Noviasari S, Kusnandar F, Setiyono A, Budijanto S. Beras Analog Sebagai Pangan Fungsional Dengan Indeks Glikemik Rendah. Jurnal Gizi dan Pangan. 2016;10(3):225–32.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.4

OPEN ACCESS

Indonesian Journal of Human Nutrition
P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

Knowledge of Dietary Recommendations, Food Availability, and Food Selection Attitudes of Adults during the COVID-19 Pandemic

Elvira Dona Lukmana [1*)], Meirina Dwi Larasati [2], Mohammad Jaelani [3]

[1*)] Nutrition and Dietetics, Nutrition Department, Semarang Health Polytechnic of Ministry of Health
[2,3] Nutrition and Dietetics, Nutrition Department, Semarang Health Polytechnic of Ministry of Health

*Corresponding author: Elvira Dona Lukmana. Email: lukmanaelvira@gmail.com

Accepted: December 2021 Reviewed: September 2022 Published: July 2023

ABSTRACT

SARS-CoV-2, the novel coronavirus responsible for COVID-19 disease, has affected all regions of Indonesia, leading to an increase in cases and prompting the Indonesian government to impose Large-Scale Social Restrictions (LSSR). Prolonged exposure to LSSR can potentially impact diet, dietary availability, and food preferences. Therefore, understanding the knowledge of dietary recommendations during the COVID-19 pandemic is crucial to support individuals in maintaining a healthy diet and lifestyle. This study aims to investigate the relationship between knowledge of dietary intake recommendations, food availability, and food selection attitudes among adults during the COVID-19 pandemic. A cross-sectional design was employed, and 124 individuals were selected as research subjects using a purposive sampling technique. The data on knowledge, food availability, and attitudes toward food selection were collected through a Google Forms questionnaire. Statistical test was conducted using the Fisher Exact test to determine the relationship between variables. The findings of this study demonstrated no correlation between knowledge and food selection attitude ($p>0.05$), as well as between food availability and food selection attitude ($p>0.05$). However, there was a tendency for individuals with good knowledge to have good attitudes and individuals with good attitudes to have sufficient food availability, despite the absence of statistical correlation.

Keywords: food availability, knowledge, food selection attitude, COVID-19 pandemic

ABSTRAK

SARS-CoV-2 merupakan virus corona jenis baru yang menjadi penyebab penyakit infeksi menular yaitu COVID-19. Penyebaran COVID-19 yang sudah menjangkau ke seluruh wilayah di Indonesia dengan jumlah kasus yang terus meningkat, maka Pemerintah Indonesia memberlakukan PSBB. PSBB dalam jangka waktu lama dapat mempengaruhi pola makan, ketersediaan pangan, dan pemilihan makan pada individu. Hal tersebut perlu didukung dengan pengetahuan rekomendasi asupan makan selama pandemi COVID-19 yang diharapkan dapat membantu mempertahankan asupan zat gizi dan gaya hidup yang sehat. Penelitian ini bertujuan untuk mengetahui hubungan pengetahuan rekomendasi asupan makan dan ketersediaan pangan terhadap sikap pemilihan

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.5

makanan orang dewasa selama pandemi COVID-19. Penelitian ini menggunakan rancangan *cross sectional*. Pengambilan sampel dilakukan dengan teknik *purposive sampling* dan didapatkan subyek penelitian sebanyak 124 orang. Data pengetahuan, ketersediaan pangan, dan sikap pemilihan makanan didapat dari pengisian kuesioner online melalui Google Form. Uji statistik untuk mengetahui hubungan antar variable menggunakan uji *Fisher Exact*. Hasil penelitian menunjukkan bahwa tidak ada hubungan hubungan pengetahuan dan sikap pemilihan makanan ($p>0.05$), begitu juga tidak ada hubungan ketersediaan pangan dan sikap pemilihan makanan ($p>0.05$). Hasil penelitian ini menunjukkan ada kecenderungan pengetahuan baik memiliki sikap baik, dan sikap yang baik memiliki ketersediaan pangan cukup meskipun tidak ada hubungan secara statistik.

Kata kunci: ketersediaan pangan, pengetahuan, sikap pemilihan makanan, pandemi COVID-19

INTRODUCTION

SARS-CoV-2 (Severe Acute Respiratory Syndrome-coronavirus-2) is a newly identified coronavirus responsible for COVID-19 disease [1]. Similar to other respiratory illnesses, such as influenza, MERS, and SARS, SARS-CoV-2 can be transmitted to humans via the respiratory system [2,3]. COVID-19 is causing a global pandemic due to its extensive dissemination. As of the end of September, WHO had reported 33,502,430 confirmed positive cases of COVID-19 worldwide. In Indonesia, the number of confirmed positive cases was 282,724 and continuously increasing [4]. In response to the escalating spread of COVID-19, the Indonesian government commenced imposing Large-Scale Social Restrictions (LSSR), which were implemented in nearly all provinces in Indonesia [5]. The objective of LSSR was to curb and prevent COVID-19 transmission by imposing restrictions on activities for individuals in a suspected COVID-19-infected area [6]. During LSSR, some activities were restricted, including the closure of schools and workplaces, limitations on religious activities, and closures of public facilities [7].

Prolonged implementation of LSSR could affect individuals' dietary patterns, food availability, and food selections [8]. A study showed that during a pandemic, most individuals purchased ready-to-eat foods more frequently than preparing their own [9]. Limited access to vegetables, fruit, and salmon during a pandemic, as reported by Di Renzo et al. (2020) and Górnicka et al. (2020), leads people to consume high-fat, high-sugar, and high-sodium, such as fast food, ready-to-eat cereals, and snacks [10,11]. According to Scarmozzino and Visioli's (2020) study, as many as 42.5% of participants increased their consumption of comfort foods, such as ice cream, chocolate, confectionery, and culinary nibbles [12]. The COVID-19 pandemic also rose people's concerns about food availability at home, prompting them to take the necessary precautions to feel safe and secure throughout the LSSR. Additionally, people commenced purchasing food in large quantities or panic buying, aiming to ensure they would not run out of food in the future [13,14]. Changes in food selection attitudes, affected by food availability and knowledge, alter the nutritional quality of the food consumed [15]. Efforts could be made to increase knowledge of recommended dietary intake. During the COVID-19 pandemic, the Ministry of Health issued guidelines for balanced nutrition, including maintaining a balanced and nutritious diet [16]. During the COVID-19 pandemic, these food intake recommendations aimed to increase public knowledge and attitudes regarding recommendations and the selection of food

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.5

intake; thus, they could maintain nutrient intake and a healthy lifestyle [16–19].

This study aimed to investigate the relationship between knowledge of dietary intake recommendations, food availability, and the attitude of adults toward food selections during the COVID-19 pandemic.

RESEARCH METHODS

Study Design

This research utilized a cross-sectional design.

Data Source

Primary data were collected through online questionnaires distributed via Google Forms

Research Objectives

Sampling was conducted using a purposive sampling technique, in which samples were selected based on criteria established by the researcher. The inclusion criteria for this research were 26- to 45-year-old residents of Magetan Regency who had local COVID-19 transmission and were able to read, type, and access the internet. While the exclusion criteria included subjects who did not work, had non-communicable diseases, were confirmed positive for COVID-19, and received or sought information on the treatment of COVID-19 disease. The subjects comprised of 124 individuals who met the inclusion criteria and were selected using the Slovin formula to determine the sample size.

Instrument Development and Data Collection Techniques

The data were collected directly by filling out an online questionnaire using Google Forms. The questionnaire consisted of three sections: 1) knowledge data, this section included 13 questions related to the meaning of dietary intake recommendations; foods should be increased or restricted; portions of carbohydrate meals, animal side dishes, vegetable side dishes, vegetables and fruit intake in a day; types of vitamins and minerals that play a role in improving the immune system, 2) food availability data, this section comprised 7 questions related to experiences during the last 12 months, including whether the subject had ever run out of food, food consumption, or food shortages: experienced food shortages, unbalanced food consumption, ran out of money to buy food and reduced meal portions, and 3) food selection attitude data, this section included 13 questions related to whether the subject consumed a variety of foods and in accordance with the amount his body needed, regular eating habit, and reduced cigarette and alcohol consumption during the COVID-19 pandemic.

Assessment criteria were: 1) Knowledge was deemed adequate if the subject understood the meaning of dietary intake recommendations; what foods should be increased/restricted; portions of carbohydrates, animal side dishes, vegetable side dishes, vegetables and fruit in a day; types of vitamins and minerals that play a role in enhancing the immune system; and types of vitamins and minerals that play a role in preventing disease. 2) Food availability was adequate if, in the past year, the subject never: experienced food shortages; failed to consume a balanced diet; ran out of money to purchase food; or reduced food portions. 3) The subject had a good food selection attitude if he consumed various foods in proportion to his body's requirements, eats routinely, and reduced his cigarette and alcohol consumption during the COVID-19 pandemic.

The questionnaire devised for this study had been subjected to validity and reliability test by administering a pilot test involving 39 adults aged 26 to 45 in Magetan Regency.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.5

Data Analysis Technique

The relationship between knowledge of food intake recommendations and food selection attitudes, as well as the relationship between food availability and food selection attitudes were tested using Fisher's Exact Test.

This study has been authorized by the Health Research Ethics Committee, Faculty of Medicine, Jenderal Soedirman University (KEPK FK UNSOED), with the ethical clearance number 082/KEPK/III/2021.

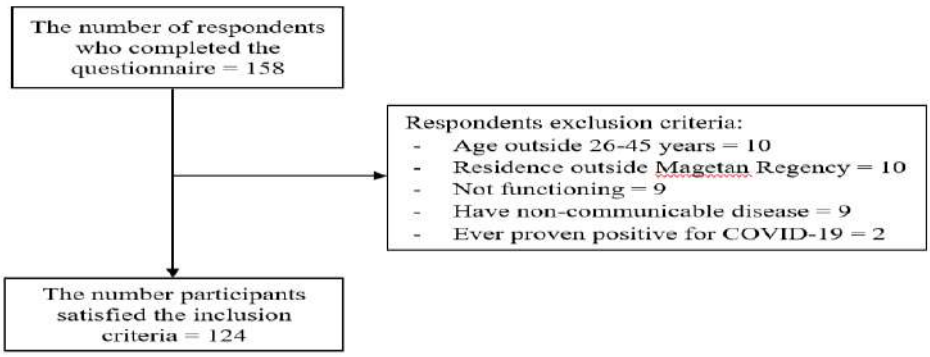
RESEARCH RESULTS

Subject Characteristics

The data collection took place from 25th April to 26th May 2021. A total of 158 participants completed the online questionnaire. The research sample was selected under the inclusion criteria. Excluded samples included those who were not between the age range of 26 and 45 (10 individuals), did not reside in Magetan regency (10 individuals), did not work (9 individuals), had infectious disorders (3 individuals), and tested positive for COVID-19 (2 individuals). As shown in Figure 1, the final number of subjects who satisfied the inclusion criteria was 124.

Age, gender, nutritional status, most recent education, working during the COVID-19 pandemic, and average monthly income were some of the characteristics of the subjects in this study. Table 1 displays the frequency distribution of subject characteristics.

The frequency distribution of subject characteristics by age is revealed in Table 1; all 124 subjects fell within the age range of 26 to 45 years, the eldest subject was 45 years old, and the youngest individual was 26 years old. The majority of the population was female (72 people, or 58.1%), while the remaining were male (52 people, or 41.9%). Based on a report or acknowledgment of the subject's weight and height, nutritional status was computed using the Body Mass Index (BMI). Of the subjects, 58 individuals (46.8%) had a normal nutritional status, while 8 individuals (6.5%) had an undernourished nutritional status. The sample with the lowest nutritional status weighs 16.3 kg/m2, and the sample with the most significant nutritional status weighs 35.5 kg/m2. Most of the participants had Diploma / Bachelor / Postgraduate degrees, or 92 individuals (74.2%), and on the other hand, the remaining participants were Senior High School equivalent degrees, or 32 people (25.8%). During the COVID-19 pandemic, the majority of the samples continued to work without changes, directly to the workplace (79 people, or 63.7%), and the remainder worked full-time remotely (45 people, or 36.3%). The average monthly income was predominantly 2,500,000 IDR (59 people, or 47.6%), and the remainder were between 500,000 and 1,000,000 IDR (28 people, or 22.6%).



DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.5

Figure 1. Flowchart of the Sampling Process

Table 1. Subject Characteristics

Subject Characteristics	Frequency (n)	Percentage (%)
Age		
26-45 years old	124	100%
Gender		
Male	52	41.9%
Female	72	58.1%
Nutrition Status		
Undernourished	8	6.5%
Normal	58	46.8%
Overweight	54	43.5%
Unknown	4	3.2%
Last Education		
Diploma/Bachelor's Degree/Postgraduate	92	74.2%
High school/equivalent	32	25.8%
How to work during the COVID-19 pandemic		
Working full-time remotely	45	36.3%
Working without change (straight to the workplace)	79	63.7%
Average Income per Month		
≥2.500.000	59	47.6%
1.000.000 - <2.500.000	37	29.8%
500.000 - 1.000.000	28	22.6%

Knowledge

Table 2. Knowledge Level

Knowledge Level	Frequency (n)	Percentage (%)
Less	37	29.8
Fair-Good	87	70.2
Total	124	100

Table 2 shows that most subjects had a moderately decent knowledge level, comprising 87 individuals (70.2%). Fair-good knowledge of dietary intake recommendations indicated that subjects comprehend the meaning of dietary intake recommendations, what foods should be increased/restricted, recommended portions of carbohydrates, animal side dishes, vegetable side dishes, vegetables and fruits in a day, and types of vitamins and minerals that played a role in enhancing the immune system.

Food Availability

Table 3. Food Availability Level

Food availability level	Frequency (n)	Percentage (%)
Less	15	12.1
Good	109	87.9
Total	124	100

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.5

Table 3 demonstrates that the food availability level of the vast majority of subjects, 109 individuals (87.9%), fell within an acceptable range. A subject's food availability was regarded as good if, in the last 12 months, they never experienced running out of food, not eating a balanced diet, running out of money to purchase food, or reducing meal portions.

Food Selection Attitude

Table 4. Food Selection Attitude Level

Food selection attitude	Frequency (n)	Percentage (%)
Less	6	4.8
Good	118	95.2
Total	124	100

According to Table 4, 118 (or 95.2%) of the subjects exhibited food selection attitudes that fell into the good category. A good food selection attitude was determined by several factors, including consuming various foods in proportion to the body's requirements, maintaining regular eating habits, and reducing cigarette and alcohol consumption during the COVID-19 pandemic.

Relationship between Knowledge and Food Selection Attitude

Table 5. Relationship between Knowledge and Food Selection Attitude

Knowledge	Food Selection Attitude				Total		P *value*
	Less		Good				
	N	%	N	%	N	%	
Less	3	2.4	34	27.5	37	29.9	
	50.0%		28.8%		29.9%		
Fair-Good	3	2.4	84	67.7	87	70.1	
	50.0%		71.2%		70.1%		
Total	6	4.8	118	95.2	124	100	
	100.0%		100.0%		100.0%		

*Correlation Test *Fisher Exact*

The analysis presented in Table 5 indicated no correlation between knowledge and food selection attitude (p=0.362). Although the statistical analyses revealed no significant correlation between knowledge and food selection attitudes, there was a 50.0% correlation between inadequate knowledge and poor food selection attitudes. If knowledge was sufficient, attitudes towards food selection were also good (71.2%).

Relationship between Food Availability and Food Selection Attitude

Table 6: Relationship between Food Availability and Food Selection Attitude

Food Availability	Food Selection Attitude				Total		P *value*
	Less		Good				
	N	%	N	%	N	%	
Less	1	0,8	14	11.3	15	12.1	
	16.7%		11.9%		12.1 %		
Good	5	4,0	104	83.9	109	87.9	
	83.3%		88.1%		87.9%		
Total	6	4,8	118	95.2	124	100	
	100.0%		100.0%		100.0%		

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.5

*Correlation Test *Fisher Exact*

Table 6 demonstrates no relationship between food availability and food selection attitude (p=0.547). However, there was a tendency that when food availability was limited, the level of food selection attitude was also lower (16.7%). On the other hand, if food availability was sufficient, the food selection attitude tended to be good (88.1%) despite no statistical relationship between the two.

DISCUSSION

Relationship between Knowledge and Food Selection Attitude

The Fisher-Exact correlation test analysis of the relationship between knowledge and food selection attitudes revealed no correlation between knowledge and food selection attitudes (p=0.362). The test findings indicated a correlation that was not statistically significant; however, subjects with a high level of knowledge tended to have good attitudes toward food selection. Attitudes and behaviors regarding food consumption are correlated with nutrition and health knowledge. Those with greater knowledge generally have better attitudes and behavior toward food selection [20]. Nonetheless, attitudes and dietary preferences were contingent on knowledge and environmental factors [21].

Relationship between Food Availability and Food Selection Attitude

The Fisher-Exact correlation test analysis of the relationship between food availability and food selection attitudes revealed no correlation (p=0.547). Subjects with sufficient food availability tend to have a good attitude toward food selection. Contrary to the findings of Story in Mohammad and Madanijah (2015), the study results indicated a correlation between food availability at home and consumption of vegetables and fruits. It is because food availability factors were not only related to food selection attitudes, and having sufficient food availability does not guarantee that an individual will choose healthy foods [22].

According to the findings of Aprillia and Dieny (2011), there was no correlation between the availability of healthy and harmful foods and attitudes toward refreshment selection. This suggests that food availability is not the sole factor associated with food selection attitudes; thus, adequate food availability does not guarantee the selection of healthy foods [23]. Several factors, including individual characteristics, such as age, gender, education level, level of knowledge, and psychological condition; food characteristics, such as organoleptic properties of food, food storage methods, ease of digestion, and food availability; and environmental characteristics, such as food temperature affected food selection attitudes [24]. The fact that most research results on subject characteristics related to food availability are classified as adequate do not guarantee that an individual could determine a good food selection attitude.

CONCLUSIONS

Knowledge occasionally results in good food selection attitudes. Good food selection attitudes are not the only factor determining adequate food supply. Other factors affecting food selection attitudes include the motivation to live a healthful lifestyle, the environment, and culture. During the COVID-19 pandemic, these factors were additional determinants associated with food selection attitudes and food availability. Consequently, it is necessary to analyze other factors affecting the research variables.

