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Original Research

Effect of Room Service on Patient's Macronutrient Consumption Level

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ABSTRACT

Foodservice in hospitals is aimed at providing high-quality meals and ensuring nutrition intake for patients. However, this aspect of healthcare faces numerous challenges, including high levels of food waste and patient dissatisfaction, often attributed to conventional food delivery practices in hospitals. The consumption of energy and macronutrients, such as carbohydrate, protein, and fat, contribute greatly to hospitalized patients. Therefore, this study tried to implement a room service-like method in the foodservice system. This research was conducted in Class 1 and 2 of the inpatient wards of Waled Regional General Hospital, using a static pre-experimental design with two groups. Each group consisted of 38 patients selected from quota sampling. The control group followed the conventional foodservice method, while the treatment group was given a room service approach. The treatment group was provided with a list of three menu options for each of the nine mealtimes, allowing them to choose their desired food by sending a short message at the designated meal hour. Ordering times were specified as follows: 05:15 to 07:00 for breakfast, 10:00 to 12:00 for lunch, and 15:00 to 17:00 for dinner. Foods were prepared within 45 minutes after the order was placed. T-test analysis revealed a distinct trend in the levels of energy, carbohydrates, proteins, and fats consumption between the control and treatment groups. The correlation between group variables and the level of energy consumption reached 15%, while the correlation between group variables and the level of protein consumption was 14%.

Keywords: Moom Service, Food Service, Macronutrients, Hospital Patient

INTRODUCTION

Foodservice in hospitals is designed with the primary objective of delivering high-quality food ensuring that the nutrition intake needed by patients is met. Organizing food in hospitals as part of nutrition service activities has several series of activities, including menu planning, budgeting, procurement, receiving, inventory, production, and food distribution, as well as documentation, reporting, and evaluation. These comprehensive activities collectively aim to provide quality, cost-effective, acceptable, and safe food, and the nutritional needs of each patient are met so that optimal nutritional status is achieved (1,2).

However, this service has always been facing obstacles, manifesting in issues such as

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excessive food wastage and patient dissatisfaction. The results of research conducted by Schueren et al. (1) found that 61% of patients had an energy intake below 90%, and 75% had a protein intake below 90% of their requirements. It is not surprising that, in the end, this high food wastage leads to inadequate energy and protein consumption by the patient. In line with the results of Barton et al. (2) on 2000 hospital patients, the average patient's leftovers reached more than 40%, which impacted the patient's energy and protein consumption, falling below 80% of their nutritional needs.

The root cause of these issues could be attributed to the conventional foodservice adopted by hospitals. Consumption of energy and macronutrients, such as carbohydrate, protein, and fat, is recognized for its substantial contribution to nutritional adequacy. Therefore, adopting a foodservice approach similar to room service appears to be a valuable scheme. Under this model, patients have the flexibility to select their meals at specified times, which are then prepared within a timeframe of up to 45 minutes before being delivered to their rooms. Failure to meet nutritional requirements could lead to a decline in nutritional status and an extended duration of hospitalization for the patients (3, 4, 5).

We are interested in further research regarding the effect of room service practice on the level of energy and macronutrients (carbohydrate, protein, and fat) consumption of inpatients in hospitals. Predicting the quantity of consumption can be facilitated by analyzing the food waste generated by patients. It is also of the interest to investigate the strength of the correlation between the levels of energy, carbohydrate, protein, and fat consumption and the implemented foodservice system, the characteristics of the subjects, and other influential factors.

METHOD

Research Design

The research was conducted using a static pre-experimental design involving two groups, each consisting of 38 subjects acquired from quota sampling. The data used in this study were primary data, the visual plate waste Comstock method (on a 7-point scale) within both groups of patients.

Research Subjects

Subjects of the research were the inpatients from Class 1 and 2 of Waled Regional General Hospital. Sample selection adhered to inclusion criteria, specifically those general inpatients of Class 1 (Nusa Indah, Anggrek, and Dahlia) and Class 2 (Anggrek and Dahlia) of the hospital, aged between 18 to 65 years old, requiring a special diet of rice or soft foods, processing compos mentis, and demonstrating well communication. Exclusion criteria were applied to exclude blind patients and individuals undergoing fasting treatment.