REFERENCES

1. WHO. Pertanyaan dan Jawaban

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.5

terkait Coronavirus. 2020; Available from: https://www.who.int/indonesia/news/novel-coronavirus/qa-for-public
2. Setiawan AR. Lembar Kegiatan Literasi Saintifik untuk Pembelajaran Jarak Jauh Topik Penyakit Coronavirus 2019 (COVID-19). Edukatif J Ilmu Pendidik. 2020;2(1):28–37.
3. Aaseth J. Early Nutritional Interventions with Zinc, Selenium Against Progressive COVID-19. Nutrients. 2020;12:1–12.
4. WHO. Coronavirus Disease (COVID-19) Pandemic [Internet]. 2020. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019
5. Kementerian Kesehatan RI. Pedoman Pencegahan dan Pengendalian COVID-19. Math Didactic: Jurnal Pendidikan Matematika. 2020. p. 1–214.
6. Herdiana D. Implementasi Kebijakan Pembatasan Sosial Berskala Besar (PSBB) sebagai Upaya Penanggulangan Corona Virus Disease 2019 (COVID-19). Vol. 2019. STIA CIMAHI; 2019.
7. Fauzi A. Implementasi Pembatasan Sosial Berskala Besar, Sebuah Kebijakan Publik dalam Penanganan Pandemi COVID-19. J Ilmu Adm Negara. 2020;16(1):174–8.
8. Caulfield T. Pseudoscience and COVID-19 — We've Had Enough Already. Nature. 2020 Apr;
9. Sidor A, Rzymski P. Dietary Choices and Habits during COVID-19 Lockdown: Experience from Poland. Nutrients. 2020;12(6):1–13.
10. Górnicka M, Drywień ME, Zielinska MA, Hamułka J. Dietary and Lifestyle Changes During COVID-19 and the Subsequent Lockdowns among Polish Adults: A Cross-Sectional Online Survey PLifeCOVID-19 Study. Nutrients. 2020;12(2324):1–20.
11. Di Renzo L, Gualtieri P, Pivari F, Soldati L, Attinà A, Cinelli G, et al. Eating Habits and Lifestyle Changes during COVID-19 Lockdown: An Italian Survey. J Transl Med [Internet]. 2020;18(1):1–15. Available from: https://doi.org/10.1186/s12967-020-02399-5
12. Scarmozzino F, Visioli F. Covid-19 and the Subsequent Lockdown Modified Dietary Habits of Almost Half the Population in an Italian Sample. Foods. 2020;9(5):1–8.
13. Eva N, Saputra DR, Wulandari DA, Yahya FA, Annisa W. Panic-Buying Behaviour During the COVID-19 Outbreak: A Cross-Cultural Psychological Study. KnE Soc Sci. 2021;2020:80–7.
14. Jeżewska-Zychowicz M. Consumers' Fears Regarding Food Availability and Purchasing Behaviors during The COVID-19 Pandemic: The Importance of Trust and Perceived Stress. Nutrients. 2020;12(9):1–14.
15. Marty L, Lauzon-guillain B De, Labesse M, Nicklaus S. Food Choice Motives and The Nutritional Quality of Diet during The COVID-19 Lockdown in France. Elsevier. 2020;157(January):1–7.
16. Kementerian Kesehatan RI. Panduan Gizi Seimbang pada Masa Pandemi COVID-19 [Internet]. 2020. p. 1–32. Available from: https://covid19.go.id/storage/app/media/Materi Edukasi/final-panduan-gizi-seimbang-pada-masa-covid-19-1.pdf
17. Larasati MD, Yuliana S. Food Intake, Nutritional Status and Cardio Respiration Health Of Swimming Athletes. J Ris Gizi.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.5

2020;8(1):37–43.
18. Laila MN, Muninggar DLP, Jaelani M. Nutrition Education Based on Android Application on Knowledge Level of Diabetes' Four Pillars Management in Prolanis Participants. J Ris Gizi [Internet]. 2020;8(1):18–24. Available from: http://ejournal.poltekkes-smg.ac.id/ojs/index.php/jrg/article/view/6273/2008
19. Luo Y, Chen L, Xu F, Gao X, Han D, Na L. Investigation on Knowledge, Attitudes and Practices about Food Safety and Nutrition in the China during the Epidemic of Corona Virus Disease 2019. Public Health Nutr. 2021;24(2):267–74.
20. Wandasari N. Hubungan Pengetahuan Ibu tentang Mie Instan dan Perilaku Konsumsi Mie Instan pada Balita di RW 04 Perumahan Villa Balaraja Kabupaten Tangerang. 2014;11(3):386–401.
21. Martini. Hubungan Antara Pengetahuan Lingkungan dengan Perilaku Prolingkungan Sekolah Adiwiyata. Rang Tek J. 2019;2(1):71–8.
22. Mohammad A, Madanijah S. Konsumsi Buah dan Sayur Anak Usia Sekolah Dasar Di Bogor. J Gizi dan Pangan. 2015;10(1):71–6.
23. Aprillia BA, Dieny FF. Faktor yang Berhubungan dengan Pemilihan Makanan Jajanan pada Anak Sekolah Dasar. Science (80-). 2011;1–63.
24. Sartika I, Nikmawati EE, Mahmudatussa'adah A. Pengetahuan dan Keterampilan Pemilihan Makanan Sehari-Hari Mahasiswa Program Studi Pendidikan Tata Busana. Media Pendidikan, Gizi, dan Kuliner. 2017;3(1):65–76.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.5

OPEN ACCESS

Indonesian Journal of Human Nutrition

P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

Effect of Energy Restriction on Malondialdehyde Levels in Rats

A. Millaty Halifah Dirgahayu[1,2*)], Aminuddin Aminuddin[3], Arif Santoso[4], Nurpudji Astuti Daud[5], Ika Yustisia[6], Irfan Idris[7]

[1] Concentration on Aging and Regenerative Medicine, Postgraduate Program in Biomedical Sciences, Graduate School of Hasanuddin University, Makassar, South Sulawesi
[2.] Departement of Physiology, Faculty of Medicine, University Muslim of Indonesia, Makassar, South Sulawesi
[3] Departement of Clinical Nutrition, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi
[4] Departement of Pulmonology, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi
[5] Departement of Clinical Nutrition, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi
[6] Departemen Biochemistry, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi
[7] Departement of Physiology, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi

*Correspondence author: A. Millaty Halifah Dirgahayu. E-mail: titydirgahayu@gmail.com

Accepted: January 2022 Reviewed: February 2022 Published: July 2023

ABSTRACT

Elevated malondialdehyde (MDA) levels indicate the occurrence of cell membrane oxidation. Calorie restriction is known to extend life expectancy. This study aims to investigate the effect of calorie restriction on MDA levels in young and old rats. An experimental approach was employed using the Rattus norvegicus Wistar strain as the experimental animals, with a pre-post-test control group design. A total of 28 white rats were included in this study and were divided into four groups. The control groups, Group A and Group B, received standard feed and unrestricted access to distilled water, while the treatment groups, Group C and Group D, were fed with a 40% reduction in calorie intake and distilled water. Data analysis was performed using SPSS 21.0 (SPSS, Inc., Chicago, IL) with a 0.05 significance level. The results showed a difference in MDA level changes between group B (control group) and group D (treatment group) ($p<0.05$). This study concludes that MDA levels are higher in the elderly compared to young rats, and a 40% calorie restriction can reduce MDA levels

Keywords: energy restriction, malondialdehyde, Rattus novergicus

INTRODUCTION

The aging process is a complex physiological mechanism, and numerous theories about the aging process have been proposed by many experts. These theories continue to evolve, but no single theory can comprehensively explain the aging process [1]. However, theories often support and complement one another. One theory that has recently been widely embraced and trusted in understanding the aging process is the free radical theory, initially proposed by Denham Harman in 1956. In modern aging theory, this theory

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.6

is called the oxidative stress theory [2,3,4]. Oxidative stress refers to an imbalance between the production of oxidants and the capacity of detoxification by antioxidants, causing functional disturbances at the cellular and molecular level [2,4,5] Free radicals formed due to oxidative stress play a crucial role in causing damage to cell function and cell survival. These free radicals include superoxide anions, hydroxyl, peroxyl, and purine radicals, which are produced during normal cell metabolism. In addition, free radicals are also formed through mitochondrial respiration, auto-oxidation of biomolecules, and environmental pollutants and radiation [6].

Reactive oxygen species (ROS), which are compounds that contain one or more unpaired electrons, have the potential to cause cell damage, including mitochondria. Increased ROS levels result in the cessation of cell replication (replication arrest or replication senescence), leading to impaired cell viability and aging [1,9]. This process gradually affects the structure and function of all systems, which decreases the adaptive capacity and increases mortality and morbidity. Humans naturally have complex antioxidant systems, both enzymatic and non-enzymatic, which synergistically protect cells and organ systems from damage caused by free radicals. Despite this natural antidote system, some free radicals still escape. Moreover, the endogenous antioxidant levels decline with age, exacerbating the impact of oxidative stress [2]

Oxidative stress can be measured by the specific end products of the process (specific end products), as free radicals have a short lifespan in circulation. In the body, free radicals most often attack and destroy unsaturated fatty acids [3]. Lipid peroxidation occurs when lipids react with free radicals, resulting in the formation of lipid peroxides. This lipid peroxide will induce endothelial damage and inflammatory response, inhibit vasodilation, and activate macrophages. The decomposition of lipid peroxide forms several byproducts, including malondialdehyde [MDA]. High concentrations of malondialdehyde indicate the process of cell membrane oxidation [2,4,6].

Robertson et al. suggested that caloric restriction can slow oxidative damage in aging animals [7]. Caloric restriction has been studied on various organisms, including flies, worms, fish, and rats, and has been found to maximize life expectancy. Calorie restriction is an act of reducing calories without depriving the individual of nutrients [8]. Research on 20 adult rats over a period of seven weeks conducted by Chuansuo et al. showed a decrease in MDA levels. [9] Similarly, Ilyasova conducted research on humans for two years and found a decrease in oxidative stress levels, as assessed by F2-Isoprotanes levels measured in urine samples.[10]

Harianja in his research entitled "The Effect of Calorie Restriction on Hydrogen Peroxide Levels and Blood Glucose Levels in Old Rats" found that the hydrogen peroxide levels in the control were higher compared to rats receiving calorie restriction treatment.[11]

Based on the aforementioned information, previous studies have investigated the effects of caloric restriction on different organisms, including mice. This prompts researchers to conduct further investigations by measuring levels of malondialdehyde (MDA) before and after caloric restriction treatment in both old and young rats. The selection of these two age groups is based on the theory proposed by Mao et al., which suggests that free radical levels increase with age. Therefore, this study aims to determine whether the effects of caloric restriction on malondialdehyde

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.6

levels differ between old and young rats [2]

RESEARCH METHOD

Design/Research Design

This research has received ethical approval with reference number 656/UN4.6.4.5.31/PP36/2021 from Hasanuddin University Health Research Ethics Committee, Faculty of Medicine. The research was carried out in accordance with the research code of ethics.

This research is an experimental study conducted on male white rats Rattus norvegicus Sprague Dawley strain. The study employed a pre-post test with a control group design, comparing the results of observations in the experimental and control groups. The study specifically focused on investigating the effects of treatment on both old and young rats, with one group receiving the treatment and the other group serving as the untreated control.

Data Source

Maintenance and administration of animal interventions were carried out at the Biopharmaceutical Laboratory, Faculty of Pharmacy, University of Hasanuddin, Makassar. Energy restriction procedures were carried out at the Entomology Laboratory, Faculty of Medicine, University of Hasanuddin, Makassar. A 40% calorie restriction was carried out on the experimental animals by modifying their standard feed. The standard feed for experimental animals not subjected to energy restriction was Van Der Vour feed, at a quantity of 15-20 grams/day with moderate water intake. The composition of Van Der Vour's standard feed includes 20% protein, 7% fat, fiber 15-20%, calcium 1%, and phosphorus. Following the energy restriction implementation, the total normal energy requirement was reduced by 40%.

Research Objectives

The research samples used were male white rats (Rattus norvegicus) of the Sprague strain, aged 3-5 months and 12-15 months, with an average weight of 145 grams and 250 grams in healthy condition. These rats were obtained from the Veterinary Laboratory, Faculty of Medicine, Hasanuddin University. The number of samples used was 28 rats. The sample size was determined according to the one-way ANOVA comparison group design.

Prior to the experiment, cage adaptation (acclimatization) was carried out for seven days. During this period, all groups of mice were given a standard feed of approximately 15-20 grams/day and given enough drink. The cages were cleaned every day. To maintain a stable environment, the rats were placed in a room with sufficient air circulation and maintained at standard room temperature (±20-280C) with a humidity level of 50%±10%. The room lighting was set in a 12-hour dark and 12-hour light cycle. The body weight measurement of all groups of rats was recorded every week. A total of 28 rats were divided into four groups, with seven rats per group. Control groups A and B received standard feed, while treatment groups C and D were treated with a 40% energy restriction for seven weeks. The 40% energy restriction is carried out every week after weighing the treatment groups C and D

Development of Instruments and Data Techniques Collection

Body weight was measured every week using an animal scale.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.6

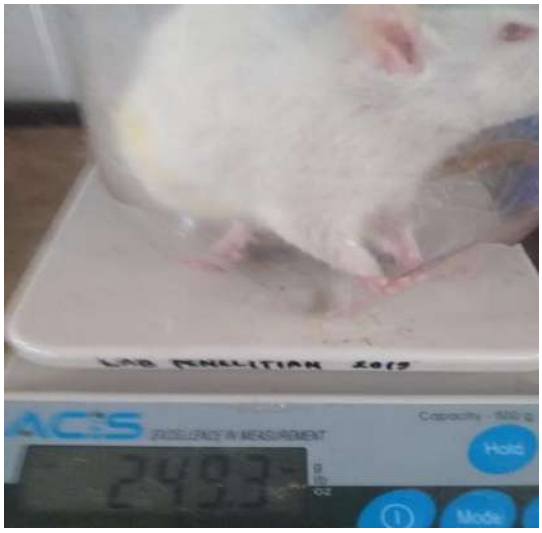


Figure 1. Weighing of young animals

Figure 2. Weighing of old animals

Data Technique Analysis

Data processing techniques used the SPSS application program with a significance of ≤ 0.05. The measurement results were presented in the form of narration and tables. The research data were then analyzed statistically using the one-way ANOVA (Analysis of Variance) test method, followed by Bonferonni post hoc test to determine the differences between groups. To compare the pre- and post-treatment data, the Paired Sample T Test was used for normally distributed data and the Wilcoxon test for non-normally distributed data.

.

RESEARCH RESULT

Statistical Test Result for Malondialdehyde (MDA) Levels in Rats

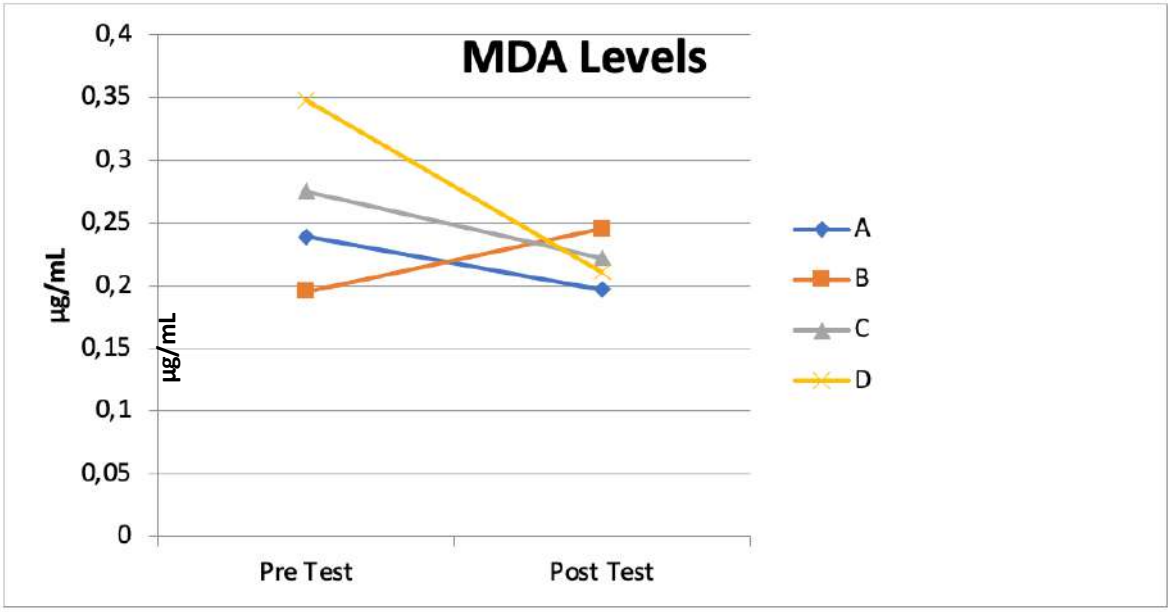
Based on Table 1 and Figure 3, the average change in rat MDA levels decreased in group A (Young Age Control) by 0.042µg/mL with a p-value of 0.162 > 0.05, so it can be concluded that the average MDA level in group A was not significant. In group B (old age control) there was an average increase in MDA levels of 049µg/mL with a p-value <0.05. This indicates a significant difference in the average MDA level in Group B. In group C (Young Age Treatment) the average MDA level decreased by 0.054µg/mL with a p-value of 0.022 <0.05. it can be concluded that the average MDA level in Group C is statistically significant. In group D (Old Age Treatment), the average mean change in MDA levels decreased by 0.137µg/mL with a p-value of <0.001. This suggests a significant difference in the average MDA levels in Group D. (Table 1 and Figure 3)

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.6

Table 1. Malondialdehyde (MDA) levels in rats by group

	MDA Levels (Mean±SD)			
Group	Pre Test	Post Test	Perubahan	p
A	0.239±0.086	0.197±0.062	0.042±0.071	0.162
B	0.195±0.044	0.245±0.039	0.049±0.049	**0.039**
C	0.275±0.075	0.222±0.061	0.054±0.047	**0.022**
D	0.348±0.046	0.211±0.028	0.137±0.029	**<0.001**

Figure 3: Malondialdehyde (MDA) Levels in Rats by Group



Based on the paired sample t-test, there was no significant difference in the average malondialdehyde (MDA) levels within the control group (both old and young). Both groups showed a slight increase in MDA levels, with an average change of 0.003 µg/mL and a p-value of 0.876 (>0.05). In contrast, the treatment group (both old and young) demonstrated a significant reduction in MDA levels, with an average change of -0.095 µg/mL and a p-value of <0.001.

The one-way ANOVA statistical test revealed no significant difference in the average change of MDA levels between the young and old age groups. The average change in MDA levels was a decrease of 0.048 µg/mL in the young age group and a decrease of 0.043 µg/mL in the old age group. The p-value was 0.884 (> 0.05), indicating no significant difference.

Comparing group A (Young Age Control) and group C (Young Age Treatment), both showed an average decrease in MDA levels of 0.042 µg/mL and 0.054 µg/mL, respectively. The p-value obtained was 0.974 (>0.05), suggesting no significant difference in the average MDA levels between the two groups.

However, there was a significant difference in the changes in MDA levels between group B (Old Age Control) and group D (Old Age Treatment). Group B exhibited an average increase in MDA

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.6

levels by 0.049 µg/mL, while group D showed an average decrease in MDA levels by 0.137 µg/mL. The obtained p-value was < 0.001, indicating a significant difference in the average MDA levels between the two groups.

Table 2. Differences in Changes of Malondialdehyde (MDA) Levels in Model Rats Between Groups

Group	Difference of MDA Levels (Pre test-Post test)		
	n	Mean ±SD	p Value*
A (Young Age Control)	7	0.042±0.071	0.013
B (Old Age Control)	7	0.049±0.049	
A (Young Age Control))	7	0.042±0.071	0.974
C (Young Age Treatment)	7	0.054±0.047	
A (Young Age Control)	7	0.042±0.071	0.011
D (Old Age Treatment)	7	0.137±0.029	
B (Old Age Control)	7	0.049±0.049	0.005
C (Young Age Treatment)	7	0.054±0.047	
B (Old Age Control)	7	0.049±0.049	<0.001
D (Old Age Treatment)	7	0.137±0.029	
C (Young Age Treatment)	7	0.054±0.047	0.029
D (Old Age Treatment)	7	0.137±0.029	
Young Age	14	0.048±0.058	0.884
Old Age	14	0.043±0.104	
treatment	14	0.095±0.057	0.001
Control	14	0.003±0.075	

Based on the results of the one-way ANOVA statistical test, there was no significant difference in the average change of MDA levels between old and young age groups. In the young age groups, there was an average decrease in MDA levels of 0.048 µg/mL, while in the old age group, there was a decrease in MDA levels of 0.043 µg/mL. The obtained p-value was 0.884 (> 0.05), indicating that the difference in average MDA levels was not significant.

Comparing the changes in MDA levels between group A (Young Age Control) and group C (Young Age Treatment), both groups showed an average decrease in MDA levels of 0.042 µg/mL and 0.054 µg/mL, respectively. The p-value obtained was 0.974 (> 0.05), indicating that the difference in average MDA levels was not significantly different. However, there was a significant difference in changes in MDA levels between group B (old age control) and group D (old age treatment). Group B exhibited an average increase in MDA levels of 0.049 µg/mL, while group D showed an average decrease in MDA levels of 0.137 µg/mL. The obtained p-value was < 0.001, indicating a significant difference in the average MDA levels between the two groups.

DISCUSSION

Effect of Energy Restriction on Malondialdehyde (MDA) Levels in Rats

The study results showed changes in the malondialdehyde (MDA) levels in rats after 7 weeks of energy restriction. In Group A (Young Age Control), there was a decrease in the average MDA levels. However, in Group B (Old Age Control), Group C (Young Age Treatment), and Group D (Old Age Treatment), there was an increase in the average MDA levels. Specifically, in the control group (both old and young), there was an average increase in MDA levels

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.6

of 0.003 µg/mL, while in the treatment group (both old and young), there was an average decrease in MDA levels of 0.095 µg/mL.

Differences in Level Changes Malondialdehyde (MDA) in Inter-Group Model Rats

There were significant differences in the average malondialdehyde (MDA) levels observed in each group. In Group A (Young Age Control), there was an average decrease in MDA levels by 0.042 µg/mL, while in Group C (Young Age Treatment), there was an average decrease in MDA levels by 0.054 µg/mL. Furthermore, there was a difference in the changes in MDA levels between Group B (Old Age Control) and Group D (Old Age Treatment), with Group B showing an average increase in MDA levels of 0.049 µg/mL, and Group D showing an average decrease in MDA levels of 0.137 µg/mL.

Based on the analysis results, it can be concluded that energy restriction has an impact on MDA levels in rats, both at a young age and an old age. At a young age, the body has a natural ability to produce antioxidants, which help counteract the production of free radicals from both internal and external sources. In a healthy state, the body has mechanisms, such as enzymatic antioxidants (SOD) and Vitamin E, to maintain a balance between MDA levels and antioxidants.

A study by Hofer and Riordan has shown that caloric restriction, leading to weight loss, can significantly reduce oxidative damage to DNA and RNA in white blood cells, as well as improve left ventricular diastolic function (12). MDA, as the end product of lipid peroxidation, can serve as an indirect measure of lipid peroxidation accumulation. While experimental animal studies have shown a relationship between Superoxidase (SOD) and MDA with age, further research and epidemiological studies are needed to explore the associations of SOD or MDA with causes of death in the older age group (2).

CONCLUSION

Based on the findings of the study, it can be concluded that implementing a 40% energy restriction for seven weeks resulted in a reduction of malondialdehyde (MDA) levels in both young and old rats.

ACKNOWLEDGEMENT

The authors would like to thank all individuals who participated in this research, and also the staff at Hasanuddin University and the University of Muslim Indonesia for their assistance.

REFERENCES REFFERENCES

1. Briant T, Weinert, Timiras PS. Physiology Of Aging; Invited Review: Theories Of Aging', J ApplPhysiol, vol. 95. 2003. 1706–16
2. Mao C, et al, Associations between superoxide dismutase, malondialdehyde and all causemortality in older adults : a community-based cohort study', BMC Geriatrics, 2019. 104.
3. Harman D, The Free Radical theory of aging, Antioxid redox signal. 2003. 557-61

4. Winarsi H. Pembentukan Senyawa Oksigen Reaktif dan Radika Bebas: Antioksidan Alami & Radikal Bebas, Penerbit Kanisius, Yogyakarta. 2007

5. Pazil SNB. Perbandingan Aktivitas Antioksidan Ekstrak Daging Pisang Raja (Musa Aab "Pisang Raja") Dengan Vitamin A, Vitamin C, Dan Katekin Melalui Penghitungan Bilangan Peroksida. 2009.
6. Singh Z, et al. Use of malondialdehyde as biomarker for assessing ocidative stress in different disease pathologies : a review, Iran J Public Health, vol. 43. 2014. 7-16.

7. Robertson RP, et al.Perspective in Diabetes. Glucosa Toxicity in B-Cell : type 2 diabetes. Good Radicals gone bad and the glutathion connection, Diabetes, vol. 52. 2003. 581-7.
8. Anderson RM. The Calory Restriction paradigm. 2015 (Diunduh 11 Maret 2021). Available from: Biochemistr Society, http://www.biochemist.org
9. Chuan Suo et al. Effects of short- term calorie restriction on testicular morphology and antioxidant capacity in male rats, Animal husbandry and veterinary medicine. 2017.
10. Ilyasova et al. Effects of 2 years of caloric restriction on oxidative status assessed by urinary F2-isoprotanes:b the Calerie 2 randomized clinical trial, Aging Cell. 2018.17.
11. Harianja E, Widijanti A, Arsana PM, & Handono. Pengaruh restriksi kalori terhadap kadar hidrogen peroksida dan kadar glukosa darah pada tikus tua, Indonesian Journal of Clinical Pathology and Medical Laboratory, vol. 14, no. 1. .2018. 24-27.
12. Most J, Tosti V, Redman L, Fontana L. Calorie Restriction in Humans: an update, Ageing Research Review. 2016.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.6

OPEN ACCESS

Indonesian Journal of Human Nutrition
P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

In Vitro Evaluation of Cytotoxicity Effect of Ihau Fruit Extract (*Dimocarpus longan var. Malesianus* Leenh.) on MCF-7 Breast Cancer Cell Line

Irma Sarita Rahmawati[1], Ghina Putri Dyanti[1], Rahma Micho Widyanto[1*)], Annisa Rizky Maulidiana[1], Wyna Nabila[1], Ratna Chrismiari Purwestri[2]

[1*)] Department of Nutrition, Faculty of Health Sciences, Universitas Brawijaya, Malang, Indonesia
[2] Czech University of Life Sciences, Prague, Czech Republic

*Correspondence Address: micho@ub.ac.id

Accepted: January 2023 Reviewed: May 2023 Published: July 2022

ABSTRACT

Cancer prevalence is steadily increasing each year and becomes the second leading cause of death worldwide. In Indonesia, breast cancer had a prevalence of 16.7% in 2018. Free radicals contribute to the occurrence of breast cancer, while antioxidants play a vital role in protecting cells and repairing the damage caused by free radicals. Ihau, an endemic fruit in Kalimantan Island, contains phytochemical compounds with potential antioxidant and anticancer properties. Utilizing local food as natural antioxidants could serve as an alternative for breast cancer prevention and treatment. This study aims to assess the anticancer potential of Ihau fruit extract on the MCF-7 breast cancer cell line. A post-test-only control group design method using the MTT assay was used. The two treatment groups were water and 96% ethanol extract, with four different concentrations (125, 250, 500, and 1000 ppm), and each was replicated three times. Statistical analysis using the ANOVA test found no significant difference among all concentrations. The IC50 values of the cytotoxic activity of water and ethanol extracts were 1,197.7 ppm and 1,148 ppm, respectively. It can be concluded that both water and ethanol extract of Ihau fruit exhibited very weak cytotoxic activity.

Keywords: antioxidant, cancer, cytotoxicity, Ihau fruit, MTT assay

ABSTRAK

Setiap tahun, prevalensi kanker terus meningkat dan menjadi faktor penyebab kematian nomor dua di dunia. Pada tahun 2018, prevalensi kanker payudara di Indonesia sebanyak 16,7%. Radikal bebas merupakan salah satu penyebab terjadinya kanker payudara. Antioksidan merupakan suatu senyawa yang mampu menangkal radikal bebas. Buah Ihau merupakan buah endemik khas Kalimantan yang diketahui memiliki kandungan senyawa fitokimia yang berpotensi sebagai antioksidan dan antikanker. Pemanfaatan bahan pangan lokal sebagai antioksian alami dapat menjadi suatu alternatif pencegahan dan penanganan kanker payudara. Penelitian ini bertujuan untuk mengetahui potensi ekstrak daging buah Ihau sebagai agen antikanker pada sel kanker payudara MCF-7. Metode *post-test only control group design* dengan MTT assay dilakukan pada dua kelompok perlakuan ekstrak air dan etanol (konsentrasi 125, 250, 500, dan 1000 ppm) dengan tiga kali pengulangan. Analisis data

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.7

menggunakan One-Way ANOVA menunjukkan bahwa tidak ada perbedaan pada seluruh konsentrasi. Nilai IC50 aktivitas sitotoksik ekstrak air dan etanol masing-masing sebesar 1.197,7 ppm dan 1.148 ppm. Dapat disimpulkan baik ekstrak air maupun etanol daging buah Ihau memiliki aktivitas sitotoksik yang sangat lemah.

Kata kunci: antioksidan, kanker, sitotoksisitas, buah Ihau, MTT assay

INTRODUCTION

Cancer is a major health problem and the second leading cause of death after cardiovascular disease in the world, accounting for around 10 million deaths in 2020 (1). In Indonesia, the prevalence of cancer in people of all ages exceeds one million people (2). Breast cancer is one of the most common cancers. Breast cancer is a type of cancer, originating from the ductal epithelium or its lobules (3). According to the 2018 Global Cancer Observatory Data, breast cancer is a leading cancer case in Indonesia with a prevalence of 16.7% (4). Breast cancer can be treated with chemotherapy treatment, using drugs and natural ingredients that contain antioxidants and have the potential as chemo-preventive agents (5).

Cell damage caused by free radicals is a known factor causing various conditions, from premature aging to diseases such as cancer and coronary heart disease (6). Antioxidants are compounds that can counteract the negative effects of excess oxidants in the body. Naturally, antioxidants are found in food with phenolic structures, particularly flavonoids. Synthetic antioxidants can also be added to foods to prevent damage to the taste, smell, and color. However, previous studies indicated potential toxic effects in synthetic antioxidants; thus, their use has been limited to date (7,8). Therefore, exploring and developing natural food sources with antioxidant properties becomes an alternative solution worth investigating.

Ihau fruit (*Dimocarpus longan var. malesianus* Leenh.) is an endemic fruit grown in East Kalimantan, Indonesia. Ihau fruit has a morphology similar to the longan fruit, but it is distinguished from the prominent nodules in the skin of the Ihau fruit (9). With a vitamin C content of 66.9 mg/100 g (10), Ihau fruit has the potential as an antioxidant due to its phenolic and flavonoid content. A previous study has demonstrated the antioxidant activity of Ihau fruit extract, with an IC50 value of 698.3 µg/ml for fruit water extract and 681.05 µg/ml for the ethanol extract (11).

The polyphenolic and phenolic compounds in Ihau fruit, such as gallic acid, gallic acid, flavone glycosides, quercetin glycosides, and kaempferol, contribute to its anticancer potential and anti-tyrosinase activity (12). Quercetin acts as an immunomodulator and activates signal transduction pathways to inhibit cancer cell proliferation and induce cancer cell apoptosis (13).

In addition, phytochemicals present in Ihau fruit exhibit antibacterial properties. Flavonoids can inhibit bacterial growth by targeting DNA gyrase, while the hydroxyl groups of flavonoids lead to changes in organic components and nutrient transport in bacteria (14, 15). Quercetin can denature proteins in bacteria, leading to reduced bacterial metabolism and bacterial growth inhibition (16). Therefore, this study aims to investigate the potential cytotoxic activity in aqueous and ethanol extracts of Ihau fruit flesh on the MC7 breast cancer cell line.

METHODS

Study Design

This study utilized an in vitro true experimental laboratory approach using a

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.7

post-test-only control group design. The Ihau fruit used was obtained from Ihau fruit suppliers in Melak District, West Kutai Regency, East Kalimantan, Indonesia. Ihau fruit was extracted by maceration method using two different solvents, water and 96% ethanol. The cytotoxicity effect was assessed using an MTT assay.

Material preparation

Ihau fruits were selected on specific criteria: not slimy, not rotten, having yellow to brown skin surface color, and no change in aroma and foreign matter. Then, the fruits were separated from the skin and seeds to obtain the whole flesh. The flesh was squeezed and chopped before being dried using a food dehydrator at 75°C for 2 hours (17). The dried material was ground using a blender to reduce the particle size and ensure homogeneity, which increases the surface area and enhances the extraction process, allowing for better penetration of the extraction solvent into the cells to extract more bioactive compounds (18).

Extraction process

For the water solvent extraction, a total of 500 ml distilled water was boiled to 100°C and then allowed to stand to a temperature of 70-80°C. As much as 125 grams of powdered material was added to the distilled water in a ratio of 1:4, stirred for 30 minutes, and filtered using filter paper to obtain the filtrate. The filtrate was centrifuged at 10 rpm for 10 minutes. Then, the result was evaporated in an oven at 100°C to remove the water solvent and obtain a thick extract. The characteristics of the thick extract included a very small amount of water content, not in a paste form, and no liquid residue when rubbed against a paper towel. The final extract weighed 54.55 g.

For the ethanol solvent, a total of 113 grams of powdered material was macerated with 791 ml of 96% ethanol solvent in a ratio of 1:7 at room temperature for 7 days and stirred for 5 minutes every day. Then, the mixture was centrifuged at 10 rpm for 10 minutes, and the supernatant was collected and distilled at a temperature range of 70-80°C, as ethanol has a boiling point of 78.6°C (19) to obtain a thick extract. To evaporate the remaining ethanol, the extract was heated until the smell of ethanol was gone, and the desired consistency was achieved. The weight obtained was 49.1 g of ethanol extract.

Cytotoxicity test

MCF-7 cell lines were planted in 100 ml of RPMI medium with a cell count of 5x104 cells/well. The solution was resuspended every time it filled 12 wells to ensure homogeneous distribution of cells (20). Then, the cells were incubated in a 5% CO_2 incubator at 37ºC for 24 hours to obtain good cell growth (21) and allow for cell recovery after harvesting (20). After incubation, the microplate containing the cells was inverted, and the remaining liquid in the plate wells was drained using a tissue. The cells were then washed with 100 L of PBS once before being treated with four series of concentrations in the range of 125 ppm, 250 ppm, 500 ppm, and 1,000 ppm. After that, the cells were placed in a CO_2 incubator for 24 hours.

MTT staining was performed by removing the culture medium containing the test compound and washing the cells with 100 µl of PBS. A total of 100 µl MTT was added to the culture medium at a concentration of 0.5 mg/ml. The microplate was put in a CO_2 incubator for 4 hours. To stop the MTT reaction, 10% SDS (in 0.01 N HCl) was added to the media containing 100 µl of MTT and incubated at room temperature for 12 hours, with the microplate covered in aluminum foil (20). After 4 hours of incubation, observations were made by observing the purple formazan crystals

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.7

formed under a microscope (21). To dissolve formazan, the microplate was shaken on a shaker at 100 rpm for 10 minutes. The absorbance results were then read using an ELISA reader at a wavelength of 570 nm. The resultant cells that were still alive would produce a purple color in response to MTT (20).

Statistical analysis

Cytotoxic activity was assessed by determining the IC50 value, which is a concentration that causes the death of 50% of the cell population (22). The percentage of inhibition of cancer cell proliferation was determined by using the following formula:

$$\frac{\text{Treatment[abs]} - \text{Media Control [abs]}}{\text{Negative Control [abs]} - \text{Media Control [abs]}} \text{ x } 100\%$$

*abs = absorption

Regression curves were generated using the sample concentration data (x) and the percentage inhibition of cancer cell proliferation (y) to obtain the regression equation and the R^2 value (20). The IC50 value was obtained from the regression equation, y=ax+b. A smaller IC50 value indicates a higher cytotoxic activity. Table 1 shows the toxicity characteristic cut-off values for IC50 value.

Table 1. IC50 value category on cytotoxic compounds

IC_{50} Value	Category
<100 µg/ml	Potentially cytotoxic
100 – 1000 µg/mL	Moderately cytotoxic
>1000 µg/mL	No toxic

To detect statistical differences across the treatment groups, a one-way ANOVA test was performed. The significance level used was a p-value of <0.05. All data were analyzed using SPSS version 25.

RESULTS

This study aimed to determine the potential toxicity of water and ethanol extract of Ihau fruit against MCF-7 breast cancer cell lines. In vitro cytotoxicity test is one of the research models commonly used to study the effect of anticancer molecules of a medicinal plant (23). Cytotoxicity tests were performed on water and ethanol extracts using concentrations of 125 ppm, 250 ppm, 500 ppm, and 1000 ppm. The blank was used as a control solvent. Based on Table 2, the lowest percentage of alive MCF-7 cells were found in water and ethanol extract at the highest concentration, and vice versa, indicating an inverse correlation between extract concentration and percentage of alive cells. However, no significant difference was found among the four concentrations in both of water and ethanol extract.