Data Collection/Materials and Tools

The control group was treated with conventional foodservice while the treatment group was subjected to a room service system. Within the treatment group, individuals were presented with a selection of three main course options for each of the nine designated mealtimes. The first option aligned with the hospital's provided menu, while the second and third options were modified. Subjects within the treatment group could choose one of these meals by sending a short message during the specified mealtime. Breakfast orders were accepted between 05:15 and 07:00, lunch between 10:00 and 12:00, and dinner between 15:00 and 17:00. The chosen meal was prepared within a 45-minute timeframe before being delivered to the subjects' rooms. Visual measurement of food waste was conducted for each inpatient after every mealtime, and the results were interpreted to determine the levels of energy, carbohydrate, protein, and fat consumption. Additionally, a daily in-depth interview was carried out with patients and their families to gather insights into the consumption of food from outside the hospital.

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Table 1. Characteristics of Subjects

Variable	Group		p *value*
	Control n=38 (100%)	**Treatment n=38 (100%)**	
Gender(n(%))			
Female	21 (55.26%)	20 (52.63%)	0.82[a]
Male	17 (44.74%)	18 (47.37%)	
Age (n(%))			
Adult	14 (36.84%)	20 (52.63%)	0.17[a]
Elderly	24 (63.16%)	18 (47.37%)	
Education (n(%))			
< Highschool	36 (94.74%)	32 (84.21%)	0.26[b]
> Highschool	2 (5.26%)	6 (15.79%)	
Nursing Class (n(%))			
Class 1	22 (57.89%)	25 (65.79%)	0.48[a]
Class 2	16 (42.11%)	13 (34.21%)	
Gastrointestinal disorder			
Yes	14 (36.84%)	16 (42.11%)	0.64[a]
No	24 (63.16%)	22 (57.89%)	

a=*Chi-Square test*, b=*Fisher test*

Table 2. Factors that Influence Level of Food Consumption

Variable	Group		p *value*
	Control (n=38)	**Treatment n=38**	
Appearance (n(%))			
Intersting	29 (76.32)	35 (92.11)	0.06[a]
Not interesting	9 (23.68)	3 (7.89)	
Taste (n(%))			
Delicius	21 (55.26)	34 (89.47)	0.001[a*]
Not delicius	17 (44.74)	4 (10.53)	
Consuming food from outside of the hospital (n(%))			
No	8 (21.05%)	12 (31.58%)	0.30[a]
Yes	30 (78.95%)	26 (68.42%)	

a=t-*test*, b=*Mann-Whitney*, *=significance

Data Analysis

The dependent variables of the research were the level of energy, carbohydrate, protein, and fat consumption while the independent variables were the control and treatment groups. Analysis of the data was conducted using univariate, bivariate, and multivariate methods.

RESULT

Univariate analysis (Table 1) shows the characteristics of subjects in the control and treatment groups based on sex (p=0.82), age

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(p=0.71), education (p=0.26), treatment class (p=0.48), and gastrointestinal tract disorder (p=0.64). Univariate analysis was also done on the factors influencing the level of food consumption. The result (Table 2) shows that there are more subjects (30 subjects) in the control group who consumed food from outside the hospital compared to those in the treatment group (26 subjects). However, the foods from outside the hospital are still on the list of foods allowed for the patients.

DISCUSSION

The characteristic of subjects in the control and treatment groups shows homogeneity based on sex, age, education, treatment class, and gastrointestinal tract disorder (Table 1). Despite a higher number of subjects in the control group consuming food from outside the hospital compared to the treatment group, it is important to note that the external food choices fit the list of approved foods for patients.