A linear regression curve (Figure 1) was created based on the sample concentration and the percentage of alive MCF-7 cells (Table 2). The water extract exhibited an R^2 value of 0.9969, meaning that 99.69% of the decrease in MCF-7 cell proliferation was influenced by the concentration of the sample, which acts as an antioxidant.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.7

Table 2. Absorbance Value to % Alive MCF-7 Cell Lines

Sample	Concentration (ppm)	Mean Absorbance*	% Alive Cells
	Blank	0.386	0.00
	125	0.333	86.90
	250	0.327	84.31
	500	0.307	74.25
	1000	0.271	56.91
	Blank	0.352	0.00
	125	0.308	71.74
	250	0.290	66.15
	500	0.285	63.88
	1000	0.264	53.66

* Statistical analysis using One-way ANOVA

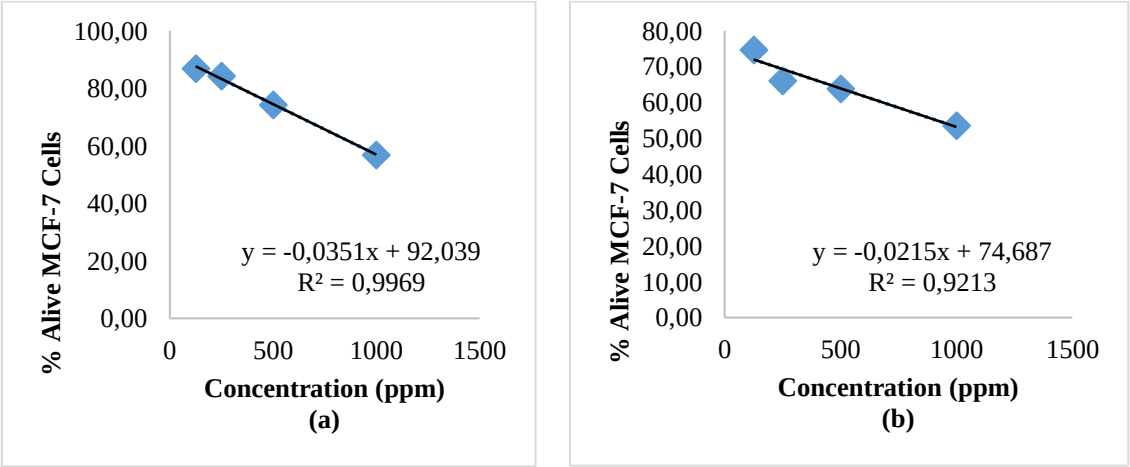


Figure 1. Regression Curve of Ihau Fruit Sample Concentration Against % Alive MCF-7 Cell Lines (a) Water Extract (b) 96% Ethanol Extract

DISCUSSION

Ihau fruit, belonging to the Dimocarpus longan species, contains various potential nutrients that offer health benefits. According to a previous study, Ihau fruit contains a total of 66.9 mg/100 g of vitamin C (10) and several secondary metabolites, such as flavones, quercetin, kaempferol, alkaloids, corilagin, ellagic acid, and flavonoids (12). Vitamin C and antioxidant contents present in Ihau fruit have the potential to suppress oxidative stress and improve the immune system. Flavonoids are antioxidant compounds that play a major role in inhibiting cancer cell growth by binding to the death receptor (TNF-R) and Fas-Associated Death Domain (FADD), which form the Death Inducing Signaling Complex (DISC). Then, the DISC complex activates caspase 8, which will stimulate the Bid protein, leading to Bax activation in the mitochondrial membrane and the release of cytochrome C as a proapoptotic molecule. Apoptosomes formed through the binding of cytochrome C with Apoptosis Activating Factor 1 (APAF-1) will trigger the process of apoptosis (24,25). In addition, quercetin acts as a metal ion chelating agent, namely Fe2+ and Cu2+ in the formation of free radicals (26).

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.7

However, the IC50 value obtained in this study showed that water and ethanol extract of Ihau fruit has very weak antioxidant activity. It can be due to the high sugar content in Ihau fruit. The antioxidant activity of an extract tends to decrease with higher sugar content, thereby impacting its ability to scavenge free radicals in the body (27). Sugar content in Ihau fruit increases during the ripening process, which consists of sucrose, fructose, and glucose (12). The sugar content in Dimocarpus longan fruits, including Ihau fruit, comprises polysaccharides with 1→6)-α-D-glucan glycosidic bonds and a chemical shift from C6. The molecular weight of polysaccharide content is 108 kDa, with a total glucose content of 661. Earlier study performed cytotoxicity tests on MCF-7 breast cancer cells and HepG2 liver cancer cells showed that the polysaccharide content had a cytotoxic effect on HepG2 cells and did not show cytotoxicity on MCF-7 cells (28). These findings align with the results of this study, which showed a low cytotoxic effect of Ihau fruit on MCF-7 breast cancer cells.

In addition, the choice of the Ihau plant part used can also influence the level of antioxidant and anticancer potential. Ihau fruit and longan fruit belong to the Sapindaceous family and share similar morphological characteristics. Research on longan plant extracts, particularly ellagic acid, demonstrated high antioxidant levels in the leaf, stem, fruit skin, and seed extracts. From the results of the DPPH test, it showed that the highest source of antioxidants in longan plants was in the stem and leaf extracts. The antioxidant effect increased with higher extract concentrations, as evidenced by IC50 values of 0.057 g/ml and 0.058 g/ml in the stem and leaf extracts, respectively. The total content of ellagic acid in the stem extract was 0.091 mg/g and 3.723 mg/g in the longan plant leaf extract (29). Longan seed extract has the ability to scavenge free radicals. Factors that affect the content of phytochemicals and antioxidants in a plant vary, including the soil condition, varieties, genetics, pesticide use, environment, and harvest timing. However, the polysaccharide content in Ihau fruit is able to undergo methylation reactions, which can reduce its effectiveness as an anticancer agent in scavenging free radicals (12).

The extraction method employed can also affect the anticancer ability of Ihau fruit. The maceration method used in this study involved stirring the material powder at room temperature and heating in an oven to obtain a thick extract. Although heating can accelerate the extraction process of phenolic compounds and flavonoids from fruit extracts, flavonoids are phenolic compounds with a conjugated aromatic system that are susceptible to damage at high temperatures. The prolonged extraction process has shown to decrease the total phenol and flavonoid content. The results of previous studies showed that high-pressure-assisted extraction (HPE) and ultrasonic waves were more effective than conventional extraction in extracting bioactive compounds from the longan pericarp. Optimizing the HPE extraction method at temperatures ranging from 30 to 90°C, durations of 2.5 to 30 minutes, and pressures of 200 to 500 mPa yielded a pericarp extract of longan fruit with cytotoxic abilities against HepG2, A549, and SGC7901 cancer cells (12).

The heating process employed after the extraction process to obtain a thick extract from water and ethanol solvents can also affect the antioxidant levels in the sample. Damage resulting from heating when drying material can be controlled by adjusting the

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.7

temperature and duration of the heating process. However, even with the correct temperature, the heating process can still potentially damage the antioxidant compounds contained in the material (29). Therefore, it is also thought to affect the total antioxidants in the sample. This study had some limitations, including the absence of analytical methods, such as proliferation test and Gas Chromatography/Mass Spectrometry (GC/MS) analysis to further investigate the anti-cancer potential of Ihau fruit.

CONCLUSION

Ihau fruit is one of the endemic fruits from Indonesia that need deeper research to find the potential health effects on human. The cytotoxic activity of water and ethanol extracts of Ihau fruit on MCF-7 breast cancer cells using the MTT assay method showed low cytotoxicity. This could be due to the high content of polysaccharides in Ihau fruit, the extraction method used, and the phytochemical compounds present in the extract. Even though no significant difference in the percentage of alive MCF-7 cells was found across different sample concentrations, as the sample concentration increased, the percentage of MCF-7 cell proliferation decreased.

Further study should consider conducting anti-proliferation tests and analyzing the bioactive compounds using techniques such as using GC/MS to investigate the anti-cancer potential of the crude extract of compound contained in lhau fruit.

ACKNOWLEDGEMENTS

This research was funded by the Research and Community Service Agency (BPPM), Faculty of Medicine, Universitas Brawijaya (Dean decree No.234 Year 2021).

REFERENCES

1. Ferlay J, Ervik M, Lam F, Colombet M, Mery L, Piñeros M, et al. Global Cancer Observatory: Cancer Today. [Internet]. Lyon: International Agency for Research on Cancer; 2020 [cited 15 Sep 21]. Available from https://gco.iarc.fr/today.
2. Kementerian Kesehatan RI. Hasil Utama Riset Kesehatan Dasar 2018. Jakarta: Badan Penelitian dan Pengembangan Kesehatan Kementerian Kesehatan Republik Indonesia. 2018.
3. Kementerian Kesehatan RI. Panduan Penatalaksanaan Kanker Payudara. [Internet]. Jakarta: Kementerian Kesehatan Republik Indonesia; 2016 [cited 15 Sep 21]. Available from http://kanker.kemkes.go.id/guidelines/PPKPayudara.pdf?opwvc=1.
4. Rukinah. Gambaran Pengetahuan Wanita Usia Subur Tentang Pencegahan Kanker Payudara di Puskesmas Maccini Sawah Makassar 2019. Jurnal Farmasi Sandi Karsa 2019;5(1):84-89.
5. Tinoco G, Warsch S, Glück S, Avancha K, Montero AJ. Treating breast cancer in the 21st century: emerging biological therapies. Journal of Cancer. 2013;4(2):117.
6. Duerbeck NB, Dowling DD, Duerbeck JM. Vitamin C: Promises not kept. Obstetrical & gynecological survey. 2016;71(3):187-93.
7. Aksoy L, Kolay E, Ağılönü Y, Aslan Z, Kargıoğlu M. Free radical scavenging activity, total phenolic content, total antioxidant status, and total oxidant status of endemic Thermopsis turcica. Saudi journal of biological sciences. 2013;20(3):235-9.
8. Atta EM, Mohamed NH. Antioxidants: An overview on the natural and synthetic types.

European Chemical Bulletin. 2017;6(8):365-75.
9. Sotyati. Buah Ihau alias Mata Kucing, Kelengkeng Asli Kalimantan. Artikel. [Internet]; 2019 [cited 1 Oct 2020]. Available from http://www.satuharapan.com/read-detail/read/buah-ihau-alias-mata-kucing-kelengkeng-asli-kalimantan.
10. Yang B, Jiang Y, Shi J, Chen F, Ashraf M. Extraction and pharmacological properties of bioactive compounds from longan (Dimocarpus longan Lour.) fruit—A review. Food Research International. 2011;44(7):1837-42.
11. Rahmawati IS, Widyanto RM, Maulidiana AR, Surya M, Madani CN. Aktivitas Antioksidan dan Antibakteri Ekstrak Etanol Buah Ihau (*Dimocarpus longan* var. *Malesianus* Leenh) Terhadap Bakteri Gram Positif (*Staphylococcus aureus*). Jurnal Al-Azhar Indonesia Seri Sains dan Teknologi. 2022;7(2):138-147.
12. Yang B, Jiang Y, Shi J, Chen F, Ashraf M. Extraction and pharmacological properties of bioactive compounds from longan (Dimocarpus longan Lour.) fruit - A review. Food Research International. 2011;44(7):1837–1842
13. Tamam B, Ashadi RW, Ramdani H. Optimasi Suhu Dan Waktu Pada Proses Pengeringan Manisan Cabai Merah Menggunakan Tunnel Dehydrator. Jurnal Pertanian. 2015;6(1): 42-55.
14. Sivasamugham LA, Nimalan V, and Subramaniam G. Antibacterial effects of Musa sp. ethanolic leaf extracts against methicillin-resistant and susceptible Staphylococcus aureus. South African Journal of Chemical Engineering. 2021;35: 107–110.
15. Manik DF, Hertiani T, Anshory H. Analisis Korelasi Antara Kadar Flavonoid dengan Aktivitas Antibakteri Ekstrak Etanol dan Fraksi-Fraksi Daun Kersen (*Muntingia calabura* L.) Terhadap *Staphylococcus aureus*. Khazanah: Jurnal Mahasiswa. 2014;6(2):1–11.
16. Apriana R, Rahmawanty D, Fitriana M. Formulasi Dan Uji Stabilitas Gel Antijerawat Yang Mengandung Kuersetin Serta Uji Efektivitas Terhadap *Staphylococcus epidermidis*. Journal Pharmascience. 2017;4(2):187–201.
17. Supomo, Supriningrum R, Junaid R. Karakterisasi Dan Skrining Fitokimia Daun Kerehau (Callicarpa Longifolia Lamk.). Jurnal Kimia Mulawarman. 2016;13(2): 89-96.
18. Handayani PA, Juniarti ER. Ekstraksi Minyak Ketumbar (Coriander Oil) Dengan Pelarut Etanol Dan n-heksana. Jurnal Bahan Alam Terbarukan. 2012;1(1): 1-7.
19. Widyanto RM, Putri JA, Rahmi Y, Proborini WD, Utomo B. Aktivitas Antioksidan dan Sitotoksisitas in vitro Ekstrak Metanol Buah Nanas (Ananas comosus) pada Sel Kanker Payudara T-47D. Jurnal Pangan dan Agroindustri. 2020; 8(2), 95-103.
20. Sitorus, Stevani. Uji Sitotoksisitas Ekstrak Etanol *Angiopteris angustifolia* C. Presl terhadap Kultur Sel Kanker Payudara (MCF-7 Cell Line) secara In Vitro. Skripsi. Fakultas Kedokteran dan Ilmu Kesehatan UIN Syarif Hidayatullah. Jakarta. 2013.
21. Widowati W, Widyanto RM, Laksmitawati DR, Erawijantari PP, Wijaya, L, Sandra F. Phytochemical, free radical scavenging and cytotoxic assay of Cucumis Melo L. extract and β-carotene. Journal of Advanced Agricultural Technologies. 2015;2(2): 114-119.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.7

22. Sak K. Cytotoxicity of Dietary Flavonoids on Different Human Cancer Types. Pharmacogonosy Reviews. 2014;8(16):122-146.
23. Putri ZS, Wati RR, Widyanto RM, Rahmi Y, Proborini WD. Pengaruh Tepung Kulit Pisang Kepok (*Musa Paradisiaca* L.) terhadap Aktivitas Antioksidan dan Sitotoksisitas pada Sel Kanker Payudara T-47D. Jurnal Al-Azhar Indonesia Seri Sains Dan Teknologi. 2020;5(3): 166-174.
24. Sari LM. Apoptosis: Mekanisme molekuler kematian sel. Cakradonya Dental Journal. 2018;10(2):65-70.
25. Liu Y, Guo M. Studies on transition metal-quercetin complexes using electrospray ionization tandem mass spectrometry. Molecules. 2015;20(5):8583-94.
26. Sa'adah H, Nurhasnawati H. Perbandingan Pelarut Etanol Dan Air Pada Pembuatan Ekstrak Umbi Bawang Tiwai (Eleutherine americana Merr) Menggunakan Metode Maserasi. Jurnal ilmiah manuntung. 2017;1(2), 149-153.
27. Yang B, Zhu Q, Jiang Y, Lin S, Wen L, Wu D, Zhao M, Chen F, Jia Y. 2013. Structural Identification of (1→6)-α-D-Glucan, a Key Responsible for the Health Benefits of Longan, and Evaluation of Anticancer Activity. Biomacromolecules 14(6): 1999-2003.
28. Luo P, Liu Y, Liu L, Mo Y, Wei C, Lu L. Antioxidant activity of longan (*Dimocarpus longan*) barks and leaves. African Journal of Biotechnology. 2012;11(27): 7038-7045.
29. Handayani H, Sriherfyna FH, Yunianta Y. Ekstraksi Antioksidan Daun Sirsak Metode Ultrasonic Bath (Kajian Rasio Bahan: Pelarut Dan Lama Ekstraksi). Jurnal Pangan dan Agroindustri. 2016;4(1): 262-272.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.7

OPEN ACCESS

Indonesian Journal of Human Nutrition
P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

Peer Tutoring on Fish and Vegetables-Based Diets Education to Prevent Anemia and Hypoalbuminemia in Adolescents

Annasari Mustafa[1*], Endang Widajati[1], Farida Halis[2], Khairuddin Khairuddin[3]

[1] Dietitian Professional Education Study Program, Malang Health Polytechnic of Ministry of Health, Republic of Indonesia
[2] Health Promotion Study Program, Malang Health Polytechnic of Ministry of Health
[3] Diploma in Health Study Program, Malang Health Polytechnic of Ministry of Health, Republic of Indonesia
Corresponding author: Annasari Mustafa. E-mail: annasary@yahoo.com

Accepted: April 2023 Reviewed: May 2023 Published: July 2023

ABSTRACT

Early detection of nutritional problems is a vital skill for individuals as it enables timely prevention before any symptoms arise. This skill can be fostered through enhancing knowledge, practicing skills via educational activities and mentoring, and seeking support from peers who share similar challenges. This study aims to investigate the impact of peer tutoring on the development of a balanced menu and healthy snack consumption based on fish and vegetables among 11th-grade female students at a state high school in Singosari, Malang Regency. This study examined the effect of these interventions on the intake of energy, protein, and iron among the participants. Data were gathered by collecting food consumption data using the 24-hour food recall method and measurement of weight, height, Hb, and Albumin levels. The study employed a purposive sampling technique by conducting pretest, intervention, and post-test. The results showed significant improvements in the health indicators of the participants, including knowledge, intake, Hb, and Albumin levels ($p=0.000$; $\alpha=0.005$). These findings demonstrate the potential of education and mentoring through peer tutoring in promoting healthy eating habits and preventing nutrition-related problems among female adolescents.

Keywords: diet, peer tutoring, anemia, hypoalbuminemia, adolescent

INTRODUCTION

Adolescent girls aged 10 to 19 years old are going through a period of rapid physical growth and changes. Besides being highly active and engaged in various activities, including school, adolescent girls are also starting to experience monthly menstrual cycles and are preparing for reproductive health as future mothers. This critical period requires careful consideration of their nutrient intake. Middle and high school adolescents begin to become interested in idols and tend to copy their idols' physical appearance or body image. This emulation sometimes leads to the reduction of food intake as a means of achieving a desired

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.8

appearance (Permaesih & Susilowati, 2015; Pou et al., 2015). However, inadequate nutrient intake in adolescent girls can negatively affect health, such as an increased risk of giving birth to low birth weight babies (BAPPENAS, 2006). This situation requires attention from parents or trusted individuals close to these adolescent girls, especially in preparation for their future as mothers (Kemenkes, 2014).

Inadequate nutrient intake often leads to the development of chronic energy malnutrition (CEM) in adolescent girls, characterized by hypoalbuminemia, thinness, and anemia. Compared to older age groups, this age group has a higher prevalence of CEM. The transitional period from childhood to adulthood brings about rapid physical, cognitive, and psychosocial changes in adolescents (Apriyanti, 2019). Insufficient consumption of energy, protein, and micronutrients during this phase can significantly contribute to nutritional issues, including CEM (Damayanti, 2017). According to the 2018 Basic Health Research, the national prevalence of CEM risk in non-pregnant women of childbearing age is 14.5%. Among female students, as many as 54%-55% experience CEM, while the incidence of anemia among adolescent girls in the 15-24 age group is 48.9% (Sulistyoningsih, 2011; Kemenkes, 2016).

Chronic Energy Deficiency (CED) can be identified through observable and measurable signs and symptoms. One such indicator is an Upper Arm Circumference (UAC) measuring less than 23.5 cm, which reflects nutrient availability in muscles and adipose tissues. CED occurs when a lack of nutrient intake, influenced by environmental and individual factors, leads to the depletion of the body's nutrient stores as they are utilized to meet physiological demands. The prolonged persistence of this condition results in tissue deterioration (Supariasa et al., 2012). Various factors influence the occurrence of CED, as highlighted by Permaesih (Permaesih, 2005). These factors encompass food intake, activity levels, infectious diseases, nutritional knowledge, and family income.

Meeting the nutritional needs of adolescents is of utmost importance due to its direct influences on their growth and development. Nutrients play a vital role in cellular growth, making it essential to ensure an adequate intake. Furthermore, eating patterns significantly impacts the growth and development of adolescents. Those with poor eating patterns face a 1.2 times higher risk of developing anemia compared to their counterparts who follow regular and healthy eating patterns. Inadequate nutrient intake and unhealthy eating patterns contribute to low hemoglobin levels, adversely affecting overall health. Insufficient energy intake from macronutrients and micronutrients due to poor eating patterns can lead to the breakdown of proteins as a continuous energy source (Choudhary et al., 2015).

To prevent nutritional problems such as anemia, hypoalbuminemia, and protein-energy malnutrition (PEM), maintaining a healthy diet is crucial. Consuming high-energy foods rich in protein and micronutrients like iron and vitamin C is essential. Several studies have demonstrated a direct correlation between energy, protein, and iron consumption and changes in hemoglobin levels. Therefore, it is crucial to educate adolescent girls about the importance of a balanced diet that includes adequate protein and iron sources such as fish and vegetable-based foods. Providing nutrition education to adolescents is vital, as it can increase their nutrition knowledge by 54.3% and equip them with the necessary skills and awareness to prevent nutritional problems (Choudhary et al., 2015).

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.8

Although Indonesia is a maritime country with abundant food sources, the consumption of fish in Indonesian society remains relatively low. One notable animal-based protein source is the Snakehead fish, scientifically known as Channa striata, which is frequently used in research due to its high protein and albumin content. The Snakehead fish belongs to the Channa genus and is commonly found in rivers and freshwater environments. Compared to plant-based protein sources, animal-based proteins offer a more complete profile of essential amino acids. Many studies have utilized Snakehead fish as a dietary component to enhance hemoglobin levels and improve overall nutritional status (Fajri et al., 2020).

A study conducted by Choudhary et al. (Choudhary et al., 2015) examined 39 malnourished adolescent girls randomly selected from a group of 273 girls across seven villages. The results revealed a significant relationship between protein intake and nutritional status. Similar findings were reported in a study conducted by Tri (Pujiatun, 2014) on adolescent girls, showing strong correlations between energy and protein consumption levels and the incidence of CED. Therefore, it is crucial to consider meeting nutritional needs during adolescence due to the increased demand for supporting physical and psychological growth and development, which undergo rapid changes during this period.

The adequacy of protein intake can be assessed by measuring the level of albumin, as a storage protein in the body, which is related to changes in nutritional status. In protein-energy malnutrition cases, the levels of total protein and albumin in serum significantly decrease. Currently, the measurement of albumin levels is considered the gold standard in evaluating nutritional status conditions, and its indicative value increases when combined with prealbumin, transferrin, or cholinesterase. The synthesis of albumin and its level in plasma is very sensitive to protein intake. It can decrease drastically during periods of food shortage and increase when the deficiency is corrected (Oy et al., 2019).

Studies have demonstrated that the consumption of snakehead fish can elevate albumin levels and enhance immune function. Snakehead fish contains a superior profile of essential and non-essential amino acids compared to egg albumin. With its albumin content of 62.24 g/kg, consuming 2 grams of snakehead fish every day can increase albumin levels in the blood by 0.6 to 0.8 g/dl for 7-10 days.

Based on the above discussion regarding anemic adolescent girls, this study aimed to investigate how nutritional education about fish and vegetable-based innovative food products through peer tutoring can help increase their nutritional knowledge, dietary intake, Hb, and Albumin level. The study also evaluated the effectiveness of providing education and mentoring on implementing a balanced menu and fish and vegetable-based snacks in raising awareness of nutrition problems in adolescents.

RESEARCH METHOD

Data Source

This research was conducted at Singosari State High School, located in Malang Regency, Indonesia. The study was carried out between May and October 2022.

Research Participants

The study focused on female students who exhibited undernutrition, defined as having Hb levels below 12 g/dL, and/or BMI of 18.5 kg/m2 or less, and/or MUAC of 23.5 cm or less. Out of the 475 students screened, 47 students met the inclusion criteria and were selected as research participants. Inclusion criteria

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.8

included a willingness to participate from start to finish, an age range of 16 to 18 years, and no history of underlying diseases or illnesses with specific prohibitions. Exclusion criteria were applied to exclude respondents who were absent at the research location more than three times during data collection and intervention, or who experienced illness during the study, as confirmed by a medical certificate.

Instrument

The primary objective of the training was to strengthen the capabilities of the cadres of "Prestasi," the health affairs student body at Singosari High School, as peer tutors and agents of change in the field of adolescent health. The training covered crucial topics such as adolescent characteristics, balanced menus, healthy snacks, proper nutrition, common nutrition issues, and personal hygiene. Additionally, participants received reinforced training to improve their skills in conducting health screenings and anthropometric measurements, with a focus on height, weight, and upper arm circumference.

Data Collection

During the training, participants were taught how to measure adolescent nutrition and health knowledge, conduct a 24-hour dietary recall, and distribute healthy snacks to their peers. Each health cadre was responsible for accompanying 2-3 peers who faced nutrition-related problems. The accompaniment took place twice a week for a period of 2 months. The intervention involved education through accompaniment by the health cadres, who were selected and formed prior to the study, as well as by the research team. The aim was to familiarize adolescents with consuming healthy meal menus and providing healthy snacks based on snakehead fish and vegetables.

Data Analysis

Pre- and post-intervention assessments included measurements of adolescent nutrition and health knowledge, a 24-hour dietary recall, and anthropometric measurements (height, weight). Data collection involved various methods, including a questionnaire form to identify anemic adolescent girls, an informed consent form to obtain participants' willingness to participate, and a 24-hour food recall form. Food consumption data were collected using the 2x24-hour food recall method, which utilized the use of food images and household measurement units converted to weight (grams). Anthropometric data, such as height and weight, were collected through measurement and weighing.

Furthermore, the process of creating snacks based on the Snakehead Fish (Channa striata) was carried out at the Center of Excellence Laboratory of the Health Polytechnic of the Ministry of Health in Malang. Acceptance tests were conducted in March 2022 for three snack products based on Snakehead Fish, resulting in changes in weight and quantity for each product. Siomay was adjusted to 5 pieces weighing 25 g each, while nuggets remained at 3 pieces

RESULT

A total of 47 female students were assessed for student knowledge, hemoglobin (Hb) level, and albumin level.

Knowledge

Student knowledge data, collected through a questionnaire, revealed a normal distribution (p-value=0.200). Prior to the treatment, the baseline level of knowledge was 56.23±9.48. Following the treatment, which consisted of educational support and snacks for 16 sessions, a significant increase in the mean score was observed (p=0.000), resulting in a final score of 68.68±8.53.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.8

Hemoglobin

The hemoglobin level data from the 47 female students showed a normal distribution (p=0.09). The mean hemoglobin level prior to the treatment was 11.73±1.69. Following the treatment, a significant increase in the mean hemoglobin level was observed (p=0.000), with a mean value of 13.37±1.58.

Albumin

The albumin level data measured from 33 female students exhibited a non-normal distribution (p=0.000). Prior to the treatment, the mean albumin level was 4.20 (ranging from 3.40 to 5.31). After the treatment, a significant increase in the mean albumin level was observed (p=0.000), with a mean value of 4.62 (ranging from 4.29 to 5.92).

Table 1 shows that after treatment, Knowledge, Hemoglobin and Albumin levels increased. Prior to the treatment, 34 female students had Hb levels below 12.00g/dL, but by the end of the study, only 9 students had Hb levels below the normal range. Although all female students had albumin levels within the normal category, the mean score increased from 4.20 to 4.62 mg/L. The statistical analysis using the Paired T-Test at a 95% confidence level revealed a significant difference (p=0.000) in all variables studied, including Knowledge, and Hb levels. Additionally, the increase in albumin levels was found to be significant (p=0.000) using the Wilcoxon Signed Rank Test

No	Variables	Data Distribution	Average/Mean	N	p Value,
1	Knowledge	Normal	56,23±9,48	47	0,000*
			68,68±8,53		
2	Hb	Normal	11,73±1,69	47	0,000*
			13,37±1,58		
3	Albumin	Abnormal	4,20 (3,40-5,31)	33	0,000†
			4,62 (4,29-5,92)		

Note: * Paired t-test; †Wilcoxon signed Rank Test α 0.05

Table 1. Changes in Knowledge Indicator, Hemoglobin Level, and Albumin Level of the Female Adolescents

DISCUSSION

The positive impact of education on health is reflected in the significant improvement in the scores of various health indicators. Research by Asmarudin (Pakhri et al., 2018) supports the relationship between education and knowledge enhancement. In their study, nutrition education using healthy food materials was provided to teenagers, resulting in a significant increase in their average nutritional status. This improvement can be attributed to the increased awareness and understanding of nutrition among the respondents, as well as the support from their close relatives.

The energy content derived from carbohydrates, protein, and fat is an essential component of the diet. The study results showed that the average energy intake of female students before the intervention was 1174 calories, which significantly increased to 1371 calories ($p = 0.008 < 0.05$) after the intervention.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.8

Insufficient energy intake can lead to weight loss and chronic energy deficiency, as pointed out by Suarjana (Suarjana, 2020). Moreover, the average protein intake of female students also showed a substantial increase, rising from 44.6 grams to 53.7 grams ($p = 0.001 < 0.05$). Protein plays a vital role in various bodily functions, including cell repair and tissue synthesis, hormone production, and regulation of the acid-base balance. However, thin teenagers tend to consume inadequate amounts of protein, as revealed by the recall data. To address this, adolescents are advised to incorporate a variety of high-protein foods into their diet, encompassing both animal and plant sources. Animal-based protein options include beef, lamb, poultry, eggs, fish, milk, and other processed products. Meanwhile, the plant-based protein group includes legumes such as nuts, tofu, tempeh, green beans, red beans, and lentils, among others (Apriyanti, 2019). These foods are recommended as part of a balanced diet according to the dietary guidelines provided by the Ministry of Health in Indonesia (Kemenkes, 2014).

The statistical analysis conducted showed no significant increase in iron intake among female students at Singosari State High School ($0.09 > 0.05$). This suggests that education on iron consumption among students did not have a significant difference. Iron is an essential component in hemoglobin formation, and inadequate nutritional intake can lead to a deficiency in the body, particularly in nutrients such as iron. Insufficient iron intake can lead to a decrease in the production of red blood cells, leading to anemia. This finding is supported by Pakhri's study (Pakhri et al., 2018), indicating nutrition education did not significantly affect iron consumption, possibly, due to limited food diversity and inadequate nutritional intake, including iron.

However, before consuming snakehead fish snacks, the average hemoglobin level of female students was 11.7 g/dL, while after consuming snakehead fish snacks, it significantly increased to 13.3 g/dL ($p = 0.000 < 0.05$). The research results demonstrate that snakehead fish meat has a very good chemical composition and can be consumed as a healthy snack (Karnila et al., 2017). This significant increase in hemoglobin levels before and after the intervention indicates the positive impact of snakehead fish consumption. Hemoglobin is responsible for transporting oxygen and carbon dioxide in the body, and changes in hemoglobin levels can be influenced by factors such as nutrition, knowledge of nutrition and health, eating patterns, and iron supplements. Increased iron needs occur mainly during menstruation or chronic illness (Oy et al., 2019). Protein plays a crucial role in hemoglobin formation, as it assists in the absorption of iron. Protein is an essential building block throughout the human life cycle. Food that enhances iron absorption, especially non-heme iron, is vitamin C and other animal protein sources such as fish and chicken. Protein from meat sources, such as fish and chicken, can increase the absorption of non-heme iron derived from cereals and plants. Iron is essential for hemoglobin production, and the majority of iron is recycled from broken-down red blood cells. However, when there is a deficiency, it must be replenished through dietary intake. Anemia can occur when there is insufficient iron absorption in the intestines, which may be caused by intestinal disorders or surgical procedures (Adriani & Wirjatmadi, 2012).

Study results found a correlation between protein intake and hemoglobin levels in females (Kristin et al., 2022). Protein plays a crucial role in the storage, transport, and absorption of iron. Insufficient protein intake can disrupt the

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.8

transportation of iron, leading to iron deficiency and low hemoglobin levels. The measurement of albumin levels showed that 31 respondents experienced a significant increase in albumin levels ($p = 0.000 < 0.05$) between the results of blood albumin tests before and after the intervention. Albumin levels are an indicator of a person's nutritional status and usually occur over a prolonged period. Changes in albumin levels can cause platelet function disorders. Albumin level tests are usually performed to determine low energy and protein intake, and they are considered more accurate than anthropometry measurements. Albumin is the most abundant protein in blood plasma, and its value can be used as an indicator of health status and a long-term disturbance in nutrient intake, particularly protein (Aulia, 2019).

Peer tutors have been found to have a significant impact on adolescents, making them an ideal choice for delivering messages. Adolescents are highly influenced by their peers, whether in terms of eating habits, fashion choices, or lifestyle preferences. A study conducted by Lidiawati et al. (2020) specifically highlights the significant influence of peers of the same age on the eating behavior of adolescents. This influence can be harnessed to create positive impacts among adolescents. Furthermore, research conducted by Nuryani and Paramata (2018) emphasizes the effectiveness of peer tutoring and education provided by peers in improving knowledge, attitudes, and behaviors related to balanced nutrition in adolescents. Therefore, utilizing peer tutors as messengers can be a powerful strategy to promote healthy behaviors and empower adolescents in making informed choices.

CONCLUSION

The study findings indicate that utilizing peer tutors as an intervention is an effective method for transferring knowledge and encouraging healthy eating and lifestyle habits. Providing female students who suffer from malnutrition or low hemoglobin levels with 16 educational sessions, each lasting 10-15 minutes, significantly improve their understanding of nutrition and health. Moreover, offering healthy snacks weighing between 60-100 grams during these sessions further improves their overall health status. Interventions, such as providing healthy snacks based on snakehead fish and vegetables, can be a viable alternative in preventing anemia and hypoalbuminemia in adolescents.

The present study recommends utilizing the Achievement Cadres of Singosari State High School to assist the School Health Unit in monitoring the health development of students at school, facilitating early detection of health issues. To sustainably maintain and improve student health, periodically refresh and train the school Cadres are crucial. Incorporating nutrition and health topics into learning activities and promoting best practices related to nutrition and health can significantly enhance student awareness for early prevention of anemia and hypoalbuminemia.

REFERENCES

1. Adriani, M., & Wirjatmadi, B. (2012). *Pengantar Gizi Masyarakat* (kedua). Kencana Prenada Media Group. https://opac.perpusnas.go.id/DetailOpac.aspx?id=860987
2. Apriyanti, F. (2019). Hubungan Status Gizi Dengan Kejadian Anemia Pada Remaja Putri SMAN 1 Pangkalan Kerinci Kabupaten Pelalawan Tahun 2019. *Jurnal Doppler Universitas Pahlawan Tuanku Tambusai*, *3*(2), 18–21. https://journal.universitaspahlawan.ac.id/index.php/doppler/article/v

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.8

iew/429

3. Aulia, N. (2019). *No TitlNikmah Aulia, 2019. Perbedaan Rerata Kadar Albumin Pada Balita Stunting dan Non-Stunting di Kecamatan Gunung Sugih Kabupaten Lampung Tengah*. Universitas Lampung.
4. BAPPENAS, B. P. P. N. (2006). *Rencana Aksi Nasional Pangan dan Gizi 2011-2015*. https://jdih.bappenas.go.id/peraturan/detailperaturan/454
5. Choudhary, S., Saluja, N., Sharma, S., Dube, S., S.M. Pandey, S. ., & Kumar, A. (2015). Association of energy balance and protein intake with nutritional status of adolescent girls in a rural area of Haryana. *Journal of Evolution of Medical and Dental Sciences*, *4*(1). https://go.gale.com/ps/i.do?id=GALE%7CA468334740&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=22784748&p=AONE&sw=w&userGroupName=anon~9b39406d&aty=open+web+entry
6. Damayanti, D. (2017). Buku Ilmu Gizi Teori Dan Aplikasi. In Hardinsyah & D. Nyoman Supariasa (Eds.), *Buku Ilmu Gizi Teori Dan Aplikasi*. Penerbit Buku Kedokteran EGC. https://scholar.google.co.id/citations?view_op=view_citation&hl=id&user=DbnR1LkAAAAJ&citation_for_view=DbnR1LkAAAAJ:ufrVoPGSRksC
7. Fajri, U. N., Hadisaputro, S., & Soejoenoes, A. (2020). Ekstrak Ikan Gabus (Channa Satria) untuk Meningkatkan Kadar Hemoglobin pada Ibu Nifas Anemia di RSUD Hj. Anna Lasmanah Banjarnegara. *Medsains*, *6*(02), 37–41. http://download.garuda.kemdikbud.go.id/article.php?article=2987641&val=26817&title=ESTRAK IKAN GABUS CHANNA STRIATA UNTUK MENINGKATKAN KADAR HEMOGLOBIN PADA IBU NIFAS ANEMIA DI RSUD HjANNA LASMANAH BANJARNEGARA
8. Karnila, R., Mahardika, N., & Edison. (2017). Analisis Komposisi Kimia Daging dan Tepung Ikan Gabus (Channa striata). *Jurnal*, 1–8. https://jom.unri.ac.id/index.php/JOMFAPERIKA/article/viewFile/17499/16903
9. Kemenkes. (2014). *Peraturan Menteri Kesehatan Republik Indonesia Nomor 41 Tahun 2014*. Applied Microbiology and Biotechnology. https://peraturan.bpk.go.id/Home/Details/119080/permenkes-no-41-tahun-2014
10. Kemenkes. (2016). *Pedoman Pencegahan Dan Penanggulangan Anemia Pada Remaja Putri Dan Wanita Usia Subur (WUS)*. Kementrian Kesehatan Republik Indonesia. https://promkes.kemkes.go.id/download/fpcl/files99778Revisi Buku Pencegahan dan Penanggulangan Anemia pada Rematri dan WUS.pdf
11. Kristin, N., Jutomo, L., & Boeky, D. L. A. (2022). *Hubungan Asupan Zat Gizi Besi Dengan Kadar Hemoglobin Remaja Putri*. *1*(3), 189–195. https://doi.org/10.54259/sehatrakyat.v1i3.1077
12. Lidiawati, M., Lumongga, N., & Anto. (2020). Faktor Yang Mempengaruhi Perilaku Makan pada Remaja Obesitas di SMA Kota Banda Aceh. *Jurnal Aceh Mdedika*, *4*(1), 52–62. http://jurnal.abulyatama.ac.id/index.php/acehmedika