The control group utilized a conventional food delivery method that offers a single type of food, with fixed mealtime schedules predetermined by the hospital. This approach failed to notice patients' food preferences, leading to dissatisfaction with the hospital's foodservice (Theurer, 2011). Subjects in the control group consumed food from outside the hospital, often due to snacking habits involving items like biscuits or fruits. Interestingly, despite 26 subjects in the treatment group also consuming food from outside the hospital, their intake was lower than that of the 30 subjects in the control group. The average energy consumption in the treatment group was 2.67% kkal and 1.93% gram for protein consumption compared to an average of 8.61% kkal of energy consumption and 4.57% gram of protein intake in the control group. Despite the lower number of subjects consuming food from the treatment group, their average consumption of energy and protein was still higher than those in the control group.

Bivariate analysis shows significant differences in the levels of energy consumption (p=0.0003), carbohydrate consumption (p=0.005), protein consumption (p=0.0005), and fat consumption (p=0.0005) in the control group compared to subjects from the treatment group. The level of consumption in subjects from the treatment group is higher than that in subjects from the control group. This can be attributed to the different treatments given to the treatment group in the form of three menu options at every mealtime for a total of nine times. This treatment offers more varied foods, giving patients more choices compared to the limited options in conventional food delivery. In addition to that, the time for ordering, which is quite flexible though limited, accommodates patient's appetite as it enables them to order food whenever they feel the need. The fact that all food can be served within 45 minutes is also believed to be able to preserve the quality of the food, a characteristic that may be compromised in the conventional method.

In accordance with the research conducted in 2006 by Kuperberg et al. (3) on pediatric patients, there is an increase in the consumption of energy, carbohydrate, protein, and fat. Other studies also show that food delivery using the room service method increased patient satisfaction through a regulation that gives the patients the freedom to choose their mealtime and their preferred food from several choices and receive service from qualified personnel in the field (4, 5, 6).

Multivariate analysis was employed to assess the correlation strength between groups and their consumption of food from outside the hospital, along with the levels of energy and protein consumption. This specific analytical method could not be applied to carbohydrate and fat intakes due to non-normally distributed data. Prior to the multivariate analysis, the result of the bivariate analysis shows that groups have an effect on the level of energy and protein consumption, while consumption of food from outside the hospital has no influence on the consumption level of both substances.

In the control group, the number of subjects consuming food from outside the hospital was slightly higher than in the treatment group, with 30 and 26 subjects, respectively. The conventional food delivery method employed in the control group offers only one menu, and the mealtime has already been determined

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earlier by the hospital. This method does not consider the patients' food preferences and results in the dissatisfaction of the patients towards foodservice in the hospital (5, 7, 8). Although not statistically significant (p=0.30), 26 subjects from the treatment group consumed food from outside the hospital. However, their average energy and protein consumption is only 2.67% and 1.93%, respectively. This is notably lower than the figures for the 30 subjects in the control group, whose energy and protein consumption is 8.61% and 4.57%, respectively. Therefore, the data suggest that the level of energy and protein consumption from hospital-provided meals is higher among the subjects in the treatment group.

Furthermore, a multivariate analysis was conducted using group variables to quantify the extent of energy consumption. The equation for the level of energy consumption is represented as y=61.18 + 14.55(group), with category dummy variable of the control group = 0, and of the treatment group = 1. The adjusted R-square value is 0.15, indicating that the equation elucidates 15% of the variance in energy consumption, while the remaining 85% is attributed to unobserved variables outside the scope of this research.

Multivariate analysis was also used to measure the level of protein consumption by using group variables. The equation for measuring the level of protein intake is y=60.27+15.19(group) with category dummy variable of control group = 0 and of treatment group = 1. The adjusted R-square value is 0.14, signifying that the equation accounts for 14% of the variance in protein consumption, while the other 86% is explained by other variables that are not observed.

The research findings highlight a 15% correlation between the group variable and the level of energy consumption, indicating that the treatment group can enhance the energy consumption of its subjects by 14.55%. This needed energy is crucial for their survival, growth, and activity. Additionally, there is a 14% correlation between the group variable and the level of protein consumption, and the treatment group has the capacity to elevate subjects' protein consumption by 15.19%. Protein plays a significant role in physical growth and the maintenance of body tissues (6).