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.8

13. Nuryani, N., & Paramata, Y. (2018). Intervensi Pendidik Sebaya Meningkatkan Pengetahuan, Sikap, dan Perilaku Gizi Seimbang pada Remaja di MTsN Model Limboto. *Indonesian Journal of Human Nutrition*, *5*(2), 96–112. https://doi.org/10.21776/ub.ijhn.2018.005.02.4
14. Oy, S., Witjaksono, F., Mustafa, A., Setyobudi, S. I., & Fahmida, U. (2019). Problem Nutrients in Adolescent Girls With Anemia Versus Nonanemic Adolescent Girls and the Optimized Food-Based Recommendations to Meet Adequacy of These Nutrients in Adolescent School Girls in East Java, Indonesia. *Food and Nutrition Bulletin*, *40*(3), 295–307. https://doi.org/10.1177/0379572119851326
15. Pakhri, A., Gizi, J., Kesehatan, P., & Makassar, K. (2018). *Kebutuhan Asupan Energi , Protein Dan Besi Pada Remaja*. 39–43. https://journal.poltekkes-mks.ac.id/ojs2/index.php/mediakesehatan/article/view/97/39
16. Permaesih, D. (2005). Faktor yang Mempengaruhi Anemia pada Remaja. *Buletin Penelitian Kesehatan*, *33*(4), 172–182. http://katalog.pustaka.unand.ac.id//index.php?p=show_detail&id=90203
17. Permaesih, D., & Susilowati, H. (2015). Faktor-faktor yang Mempengaruhi Anemia pada Remaja. In *Buletin Penelitian Kesehatan* (Vol. 33, Issue 4, p. 163). https://media.neliti.com/media/publications/20280-ID-faktor-faktor-yang-mempengaruhi-anemia-pada-remaja.pdf
18. Pou, L. La, Kapantow, N. H., & Punuh, M. I. (2015). Hubungan Antara Status Gizi Dengan Kejadian Anemia Pada Siswi SMP Negeri 10 Manado. *Pharmacon*, *4*(4), 309–315.
19. Pujiatun, T. (2014). *Hubungan Tingkat Konsumsi Energi Dan Protein Dengan KejadianKurang Energi Kronis (KEk) Pada Siswa Putri Di SMAMuhammadiyah 6 Surakarta* [Universita Muhammadiyah Surakarta]. https://eprints.ums.ac.id/29989/1/03._Halaman_Depan.pdf
20. Suarjana, I. (2020). Kurang Energi Kronik (KEK) Remaja Putri Pelajar SMU/SMK dI Kabupaten Karangasem Propinsi Bali. *Jurnal Sehat Mandiri*, *15*(1), 41–51. https://doi.org/10.33761/jsm.v15i1.106
21. Sulistyoningsih, H. (2011). *Gizi untuk kesehatan ibu dan anak*. Graha Ilmu. https://opac.perpusnas.go.id/DetailOpac.aspx?id=105556#
22. Supariasa, I., Bakri, B., & Fajar, I. (2012). *Pendidikan dan Konsultasi Gizi*. Penerbit Buku Kedokteran EGC:

OPEN ACCESS

Indonesian Journal of Human Nutrition
P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

Effect of Brown Rice Intervention on BMI and Waist Circumference in Patients with Type 2 Diabetes Mellitus

Dea Intan Permatasari [1*)], Endang Sutjiati[2], Etik Sulistyowati[2]

[1*)] Undergraduate Program in Applied Nutrition and Dietetics, Department of Nutrition, Malang Health Polytechnic
[2]Applied Nutrition and Dietetics Study Program, Department of Nutrition, Malang Health Polytechnic

Corresponding author: Dea Intan Permatasari. E-mail: deaintan.di@gmail.com

Accepted: August 2022 Reviewed: October 2022 Published: July 2022

ABSTRACT

Brown rice, derived from white rice with the removal of the husk, contains higher dietary fiber and a lower glycemic index than regular white rice. These advantages can be an alternative diet for individuals with type 2 diabetes mellitus. Type 2 diabetes mellitus is a metabolic disease ranked as the fourth leading cause of death in the world, often associated with obesity. In addition, insulin insensitivity in individuals with type 2 diabetes leads to increased hunger (polyphagia) and overeating, resulting in increased BMI and waist circumference. The purpose of this study is to determine the effect of the brown rice diet intervention on BMI and waist circumference of patients with type 2 diabetes. This study was a pre-experimental study without control variables and the sample was not selected randomly, using a one-group pretest-posttest design with a 3-month intervention. Data analysis in this study used the Shapiro-Wilk normality test followed by the paired t-test to determine the difference between two paired samples. The statistical results showed significant changes in BMI and abdominal circumference ($p = 0.002$ and $p = 0.008$, respectively). In conclusion, there are differences in BMI and abdominal circumference of patients with type 2 diabetes mellitus before and after the intervention of a brown rice-based diet menu.

Keywords: type 2 diabetes mellitus, brown rice, BMI, waist circumference

INTRODUCTION

Diabetes Mellitus (DM) is a global health threat. According to data from the World Health Organization (WHO), the number of people with DM in Indonesia is projected to increase from 8.4 million in 2000 to approximately 21.3 million in 2030. The International Diabetes Federation (IDF) stated the same fact. Data on IDF confirms this trend, estimating that the number of diabetics in Indonesia in the age range of 20-79 years will increase from 10 million in 2015 to

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.9

16.2 million in 2040. Hence, Indonesia will rank sixth for people with DM Type 2 in the world by 2040 (1).

Being overweight or obese can serve as a trigger for DM. Research conducted on the population shows that the likelihood of developing DM in obese people is greater than in slim people. Type 2 DM is often associated with unhealthy lifestyle factors. There are 90-95% of all people with DM suffer from type 2 diabetes (2).

Poor diet and irregular exercise can increase the risk of central obesity. Central obesity can be measured using abdominal circumference, while Body Mass Index (BMI) can be used to determine whether someone is obese or not (3).

Most diabetic patients frequently feel hungry because the intake they consume cannot be converted into energy. Therefore, it often causes DM patients to overeat and results in an increase in BMI and abdominal circumference. According to Fatimah (2015), this situation occurs due to cellular insensitivity to insulin. Blood sugar will rise as a result of the decreased insulin secretion by pancreatic beta cells or impaired insulin function (insulin resistance).

According to research by Kozuka et al. (2013), brown rice has the potential to improve glucose tolerance and insulin resistance in type 2 DM sufferers. In addition, switching the source of carbohydrate intake from white rice to brown rice significantly reduces body weight and improves glucose and fat metabolism in people with metabolic syndrome. Brown rice is a grain that can only be consumed once the aleurone layer of rice or the outermost layer and rice husk have been removed (6). Compared to white rice, brown rice contains four times higher fiber and has a lower glycemic index, making it a healthier choice for people with obesity and diabetes to consume (5).

Brown rice has high LPL levels (*lipoprotein lipase*), which help inhibit fat accumulation and ultimately reduce the risk of central obesity. Abdominal circumference and BMI are two parameters in determining the nutritional status of whether a person is obese or not. Insufficient fiber consumption increases the likelihood of the occurrence of obesity, whereas an adequate consumption of fiber can reduce the risk of obesity and other degenerative diseases, such as DM type 2 (7).

RESEARCH METHODS

Design/Research Design

This research used a pre-experimental design without control variables, and the sample is not randomly selected (8). This study used a single-group design with one-group pretest-posttest. Testing was carried out before and after the intervention, and the differences between the results pretest-posttest were assessed as the effect of the intervention (9). The intervention was carried out for three months for each respondent.

Data Source

All data collected were primary data obtained through several methods including direct interviews and direct anthropometric measurements. The data collected included characteristics of the respondents (gender, age, occupation, medical history), weight, height, and food intake.

Research Target

The research respondents were all outpatients diagnosed with type 2 DM at Griya Bromo Clinic, Malang, Indonesia. The inclusion criteria were as follows: female, aged 40-60 years, BMI ranging from 24-28 kg/m^2, HbA1c ≤8% treated with 1 or a combination of OAD (Anti-Diabetic Drugs), and willingness to participate as a research respondent (proven by signing the informed consent).

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.9

The exclusion criteria included the presence of heart, kidney, and malignancy disorders, a history of gastrointestinal disorders requiring long-term medical therapy, an active smoker, and antibiotic use in the month prior to fecal sampling.

Development of Data Collection Instruments and Techniques

Data on respondents' characteristics were collected using a questionnaire. The nutritional status of the respondents was determined from BMI measurements using a microtoa with an accuracy of 0.1 cm to measure height and Bioelectrical Impedance Analysis for body weight measurement. Then, BMI was categorized into six groups: underweight (<18.5), normal range (18.5 – 22.9), overweight (≥23), at risk (23.0 – 24.9), obesity I (25.0 – 29.9), and obesity II (≥30). Weight measurements were conducted every month. Abdominal circumference was measured using the metline with an accuracy of 0.1 cm and categorized as normal (≤80 cm) or indicative of abdominal obesity (>80 cm). Abdominal circumference measurements were carried out before and after the intervention.

Food intake data prior to the intervention were taken using a semi-quantitative food frequency method to find out the description of the respondents' eating habits. During the intervention, food intake data were collected using a food record method three times a week for 12 weeks, specifically on two working days (Monday and Wednesday) and one day off (Saturday).

The intervention was given in the form of three main meals (with brown rice as the staple food) and three side dishes every Monday and Saturday. On Sundays, respondents were free to consume personal food while still paying attention to their daily needs.

Data Analysis Technique

The data were analyzed using the SPSS version 15 statistical program. The data normality test was carried out by testing Sapphire Wilk because the number of samples was below 50 people. Then, the test Paired T-test with a 5% error rate was performed to find out the differences between paired samples.

This research has received a Certificate of Eligibility for Research Ethics from the Ethics Commission of the Faculty of Medicine, University of Brawijaya Malang with a certificate number 143/EC/KEPK/07/2016.

RESEARCH RESULT

Overview of Respondents

All respondents were female, ranging in age from 40 to 60 years. Table 1 shows 66.6% of the respondents belong to the early elderly group (46-55 years).

Table 1. Total Distribution of Respondents by Age

No	Age (Year)	Amount	
		n	%
1	36 – 45	1	5,6
2	46 – 55	12	66,6
3	56 – 65	5	27,8
Total		18	100

Most of the respondents are housewives (61.1%). Data on respondents' occupation distribution can be seen in Table 2.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.9

Table 2. Distribution of Respondents' Occupation

Profession	Amount	
	n	%
Teacher	1	5,6
Housewife	11	61,1
Posyandu cadres	1	5,6
Headmaster	1	5,6
Church officer	1	5,6
Notary officer	1	5,6
Tailor	2	11,1
Total	18	100

In fact, one-third of the total respondents had a history of hypercholesterolemia, which is characterized by a total serum cholesterol level higher or equal to 200 mg/dL.

Furthermore, 83.3% of respondents had been living with type 2 DM for more than 6.5 years. The duration of suffering from type 2 DM was calculated from the time of the initial diagnosis. The data are presented in Table 3.

Table 3. Duration of Respondents Suffer

Duration (year)	Frequency	
	n	%
< 6,5	15	83,3
≥ 6,5	3	16,7
Total	18	100

Description of Respondents' Energy Intake

Table 4 shows that prior to receiving the intervention, 27.8% of respondents had moderate to severe deficit consumption levels, while 22.2% of respondents had a level of energy intake that exceeds their needs. However, after the intervention, the energy intake of the respondents improved, declining from the mild to normal deficit category.

Table 4. Distribution of Respondents' Energy Adequacy Levels

Energy Adequacy Level	Respondents' amount			
	Pre		Post	
	n	%	n	%
Severe deficit (<70%)	3	16,7	0	0
Moderate deficit (70 – 79%)	2	11,1	0	0
Mild deficit (80 – 89%)	3	16,7	8	44,4
Normal (90 – 119%)	6	33,3	10	55,6
Excess (>120%)	4	22,2	0	0

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.9

Description of Respondents' Fat Intake

Before the intervention, more than half of the respondents (55.5%) had fat intake below the RDA, while 16.7% of respondents had fat intake above the RDA. After the intervention, fat intake improved to a mild to normal deficit category. The data can be seen in Table 5.

Table 5. Average Level of Respondents' Fat Intake

Intake Level Classification	Amount			
	Pre		Post	
	n	%	n	%
Below the RDA (<90% RDA)	10	55,5	6	33,3
Normal (90 – 119% RDA)	5	27,8	12	66,7
Above RDA (>119% RDA)	3	16,7	0	0

Description of Respondents' BMI and Abdominal Circumference

Table 6 shows that more than half of the respondents (66.6%) were included in the obesity category I before receiving the intervention. However, the prevalence of respondents experiencing obesity I decreased by around 5% after receiving the intervention. Statistical test results also show a significant p-value of 0.002 ($p<0.05$). Furthermore, before the intervention, 83.3% of respondents were included in the abdominal obesity category; but, after the intervention, 22.2% of respondents showed a reduction in abdominal circumference and approached normal.

Table 6. Distribution of Respondents' BMI Classification and Abdominal Circumference

Variable	Pre		Post		P*
	Total		Total		
	n	%	n	%	
BMI					
Underweight (<18,5)	0	0	0	0	
Normal (18,5 – 22,9)	3	16,7	4	22,2	
Overweight (≥ 23,0)	0	0	0	0	
Risky (23,0 – 24,9)	3	16,7	3	16,7	
Obesity I (25,0 – 29,9)	12	66,6	11	61	
Obesity II (≥ 30,0)	0	0	0	0	
Abdominal circumference					
≤ 80 cm	3	16,7	2	11,1	
>80 cm	15	83,3	16	88,9	

*Statistic test

DISCUSSION

Overview of Respondents

All respondents in this study were female. The selection of female respondents was based on that women have a higher tendency to experience an increase in body mass index than men. This increase in body mass index is associated with the development of obesity, which is a risk factor for type 2 DM. It aligns with previous research conducted by Aamir et al. (2019) and Tripathy et al. (2017) that reported a higher prevalence of diabetes among

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.9

women in population surveys. Furthermore, premenstrual syndrome and postmenopausal changes contribute to the accumulation of body fat, thereby increasing the risk of developing type 2 diabetes mellitus in women (12).

In this study, respondents in the early elderly age group (46-55 years) are the most age group with type 2 DM. This finding is in line with research conducted by Cho in Asiimwe et al. (2020) that the highest prevalence of diabetes is in the age range of 45-64 years. It is because aging leads to a decline in carbohydrate metabolism, resulting in reduced blood glucose usage and glucose tolerance, as well as an increased likelihood of insulin resistance (14).

Table 2 shows that most of the respondents are housewives. Housewives have a lot of free time which results in a lack of physical activity. This sedentary lifestyle increases the risk of obesity, which is a risk factor for type 2 DM (15).

In addition to type 2 DM, some respondents also had a history of hypertension and hypercholesterolemia. The combination of type 2 DM and high cholesterol levels is proven to increase insulin plasma production, which will lead to decreased pancreatic function and beta cell dysfunction, resulting in type 2 DM (16). Furthermore, hypertension is also known to be one of the complications of diabetes, and vice versa. Patients with DM can experience an increase in blood pressure; 40-60% of cases of diabetes are also exhibiting high blood pressure. Diabetes accompanied by hypertension increases the risk of stroke and myocardial infarction due to progressive arteriosclerosis. Type 2 diabetes results in hyperinsulinemia, which stimulates sympathetic nerve activity and increases renin excretion. Active renin, in turn, will activate the sympathetic nervous system and increase cardiac output and vascular resistance. This mechanism will increase blood pressure (17).

There are 83.3% of respondents who have been diagnosed with type 2 DM for more than 6.5 years. It is important to note that as the duration of type 2 DM increases, the likelihood of experiencing complications also rises. Besides, as the duration of suffering increases, individuals may experience a decrease in their knowledge and skills related to the treatment of DM (18). This is attributed to factors such as boredom from sufferers so that it will reduce the quality of life. Consequently, the quality of life of DM patients can be improved by adopting a healthy lifestyle, one of which is by adhering to dietary recommendations designed for individuals with DM.

Analysis of Respondents' Energy and Fat Intake

Table 4 shows that before receiving the intervention, 27.8% of respondents had moderate to severe deficit consumption levels, while 22.2% of respondents had a level of energy intake exceeding their needs. People with DM are advised to follow the three eating principles (right amount, schedule, and type). The principle of eating the right amount emphasizes the importance of aligning calorie intake with daily needs. In this study, respondents received a diet tailored to their calorie needs so that their calorie intake was neither excessive nor lacking. In line with Putra, I. W. A., & Berawi (2015), patients with DM must avoid consuming excessive calories to prevent further complications. Determining the daily calories must consider several factors, such as nutritional status, age, stress, and physical activity.

One of the objectives of providing nutritional therapy to diabetic

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.9

patients, especially type 2 diabetes mellitus, is to maintain body weight within the normal range. Type 2 DM patients with obesity are advised to lose weight to improve glycemic control (20). Data in Table 4 show that 44.4% of respondents had a mild deficit in energy adequacy, and 55.6% of respondents were in the normal category. These findings are in line with the fact that 66.6% of respondents were classified as obesity I, suggesting the need for gradual weight reduction. Providing a mild level of calorie deficit is known to help improve BMI and abdominal circumference in people with obesity. Excessive calorie reduction, on the other hand, may not help improve the BMI and abdominal circumference of respondents with type 2 DM, but it increases the risk of other complications, such as hypoglycemia.

Besides the calorie intake, the selection of food ingredients for people with DM needs to be carefully considered. Patients with DM are not advised to consume food with a high Glycemic Index. Before the intervention, the respondents had the habit of consuming white rice as their staple food, which has a high glycemic index and can increase glucose intolerance. In addition, consuming white rice as a staple food will have an impact on the glycemic index load because of the dominant portion of white rice (21).

The dietary intervention given to respondents in this study was implemented using brown rice as a substitute for white rice. It is because brown rice is unpolished rice, so the amylose content is higher than white rice. According to research by Fa et al. (2019), higher amylose content in food leads to a lower glycemic index value.

Regarding fat intake, data in Table 5 shows that more than half of the respondents (55.5%) had fat intake below the RDA prior to the intervention, while 16.7% of respondents had fat intake above the RDA. Excessive fat intake, if it is not balanced with adequate physical activity, can cause fat accumulation. This fat accumulation can increase the occurrence of central obesity. From Table 5, the average fat intake during the intervention was also given below the RDA to match the RDA because 83.3% of respondents had central obesity, marked by abdominal circumference higher than 80 cm, before the intervention. Central obesity occurs when there is an accumulation of fat in a part of the body, one of which is accumulation in the abdomen or intra-abdominal and subcutaneous in the abdominal area (23). According to Bertalina & Muliani (2016), central obesity is closely related to the incidence of type 2 DM. One of the causes of central obesity is excessive consumption of fat, which causes fat accumulation.

Analysis of BMI and Respondents' Abdominal Circumference Changes

Body mass index and abdominal circumference are parameters commonly used to determine whether a person is obese or not. Obesity is a known risk factor for obesity (24). A person is stated to be obese if the BMI is $\geq$ 25 kg/m^2. BMI is applicable across the general population and does not depend on age and gender, but it may not be suitable for pregnant women and also muscular athletes.

Obesity has long been associated with a risk factor for type 2 DM. Obesity can cause insulin resistance and damage to pancreatic β cells, resulting in inadequate insulin production. One of the main contributing factors to insulin resistance is due to the elevation of plasma-free fatty acids (25).

Weight control needs to be done to reduce the risk of metabolic diseases,

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.9

including Type 2 DM. Calorie-deficit diets are commonly employed as a method to control weight (26). This study used a DM diet of 1300 -1500 kcal/day with brown rice as the staple food for type 2 DM patients with obesity. After a 3-month intervention, there was a decrease in the prevalence of obesity among respondents. Apart from being affected by mild calorie deficits, another contributing factor to improving weight is the consumption of brown rice, which is high in fiber. The high fiber content in brown rice slows down gastric emptying compared to white rice, leading to increased satiety and reduced excessive intake (27).

The results of this study showed a 5% decreased prevalence of obesity in respondents. The results of this study are in line with the research of Sawada et al. (2019), that consuming brown rice as the main food can play a role in controlling body weight. The statistical test results also showed a significance value or p-value of 0.002 ($p < 0.05$). Hence, it could be concluded that there was a difference in the BMI of respondents with type 2 DM before and after the brown rice-based diet menu intervention.

Excessive fat intake can trigger excess fat accumulation in the body and can cause central obesity when fat accumulates in a specific area. After the intervention, 22.2% of respondents achieved abdominal circumference close to normal. It can be attributed to the controlled intake of fat and calories during the intervention. Research by Hooper et al. (2015) also supports this by stating that a controlled fat diet has been shown to reduce body weight and body fat percentage, resulting in improvements in body weight and abdominal circumference. The results of the statistical test showed a p-value of 0.008 ($p < 0.05$), meaning that there was a difference between the abdominal circumference of respondents with type 2 DM before and after the intervention with the brown rice-based diet menu.

Effect of Brown Rice-Based Diet on Improvement of BMI and Abdominal Circumference

The results of this study show that the brown rice-based diet intervention improved the respondent's BMI and abdominal circumference, as indicated in Table 6. This improvement is attributed to the nutritional content of brown rice, which is better than ordinary white rice. Brown rice contains phytosterols, which act as antioxidants. Phytosterols can enhance the activity of lipoprotein lipase (LPL), an enzyme that will inhibit fat accumulation in peripheral tissues (6).

Besides, brown rice also contains gamma-oryzanol, which is an anti-obesity substance. Administering gamma-oryzanol in experimental animals fed a high-fat diet to become obese showed positive results that gamma-oryzanol is able to control weight gain and help reduce the possibility of dyslipidemia in experimental animals (30). Research by Francisqueti et al. (2017) also states that gamma-oryzanol plays a role in preventing weight gain. In line with this research, the results of this study also showed a significant improvement in the respondents' BMI and abdominal circumference.

Brown rice also contains high fiber, which contributes to its lower glycemic index than white rice. The fiber in brown rice can help reduce weight because fiber can promote satiety (6). A similar study conducted by Delzenne et al. (2020) stated that increased dietary fiber intake, either from fiber-rich foods or supplements, can help maintain or promote weight loss in individuals who are overweight.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.9

CONCLUSION

The brown rice-based diet intervention had a significant effect on the BMI and abdominal circumference of the respondents in this study. The intervention resulted in a 5.6% decrease in the prevalence of obesity I and a 5.5% increase in the prevalence of respondents with normal BMI category. Statistical test results also showed that changes in BMI before and after the intervention were significant (0.002; $p<0.05$).

Furthermore, 22.2% of respondents experienced a decrease in abdominal circumference, close to normal following the brown rice-based diet menu intervention. The statistical test results also showed significant changes in abdominal circumference before and after the intervention (0.008; $p<0.05$). However, 88.9% of respondents still had central obesity, as their abdominal circumference exceeded the normal limits of 80 cm.

ACKNOWLEDGMENTS

The authors thank Prof. Dian Handayani, SKM, M.Kes, PhD who has provided the opportunity to join the research team. The author also thanks Dr. Ir. Endang Sutjiati and Dr. Etik Sulistyowati, SST., S.Gz., M.Kes who have guided the completion of this thesis.

REFERENCES

1. Sahlan Zamaa M, Sainudin S. Hubungan Kepatuhan Pengobatan Dengan Kadar Gula Darah Sewaktu Pada Pasien Diabetes Melitus Tipe II. Jambura Nurs J. 2019;1(1):11–8.
2. Nuraini HY, Surpiatna R. ARTIKEL PENELITIAN Hubungan Pola Makan , Aktivitas Fisik dan Riwayat Penyakit Keluarga Terhadap Diabetes Melitus Tipe 2. 2016;05(01):5–14.
3. Sagita RW, Rusita I, Anto YV. Hubungan Indeks Massa Tubuh (Imt) Dengan Kadar Glukosa Darah Pada Pasien Dengan Diabetes Melitus Tipe 2 Di Rsud Wates. 2020;09(1):14–8.
4. Fatimah RN. Diabetes Melirus Tipe 2. J Major. 2015;4(5):93–101.
5. Kozuka C, Yabiku K, Takayama C, Matsushita M, Shimabukuro M, Masuzaki H. Natural food science based novel approach toward prevention and treatment of obesity and type 2 diabetes: Recent studies on brown rice and γ-oryzanol. Obes Res Clin Pract [Internet]. 2013;7(3):e165–72. Available from: http://dx.doi.org/10.1016/j.orcp.2013.02.003
6. Sulistyowati E, Rudijanto A, Soeharto S, Handayani D. The Identification of Characteristic Macro- and Micronutrients and the Bioactive Components of Indonesian Local Brown Rice as a Functional Feed in Obesity Nutrition Therapy. Curr Nutr Food Sci. 2019;16(4):494–500.
7. Maryusman T, Fauziyah A, Fatmawati I, Firdausa NI, Imtihanah S. Pengaruh Kombinasi Diet Tinggi Serat dan Senam Aerobik terhadap Penurunan Berat Badan. J Kedokt dan Kesehat. 2018;14(1):56.
8. Sugiyono. Metode Penelitian Kombinasi (Mix Method). Bandung: Alfabeta; 2015.
9. Suherman E. Strategi Pembelajaran Matematika Kontemporer. Bandung: JICA

UPI; 2013.

10. Tripathy JP, Thakur JS, Jeet G, Chawla S, Jain S, Pal A, et al. Prevalence and risk factors of diabetes in a large community-based study in North India: results from a STEPS survey in Punjab, India. Diabetol Metab Syndr. 2017;9(8):1–8.

11. Aamir AH, Ul-Haq Z, Mahar SA, Qureshi FM, Ahmad I, Jawa A, et al. Diabetes Prevalence Survey of Pakistan (DPS-PAK): Prevalence of type 2 diabetes mellitus and prediabetes using HbA1c: A population-based survey from Pakistan. BMJ Open. 2019;9(2):1–9.

12. Trisnawati SK, Setyorogo S. Faktor Risiko Kejadian Diabetes Melitus Tipe II Di Puskesmas Kecamatan Cengkareng Jakarta Barat Tahun 2012. J Ilm Kesehat. 2013;5(1):6–11.

13. Asiimwe D, Mauti GO, Kiconco R. Prevalence and Risk Factors Associated with Type 2 Diabetes in Elderly Patients Aged 45-80 Years at Kanungu District. J Diabetes Res. 2020;2020.

14. Ha MS, Son WM. Combined exercise is a modality for improving insulin resistance and aging-related hormone biomarkers in elderly Korean women. Exp Gerontol [Internet]. 2018;114(May):13–8. Available from: https://doi.org/10.1016/j.exger.2018.10.012

15. Vaidya A, Krettek A. Physical activity level and its sociodemographic correlates in a peri-urban Nepalese population: A cross-sectional study from the Jhaukhel-Duwakot health demographic surveillance site. Int J Behav Nutr Phys Act. 2014;11(1).

16. Sorop O, van den Heuvel M, van Ditzhuijzen NS, de Beer VJ, Heinonen I, van Duin RWB, et al. Coronary microvascular dysfunction after long-term diabetes and hypercholesterolemia. Am J Physiol - Hear Circ Physiol. 2016;311(6):H1339–51.

17. Ohishi M. Hypertension with diabetes mellitus: Physiology and pathology review-article. Hypertens Res. 2018;41(6):389–93.

18. Roifah I. Analisis Hubungan Lama Menderita Diabetes Mellitus Dengan Kualitas Hidup Penderita Diabetes Mellitus. J Ilmu Kesehat. 2017;4(2):7.

19. Putra, I. W. A., & Berawi K. Empat Pilar Penatalaksanaan Pasien Diabetes Mellitus Tipe 2. Majority [Internet]. 2015;4(9):8–12. Available from: http://juke.kedokteran.unila.ac.id/index.php/majority/article/view/1401

20. L. Kathleen Mahan JLR. Krause's Food & The Nutrition Care Process. Poisoning & Drug overdose. Canada: El; 2017.

21. Kaur B, Ranawana V, Henry J. The Glycemic Index of Rice and Rice Products: A Review, and Table of GI Values. Crit Rev Food Sci Nutr. 2016;56(2):215–36.

22. Fa A, Ch W, Dn F, Ne S. Hubungan antara Kandungan Karbohidrat dan Indeks Glikemik pada Pangan Tinggi Karbohidrat

Relationship between Carbohydrate Content and the Glycemic Index in High-Carbohydrate Foods. 2019;(September).

23. Wijaya A, Wande N, Wirawati IAP. Hubungan lingkar perut dengan kadar gula darah puasa pada mahasiswa Fakultas Kedokteran Universitas Udayana angkatan 2014. Intisari Sains Medis. 2019;10(2):279–83.

24. PERKENI. Pengelolaan dan Pengobatan Diabetes Melitus Tipe 2 Dewasa. Pedoman Pengelolaan dan Pencegah Diabetes Melitus Tipe 2 di Indones. 2019;1:132.

25. Verma S, Hussain ME. Obesity and diabetes: An update. Diabetes Metab Syndr Clin Res Rev [Internet]. 2017;11(1):73–9. Available from: http://dx.doi.org/10.1016/j.dsx.2016.06.017

26. Ruban A, Stoenchev K, Ashrafian H, Teare J. Current Treatments for Obesity. Clin Med (Northfield Il) [Internet]. 2019;19(3):205–12. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6542229/pdf/clinmed-19-3-205.pdf

27. Pletsch EA, Hamaker BR. Brown rice compared to white rice slows gastric emptying in humans. Eur J Clin Nutr [Internet]. 2018;72(3):367–73. Available from: http://dx.doi.org/10.1038/s41430-017-0003-z

28. Sawada K, Takemi Y, Murayama N, Ishida H. Relationship between rice consumption and body weight gain in Japanese workers: White versus brown rice/multigrain rice. Appl Physiol Nutr Metab. 2019;44(5):528–32.

29. Hooper L, Abdelhamid A, Bunn D, Brown T, Summerbell CD, Skeaff CM. Effects of total fat intake on body weight. Cochrane Database Syst Rev. 2015;2015(8).

30. Wang L, Lin Q, Yang T, Liang Y, Nie Y, Luo Y, et al. Oryzanol Modifies High Fat Diet-Induced Obesity, Liver Gene Expression Profile, and Inflammation Response in Mice. J Agric Food Chem. 2017;65(38):8374–85.

31. Francisqueti FV, Minatel IO, Ferron AJT, Bazan SGZ, Silva V dos S, Garcia JL, et al. Effect of gamma-oryzanol as therapeutic agent to prevent cardiorenal metabolic syndrome in animals submitted to high sugar-fat diet. Nutrients. 2017;9(12).

32. Delzenne NM, Olivares M, Neyrinck AM, Beaumont M, Kjølbæk L, Larsen TM, et al. Nutritional interest of dietary fiber and prebiotics in obesity: Lessons from the MyNewGut consortium. Clin Nutr. 2020;39(2):414–24.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.9

OPEN ACCESS

Indonesian Journal of Human Nutrition
P-ISSN 2442-6636
E-ISSN 2355-3987
www.ijhn.ub.ac.id

Organoleptic and Antioxidant Activities of Tomato, Pontianak Orange, and Carrot Juice for Cancer Patients

Nur Rahman[1*)], Khairuddin[1], Ajeng Fasha Shaninditha[1], Ni Putu Ayuningtyas Mirah Pradnya Dewi[1], Ary Dwi Ayu Faradina[1]

[1] Malang Health Polytechnic of Ministry of Health
*Corresponding author: Nur Rahman. E-mail: rahmancahaya@yahoo.com

Accepted: August 2022 Reviewed: October 2022 Published: July 2023

ABSTRACT

Cancer has become a leading cause of mortality worldwide, with approximately 8.2 million deaths attributed to the disease in 2012. Antioxidants have demonstrated potential in combating cancer, and natural sources rich in vitamins, such as fruits and vegetables, are believed to be beneficial. This study aims to assess the chemical and organoleptic qualities of fruit and vegetable juice (tomatoes, Pontianak oranges, and carrots) as functional food for cancer patients. The study used an experimental design with a Complete Randomized Design (CRD) approach, with distinct processing techniques for each treatment level, and three replications were conducted. Data collection involved hedonic scale tests by 20 panelists to evaluate organoleptic quality, spectrophotometric tests to measure vitamin C levels, and DPPH tests to assess antioxidant activity. The results show that the processing of fruit and vegetable juice does not significantly influence vitamin C levels, aroma, or texture ($p = 0.50$). However, it has a significant effect on antioxidant levels, color, and taste of the juice ($p=0.007$).

Keywords: antioxidants, fruits and vegetables, functional foods, cancer

INTRODUCTION

Cancer is a complex disease characterized by the uncontrolled growth and spread of abnormal cells throughout the body. It encompasses a wide range of anatomical and molecular subtypes, each requiring specialized treatment approaches (WHO, 2018). As one of the leading causes of death globally, cancer claimed approximately 8.2 million lives in 2012. Among the most prevalent and fatal types of cancer each year are lung, liver, stomach, colorectal, and breast cancer. Alarmingly, it is projected that cancer cases will increase from 14 million in 2012 to 22 million within the next two decades. In Indonesia, the prevalence of cancer was reported as 1.4 per 100 residents, affecting around 347,000 individuals, according to Basic Health Research data from 2013 (Ministry of Health, 2017). By 2018, it was estimated that cancer-related deaths reached a staggering 9.6 million worldwide. The most common cancers in men include lung, prostate, colorectal, stomach, and liver cancer, while breast, colorectal, lung,

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.10

cervical, and thyroid cancer are prevalent in women (WHO, 2018).

Traditionally seen as an ailment of the elderly, cancer poses a risk to individuals of all age groups, from infants to the elderly (Ministry of Health, 2015). However, significant progress has been made in the fight against cancer, with antioxidants emerging as potential fighters against this deadly disease. Besides their role in cancer prevention, antioxidants are vital for combating oxidative stress, a process occurring in degenerative conditions. Research has shown that both synthetic and natural antioxidants are essential for preventing oxidative stress (Werdhasari, 2014). Studies have demonstrated the impact of tomato antioxidants on breast cancer (Fitricia, Winarni, & I.B.R. Pidada, 2012) and their potential to reduce the risk of prostate carcinoma (Novaldy & Iyos, 2016). Natural ingredients rich in antioxidant, such as fruits and vegetables, have shown promise in preventing and inhibiting cancer cell growth. In line with this research, Dina Amalia (2020) explored the antioxidant activity of Moringa leaves (Moringa Oleifera) in cancer prevention, emphasizing its potential as a preventive and anticancer agent due to its abundant antioxidants, bioactive compounds, β-carotene, flavonoids, and other beneficial components.

Considering this body of research, the present study aims to develop functional food for cancer patients by creating fruit and vegetable juices. The combination of tomatoes, oranges, and carrots, which are rich in Vitamin C, has been chosen to provide a potent source of antioxidants. Oranges, in addition to their high vitamin content, contain various bioactive compounds functioning as antioxidants, combating free radicals and cancer cells within the body. Carrots, known for their β-carotene content, have been linked to a reduced risk of prostate cancer in men (Nurani, 2012). Due to their exceptional nutritional value, carrots are suitable for regular consumption.

RESEARCH METHODS

Study design

This research employed an experimental design using a completely randomized design (CRD) with three treatment levels: fruit transformed into powder, boiled fruit followed by drying, and direct blending of the fruit. Each treatment was replicated three times. The study was conducted at Malang Health Polytechnic's Food Ingredients Science Laboratory, Organoleptic Laboratory, Biochemical Laboratory, and the Herbal Materia Medica Laboratory in Batu City.

Data Source

The production of fruit and vegetable extracts in powder form (T1) involved weighing and washing the ingredients (tomatoes, Pontianak oranges, carrots). The ingredients were cut into 0.5 cm slices and dried by exposing them to sunlight for 24 hours. The dried ingredients were then pulverized. The fruit and vegetable powder was steeped in boiling water.

The production of fruit and vegetable extracts through boiling (T2) involved weighing and washing the ingredients. The ingredients were cut into 1x1 cm pieces and boiled for 3 minutes using a ratio of 1:12 between the ingredients and water. The resulting fruit and vegetable broth was poured into a basin.

For the production of fruit and vegetable extracts without boiling (T3), the ingredients were weighed and washed. The ingredients were then cut into smaller pieces and blended.

Vitamin C analysis was performed using the spectrophotometric method based on the Proceedings of the National Chemistry Seminar and Learning in 2017. Antioxidant activity analysis was

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.10

conducted using the DPPH method with spectrophotometry (Blois, 1985 in Hanani et al., 2005).

A DPPH solution was prepared in methanol with a volume of 1 mL each. The extract concentration was varied by dissolving 0.01-0.6 mg in 5 mL of methanol. The varied extracts were then mixed with the prepared DPPH solution, vortexed, and incubated at 37°C for 30 minutes. The absorbance was measured using a spectrophotometer at a wavelength of 517 nm, and a pure methanol solution served as the blank.

The antioxidant activity test was conducted in duplicate. Organoleptic quality assessment was performed using a 4-point hedonic scale questionnaire.

Development of Data Collection Instruments and Techniques

The assessment of organoleptic quality involved conducting nutritional value calculations at the biochemical laboratory of Malang Health Polytechnic. Organoleptic evaluations were carried out utilizing a Hedonic Scale Test questionnaire form, specifically targeting attributes such as color, taste, and texture. A panel of 20 sophomore D-III students from the Department of Nutrition at Malang Health Polytechnic actively participated in these evaluations.

To determine the vitamin C levels in the fruit and vegetable juices, the spectrophotometric method was utilized. This process involved a series of steps. It was started with the filtration of the packaged drink. Next, 0.5 mL of the filtered sample was carefully pipetted and added to a 100 mL volumetric flask filled with distilled water. The mixture was thoroughly homogenized, and the absorption was measured at a maximum wavelength of 265 nm using a spectrophotometer.

The vitamin C levels were calculated using the following formula: (concentration of vitamin C in the sample x 100%) / sample concentration. This enabled the accurate determination of the vitamin C content, expressed as a percentage, in the fruit and vegetable juices.

The assessment of antioxidant activity was performed using the DPPH method with the fruit and vegetable juices as samples. A DPPH solution was prepared in methanol (1 mL each), and the concentration of the extract was varied by dissolving 0.01 – 0.16 mg in 5 mL of methanol. The sample was then mixed with the prepared DPPH solution, vortexed, and incubated at a temperature of 37°C for 30 minutes. The absorbance of the solution was measured using a spectrophotometer at a wavelength of 517 nm. The methanol solution served as the blank. The antioxidant activity test was conducted in duplicate. The formula for calculating percent inhibition (%) was: (absorbance of the blank - absorbance of the sample x 100%) / absorbance of the blank.