The level of energy and protein consumption from the food given by the hospital contributes a great deal to the patients. In regard to the subjects, the increased consumption of these substances through the implementation of room service food delivery supports the healing process, particularly for those requiring higher protein intake, such as individuals dealing with anemia, fever, fractures, and burns. When the level of consumption aligns with the required nutritional adequacy, patients typically experience increased satisfaction with the hospital's food service. (3). Collectively, these measures ensure the provision of quality, cost-effective, acceptable, and safe food, meeting the nutritional needs of each patient and ultimately achieving optimal nutritional status.

CONCLUSION

Significant differences are observed in the levels of energy, carbohydrate, protein, and fat consumption among patients treated with room service food delivery in comparison to those undergoing conventional food delivery. The correlation between group variables and the level of energy consumption is notably strong at 15%, while the correlation between group variables and protein consumption stands at 14%. These findings suggest that hospitals should consider adopting a room service system for food delivery to enhance the consumption levels of energy, carbohydrate, protein, and fat in their patients.

Author contributions:

E.P.A. contributed to designing and implementing the research, analyzing the results, and writing the manuscript. Y.S. and S. provided supervision and guidance throughout the work.

Declaration of Conflict of Interest:

The authors have no conflicts of interest to declare. We certify that the submission is original work and is not under review at any other publication.

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Data availability

The data that support the findings of this study are available from the corresponding author, [E.P.A], upon reasonable request.

Ethical clearance

Description of ethical clearance was issued by the Health Research Ethics Committee of Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada.

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Original Research

Sensory Evaluation of *Gulu Naga Ijo* as a Complementary Finger Food Product

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ABSTRACT

The development of four-star complementary foods for breast milk (*Makanan Pendamping ASI* or MP-ASI) products signifies the inclusion of four nutritional elements, i.e. carbohydrates, animal protein, vegetable protein, and vegetables, needed to support the growth and development of children. This study aimed to determine the sensory evaluation, including taste, texture, aroma, appearance, and color, as well as the acceptability test of finger food products known as "Gulu Naga Ijo" made from a combination of corn, eggs, dragon fruit, and green bean flour. This research was an experimental study with a completely randomized design (CRD) on five treatment variations (P0: 0% composite flour, P1: 25% composite flour, P2: 50% composite flour, P3: 75% composite flour, and P4: 100% composite flour). This study revealed a significant difference in sensory evaluation of products and composite flour substitution ($p<0.05$). Overall, two samples (P1 and P3) obtained the highest preference from the panelists in the sensory evaluation, prompting for test acceptability score of the products. The acceptability test for infants resulted in scores of 1.3 for formula P3 and 1.8 for formula P1. The use of composite flour has a significant effect on the sensory evaluation and acceptance of finger food product development.

Keywords: Finger Food, Sensory Evaluation, Complementary Food, Gulu Naga Ijo

INTRODUCTION

The first 1000 days of life is a golden period characterized by rapid development of brain cells, growth of nerve fibers, and formation of complex nerve and brain networks (1). Breastfeeding plays a very important role in meeting the nutritional needs of infants up to 6 months old. However, beyond this period, breast milk alone cannot meet nutritional needs, so complementary foods for breast milk or *Makanan Pendamping ASI* (MP-ASI) are needed (2). The public distinguishes two types of MP-ASI, traditional MP-ASI and manufactured MP-ASI. A well-known form of manufactured MP-ASI is biscuits, which tend to be expensive, lack complete nutritional

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content, and contain preservatives (3). The introduction of MP-ASI poses a risk factor for stunting in infants aged 6-23 months, emphasizing the need for careful attention to this practice (4).