Data analysis technique

The effect of data processing on organoleptic quality was assessed using statistical analysis, the Kruskal-Wallis test at a 95% confidence level. If the obtained conclusion yields a significance value of ≤ 0.05, indicating an effect of processing on organoleptic quality, the analysis is followed with the Mann-Whitney multiple statistical test at a 95% confidence level. This additional test aimed to identify specific treatment pairs that exhibit significant differences.

To evaluate the effect of processing on vitamin C levels, the one-way ANOVA statistical analysis was employed at a confidence level of 95%.

For analyzing the antioxidant activity, the one-way ANOVA statistical analysis was utilized at a 95% confidence level. In drawing the conclusions, if the results indicate a significance value of ≤ 0.05, representing an effect of processing

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.10

on organoleptic quality, the analysis is followed by the Post Hoc LSD test at a 95% confidence level. This post hoc test is conducted to determine the specific treatment pairs that display significant differences.

Antioxidant Activity

Table 1. Average Value of Antioxidant Activity Test Results

Treatment	Average Percent Inhibition Level per 100 ml (%)
T1	66,16
T2	73,93
T3	87,02

Table 1 presents the variations in percentage inhibition observed among different treatments of fruit and vegetable extracts. The T3 treatment level (non-boiling and direct blending fruit and vegetable extract production) showed the highest percentage inhibition at 87.02%, while the lowest inhibition level was observed in the T1 treatment level (the production of fruit and vegetable extracts through sunlight exposure and soaking in boiled water) with a value of 66.16%.

Vitamin C

Table 2. Average Value of Vitamin C Test Results

Treatment	**Average Level of Vitamin C per 100 ml (%)**
T1	0,105
T2	0,006
T3	0,030

Table 2 presents the vitamin C content of fruit and vegetable extracts, indicating that the highest concentration was observed in the T1 treatment group with a value of 0.105%, while the lowest concentration was found in the T2 treatment group (boiling), with a value of 0.006%.

Organoleptic Quality of Z Fruit and Vegetable Extract Color

Panelists demonstrated a strong preference for the color of fruit and vegetable juices produced in the T3 treatment level (direct blending without powder or boiling). With an average preference score of 3.4, indicating a highly favorable response, it is evident that the bright color of the juice at this treatment level was well-received by the panelists, as seen in Figure 1.

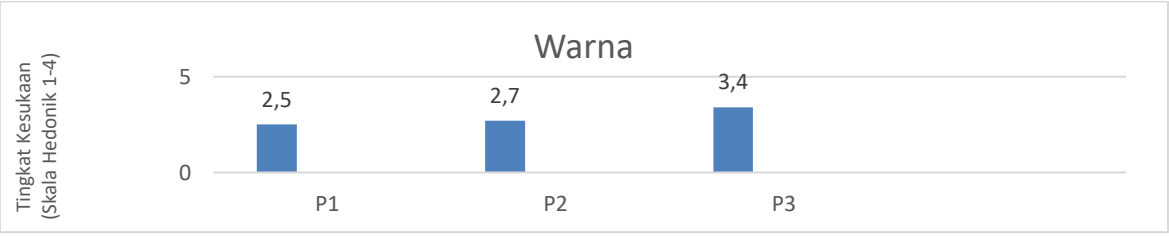


Figure 1. The average level of preference of panelists for the color of fruit and vegetable juices

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.10

Organoleptic Quality of Aroma of Fruit and Vegetable Juices

The panelists showed a strong preference for the aroma of fruit and vegetable juices in both the T1 treatment level (powdered form) and the T3 treatment level (no powder or boiling) with a score of 2.65, indicating a strong liking, as shown in Figure 2.

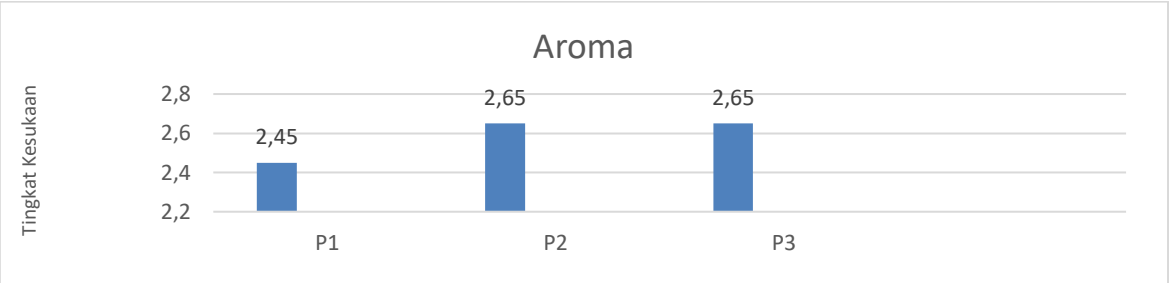


Figure 2. Average Level of Panelists' Likedness of Fruit and Vegetable Juice Aromas

Organoleptic Quality of Fruit and Vegetable Juice Taste

The panelists expressed their preference for the taste of fruit and vegetable juices in the T2 treatment level (boiling and using the boiled water) with a score of 2.65, indicating a strong liking, as seen in Figure 3

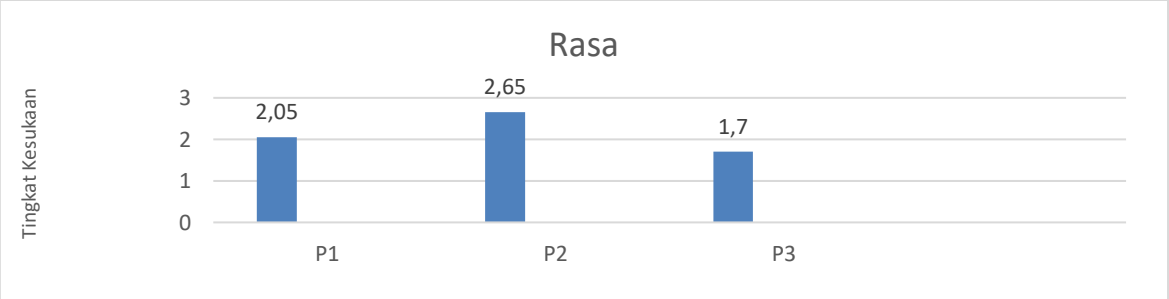


Figure 3. The average level of preference of panelists for the taste of fruit and vegetable juices

Organoleptic Quality of Fruit and Vegetable Juices

The panelists demonstrated their utmost preference for the texture of fruit and vegetable juices at the T1 treatment level (using powdered material) with a score of 2.95, indicating a strong liking, as shown in Figure 4.

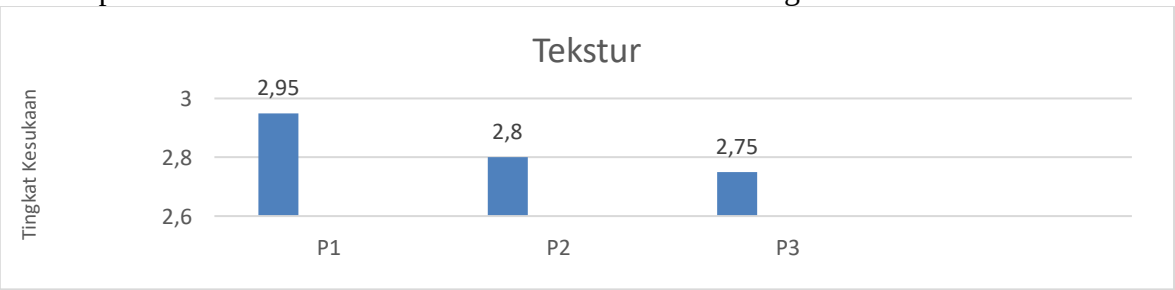


Figure 4. Average Level of Panelists' Liked Texture of Fruit and Vegetable Juices

DISCUSSION

Antioxidant Activity

The data presented in Table 1 indicates variations in the average percentage inhibition levels among

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.10

different treatment levels. These variations can be attributed not only to the different treatment methods employed but also to the varying amounts of materials used, while maintaining the same ratio. As shown in Table 7, fruit and vegetable juice processed through drying and powdering exhibited the lowest inhibition levels. This can be attributed to the fact that antioxidants are susceptible to damage when exposed to high temperatures (> 60°C) (Haijun Y, et al., 2010). On the other hand, fruit and vegetable juices that were directly blended exhibited the highest percentage of inhibition, likely due to the absence of high-temperature processing in this method.

The one-way ANOVA statistical analysis conducted at a 95% confidence level revealed a significant effect (p=0.007) of processing on the antioxidant activity of the fruit and vegetable juices. This finding aligns with the research conducted by Felicia, et al. (2017), which also demonstrated the significant impact of processing methods on antioxidant activity. It is important to note that heating during the processing can lead to a decrease in antioxidant activity (Pokorny, 1986 in Anggraeni, Santoso, & Cahyanto, 2015). In this study, the fruit and vegetable juice products exhibited inhibition percentages ranging from 66.16% to 87.02%. The serving portion of the fruit and vegetable juices was standardized at 200 ml.

Vitamin C levels

The data in Table 2 shows that the average levels of vitamin C for each treatment level are different. It is because in addition to different processing, the amount of material used for each treatment level varies, but still in the same ratio. Fruit and vegetable juices processed by boiling have the lowest levels of vitamin C, as vitamin C is destroyed when exposed to high temperatures. In addition, the treatment level carried out by boiling was only taking boiled water, not using fruits and vegetables. Meanwhile, fruit and vegetable extracts processed into powder have the highest levels of vitamin C. This is due to the large amounts of material required during drying (2 kg of tomatoes, 2.4 kg of oranges, and 4 kg of carrots), which resulted in a smaller yield of powder (50 g tomatoes, 100 g oranges, and 280 g carrots).

The results of the one-way ANOVA statistical analysis at the 95% confidence level showed no significant effect (p=0.50) of processing on the levels of vitamin C in the fruit and vegetable juices produced. This contradicts the research results of Fadil, et al (2016), which suggested a significant effect of the heating method on vitamin C levels. The fruit and vegetable juice products in the study contained 0.006 – 0.105% vitamin C. The serving portion of fruit and vegetable juices was 200 ml.

Organoleptic Quality of Color

The results of the Kruskal-Wallis analysis conducted at a 95% confidence level revealed a significant effect (p=0.001) of the processing methods on the produced fruit and vegetable juices. Further analysis using the Mann-Whitney post-hoc test indicated significant differences between the T1 and T3 treatment levels, as well as between the T2 and T3 treatment levels. However, no significant difference was observed between the T1 and T2 treatment levels.

At the T1 treatment level, where fruit and vegetable extracts were used, the resulting color of the juice was observed to be dark brown. On the other hand, the T2 treatment level, involving boiling, produced a transparent yellow color, while the T3 treatment level resulted in an orange color. The dark brown color observed at the T1 treatment level can be attributed to the damage of carotenoids, particularly β-carotene, due to the heating

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.10

process (Farrel, 1990 in Dendang, N., et al., 2016).

The variation in color among the treatment levels can be attributed to the different ingredient proportions used in each treatment level. These findings contradict the results of Firdamayanti's research (2017), which suggested that the distinct orange color of the juice can be maintained even after undergoing certain processing methods involving heating.

Aroma Organoleptic Quality

Panelists expressed a tendency to dislike the aroma of fruit and vegetable juices at the T1 treatment level. However, it is important to note that aroma assessment can vary due to individual differences influenced by psychological and physiological factors.

Analyzing the results using the Kruskal-Wallis test at a 95% confidence level found no significant effect (p=0.374) of the processing methods on the aroma of the produced fruit and vegetable juices.

Organoleptic Quality of Taste

The results of the Kruskal-Wallis analysis at a 95% confidence level revealed a significant effect (p=0.000) of the processing methods on the taste of the fruit and vegetable juices produced. Subsequent Mann-Whitney tests indicated significant differences in taste between the T1 and T2 treatment levels, as well as between the T2 and T3 treatment levels. However, no significant difference was observed between the T1 and T3 treatment levels.

It is important to note that panelists generally did not prefer the taste of the resulting fruit and vegetable juices. This could be attributed to the absence of added sugar in each treatment level. However, it is essential to acknowledge that individual taste evaluations may vary due to the influence of psychological and physiological factors.

Texture Organoleptic Quality

Figure 4 illustrates the effect of different processing methods on the panelists' preference for the texture of the fruit and vegetable juices. It can be observed that at the T2 treatment level, the resulting texture tends to be thinner compared to the T1 and T3 treatment levels.

Considering the percentage of panelists and the mode of preference level, it becomes evident that the panelists generally enjoy the texture of the fruit and vegetable juices produced. However, it is important to note that individual preferences may vary.

The results of the Kruskal-Wallis analysis at a 95% confidence level revealed no significant effect (p=0.505) on the texture of the fruit and vegetable juices produced.

CONCLUSION

In conclusion, the study revealed that the variation in processing methods for fruit and vegetable juices did not significantly affect vitamin C levels (p=0.50). However, it had a significant impact on the antioxidant levels (p=0.007) present in the juices. These findings highlight the importance of selecting processing techniques in preserving the antioxidant properties of the juices.

Furthermore, different processing methods exhibited a significant influence on the color and taste profiles of the fruit and vegetable juices. However, no significant effects were observed in terms of aroma and texture. This suggests that the selection of processing methods can play a crucial role in achieving desired sensory characteristics, particularly in terms of color and taste.

It is noteworthy that tomatoes, a key ingredient in the juice, contain lycopene, an antioxidant known for its potential in reducing the risk of cancer. Therefore, the consumption of tomato-based juice may provide significant health benefits due to its lycopene content.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.10

These findings emphasize the importance of considering processing techniques in fruit and vegetable juice production to optimize antioxidant levels, sensory attributes, and potential health benefits for consumers.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to the academic community of the Health Polytechnic of Malang for their valuable support and assistance throughout the research process. The moral and material contributions have greatly facilitated the successful implementation of this study.

Special thanks are extended to the Head of the Food Ingredients Science Laboratory, the Head of the Organoleptic Laboratory, the Biochemical Laboratory at Health Polytechnic of Malang, and the Head of Herbal Materia Medica Laboratory in Batu City. Their expertise and collaboration were instrumental in the execution of this research.

REFERENCES

1. Aisyah, Y., Rasdiansyah, R., & Muhaimin, M. (2014). Pengaruh pemanasan terhadap aktivitas antioksidan pada beberapa jenis sayuran. *Jurnal Teknologi dan Industri Pertanian Indonesia*, *6*(2).
2. Baradero, S.M dan Siswadi, Y. Klien Kanker: Seri Asuhan Keperawatan. Penerbit Buku Kedokteran EGC, Jakarta; 2005
3. Damayanti, E. T., & Kurniawati, P. (2017, November). Perbandingan metode penentuan vitamin C pada minuman kemasan menggunakan metode spektrofotometer UV-Vis dan iodimetri. In *dalam Seminar Nasional Kimia dan Pembelajarannya, Malang* (Vol. 41).
4. Fadil, S., Su'i, M., & Sudiyono, S. (2016). Pengaruh Pateurisasi dan Sterilisasi Terhadap Kualitas dan Lama Penyimpanan Sari Ubi Jalar Ungu (*Ipomoea batatas L.). Agrika, 10(1).*
5. Felicia, N., Widarta, I. W. R., & Yusasrini, N. L. A. (2016). Pengaruh ketuaan daun dan metode pengolahan terhadap aktivitas antioksidan dan karakteristik sensoris teh herbal bubuk daun alpukat (Persea americana Mill.). *Jurnal ITEPA*, *5*(2), 85-94.
6. Firdamayanti, E. (2017). Pengaruh pemanasan sari buah jeruk terhadap tingkat kehilangan vitamin c. *Perbal: Jurnal Pertanian Berkelanjutan, 5(2), 31-36*
7. Fitricia, I., Winarni, D., & I.B.R. Pidada. Pengaruh Pemberian Tomat (Solanum lycopersicum L.) Terhadap Histologi Kelenjar Mammae Mencit Yang Diinduksi 7,12-Dimetilbenz(A)Antrasena (DMBA). Jurnal Matematika Dan Ilmu Pengetahuan Alam. 2012; 15(2), 52–56.
8. Hanani, E., Mun'im, A., & Sekarini, R. (2005). Identifikasi Senyawa Antioksidan dalam Spons Callyspongia sp. dari Kepulauan Seribu. *Majalah Ilmu Kefarmasian, 2(3), 127-133.*
9. Jiang, J., Shan, L., Chen, Z., Xu, H., Wang, J., Liu, Y., & Xiong, Y. (2014). Evaluation of antioxidant-associated efficacy of flavonoid extracts from a traditional Chinese medicine Hua Ju Hong (peels of Citrus grandis (L.) Osbeck). *Journal of Ethnopharmacology*, *158*, 325-330.
10. Kementrian Kesehatan RI. (2019). Artikel Hari Kanker Sedunia 2019.https://www.depkes.go.id/ar

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.10

t
icle/view/19020100003/harikanker-sedunia-2019.html
11. Kusmardika, D. A. (2020). Potensi aktivitas antioksidan daun kelor (Moringa oleifera) dalam mencegahan kanker. *Journal of Health Science and Physiotherapy*, *2*(1), 46-50.
12. Maharani, A. I., Riskierdi, F., Febriani, I., Kurnia, K. A., Rahman, N. A., Ilahi, N. F., & Farma, S. A. (2021). Peran Antioksidan Alami Berbahan Dasar Pangan Lokal dalam Mencegah Efek Radikal Bebas. In *Prosiding Seminar Nasional Biologi* (Vol. 1, No. 2, pp. 390-399).
13. Novaldy, R., & Iyos, R. N. (2016). Pengaruh Tomat (Solanum lycopersicum) dalam Pengurangan Risiko Karsinoma Prostat. *Jurnal Majority*, *5*(5), 150-154.
14. Nurani, 2012. Ragam Manfaat Wortel, (Online), (http://health.okezone.com/read/201210/03/483/698691/ragam-manfaat- wortel, diakses 21 Pebruari 2013).
15. Octaviani, L. F., & Rahayuni, A. (2014). *Pengaruh berbagai konsentrasi gula terhadap aktivitas antioksidan dan tingkat penerimaan sari buah buni (Antidesma bunius)* (Doctoral dissertation, Diponegoro University).
16. Rawson, N. E., Ho, C. T., & Li, S. (2014). Efficacious anti-cancer property of flavonoids from citrus peels. *Food Science and Human Wellness*, *3*(3-4), 104-109.
17. Riskesdas. 2013. Penyakit Tidak Menular. Badan Penelitian dan Pengembangan Kesehatan Kemenkes RI, Jakarta
18. Royston, K. J., & Tollefsbol, T. O. (2015). The epigenetic impact of cruciferous vegetables on cancer prevention. *Current pharmacology reports*, *1*, 46-51.
19. Winarno FG. Kimia pangan dan gizi. Jakarta: PT. Gramedia Pustaka Utama. 2004
20. World Health Organization. 2018. Cancer. Swiss

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.10