Biscuits are a popular food product, especially among infants, due to their delicious taste, long shelf life, and convenience to consume anywhere and anytime (5). However, typical MP-ASI biscuits are usually made from wheat flour or rice flour, which lacks food diversity as wheat is an imported commodity and rarely produced in Indonesia (6). To address this, one of the efforts to improve infant nutrition is through an approach to improving the quality of MP-ASI and diversifying food by innovating MP-ASI by transforming it into finger food and substituting wheat flour with local food ingredients to increase nutritional value, affordability, and accessibility (2,7).
The four-star MP-ASI variation serves as an innovative approach to enhance infants' nutritional intake, which consists of four nutritional elements, namely carbohydrates, animal protein, vegetable protein, and vegetables (6,8). Using locally sourced ingredients, such as corn for carbohydrates, chicken eggs for animal protein, green beans for vegetable protein, and dragon fruit for fiber and micronutrients, forms the foundation for creating four-star MP-ASI finger food biscuits. These biscuits can be derived using composite flour from a mixture of these four flours (9,10). Corn flour is chosen due to corn's economic value and nutritional profile, particularly its high carbohydrate and protein content compared to rice (11). Green bean flour is added to complete the protein content alongside corn flour (12). Dragon fruit flour in making finger food as a natural coloring agent not only enhances visual appeal but also contributes to the elevated levels of antioxidants (13). Eggs, which have a delicious taste and high nutritional value, are included in the finger food recipe as a source of animal protein (14). Hence, the objective is to create a finger food biscuit product representing a four-star MP-ASI menu crafted from local ingredients containing corn, eggs, dragon fruit, and green beans (abbreviated as "Gulu Naga Ijo"). This study aimed to assess the sensory attributes, encompassing taste, texture, aroma, appearance, and color, alongside determining the acceptability status of this MP-ASI finger food product.

METHOD

Research Design

This experimental research study aimed to assess the sensory evaluation using organoleptic tests and consumer acceptability to a finger food product as complementary food (MP-ASI) for infants aged 6-12 months (15,16). The composite flour used to substitute a finger food product, known as "Gulu Naga Ijo," was made from corn, eggs, dragon fruit, and green bean flour. The biscuits were made in Bandung, and this study was conducted from September to November 2021. Organoleptic and acceptability testing of the finger food product was carried out at the Integrated Laboratory of the Health Polytechnic of the Ministry of Health in Bandung.
Formulation testing was carried out using five treatments (Table 1), with raw materials proportion per 100 grams detailed in Table 2. Before formulating the finger food product, a composite flour formulation was made by calculating energy, protein, fat, and carbohydrate content in corn flour, green bean flour, and dragon fruit flour based on the nutritional information listed on the packaging. The optimal percentage for composite flour was determined as 60% corn flour, 25% green bean flour, and 15% red dragon fruit flour, ensuring a balanced composition of energy, protein, fat, and carbohydrates.

Materials and Tools

Tools used in the preparation of finger food included disk mills, blenders, cabinet dryers, basins, spoons, scales, molds, and ovens. For organoleptic and acceptance testing, additional equipment used in this research were paper plates, trays, plastic forks, tissues, and pens. The ingredients used in the product development were corn flour (from the Fits brand), green bean flour (from the Fits brand), dragon fruit flour (from the Unicorn brand), purebred chicken eggs, refined sugar (from the Claris brand), butter (from the Claris Blue Band), low protein wheat flour (from the Blue Key brand), and baking powder.

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Data Collection

In the sensory testing process, finger food products, each weighing 10 grams for each formula, were selected randomly from the repetition results and evaluated by the panelists. The panelists assessed the samples based on various characteristics, including appearance, color, aroma, texture, and taste, all of which were product stimuli that engage the five senses. Subsequently, the panelists were asked to sort the samples from the most liked to the least liked (17). The assessment of finger food characteristics used a hedonic ranking test questionnaire, allowing panelists to express their preferences on a scale ranging from 1 (like very much) to 5 (dislike very much) (18). The panelists selected for organoleptic testing were untrained panelists, with a minimum number of 30 Padjadjaran University students. The number of panelists was determined based on the optimal requirements for individuals with sufficiently sensitive sensory perception (19). Selected panelists were those who met the predetermined inclusion and exclusion criteria, as follows: male or female with a minimum age of 18 years, in good health, having undergone sensory evaluation test theory, and willing to participate as a panelist by signing the consent form; while the exclusion criteria were individuals who experienced sickness, withdrew from the sensory evaluation test, and had not received sensory evaluation test theory. The acceptance testing was carried out by panelists evaluating finger food products with the best formulation presented, followed by weighing the remaining food (15**)**. The acceptance testing was categorized as "good" if the panelists consumed more than or equal to 50% of the finger food products and "poor" if the consumption was less than 50%. In the acceptability test, 30 people were given finger food products intended for infants aged 6-12 months. The criteria for infants were healthy, accompanied by parents, without dependence on certain drugs, and willing to take part in the research. However, infants unable to attend during data collection were excluded from the finger food product acceptance testing. Each infant, accompanied by their parents, consumed the finger food products, and the percentage of the product consumed was measured to determine acceptability using the food weighing record method (21).

Data Analysis

Data were obtained from the organoleptic testing results (evaluating the appearance, color, aroma, texture, and taste) and observations during the acceptance testing of finger food. Data analysis used SPSS version 16.0 and Microsoft Excel programs, and the analyzed data were presented in the form of tables and narratives. Statistical analysis was done using the One-Way ANOVA statistical test.

RESULT

Green bean, corn, and dragon fruit flour were used in the preparation of composite flour. Each flour was accurately weighed according to the predetermined composition using a digital scale. Subsequently, the three flours were combined thoroughly until achieving homogeneity. Five distinct composite flour compositions were prepared in making the finger food product, as illustrated in Figure 1.

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Figure 1. *Gulu Naga Ijo* Finger Food Products Based on Different Composite Flour Compositions

Sensory Evaluation

The results of the sensory evaluation using organoleptic tests on appearance, taste, texture, aroma, and color of Gulu Naga Ijo finger food are presented in Table 3.

Table 3 shows significant differences related to the addition of composite flour on the level of preference for appearance, taste, texture, aroma, and color ($p<0.05$). The results of Duncan's significant difference test indicate that the preference level for the appearance of P0 was not significantly different from P1, within the range of "like very much" to "like slightly". The use of composite flour caused the preference level of the appearance of samples P2, P3, and P4 to decrease significantly compared to samples P0 and P1. In the samples with significantly different results, the range was 3.13 - 4.40, indicating a preference level from "dislike slightly" to "neutral/like" for the appearance. In contrast to appearance, consistent or directly proportional results were not observed between the addition of composite flour and the preference levels for taste, texture, aroma, and color, based on the results of Duncan's difference test. Panelists tended to have the same preference level between samples P1 and P3, within the "like slightly" range (2.13-2.63). The preference levels for the two samples decreased and were significantly different compared to samples P0, P2, and P4, which were in the "neutral/like" to "like slightly" range (3.03-3.83).

The Acceptance Testing

In the acceptability test, only two finger food products were tested on infants, these two products were the products that obtained the highest ranking based on the organoleptic testing carried out by the panelists (P3 and P1). The following are the results of the acceptability test on finger food products carried out on treatment samples P3 and P1, as presented in Table 4. The assessment of finger food products was conducted with infants older than 6 months at the Integrated Service Post or *Posyandu* in Cinunuk Public Health Center Working Area. The results of the infant's acceptability test revealed scores of 1.3 for the P3 formula and 1.8 for the P1 formula. Based on the results of the acceptability test carried out, both P3 and P1 formulas have good acceptability, although P3 is more dominantly preferred than P1.

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Table 1. Variation of Formulation in The Substitution of Wheat Flour with Composite Flour

Treatment Groups	Wheat Flour (%)	Composite Flour (%)
P0	100	0
P1	75	25
P2	50	50
P3	25	75
P4	0	100

Table 2. Finger Food MP-ASI Formulation per 100 grams

Ingredient Composition	Treatment Groups				
	P0	**P1**	**P2**	**P3**	**P4**
Wheat flour, g	40	30	20	10	0
Composite flour, g	0	10	20	30	40
Refined sugar, g	15	15	15	15	15
Baking powder, g	1	1	1	1	1
Egg yolk, g	20	20	20	20	20
Egg white, g	20	20	20	20	20
Butter, g	4	4	4	4	4

Table 3. Results of Organoleptic Measurements

Preference sensory evaluation	**P0 (100%:0%)**	**P1 (75%:25%)**	**P2 (50%:50%)**	**P3 (75%:25%)**	**P4 (0%:100%)**	***p-value***
Appearance	(2.17 ± 0.95)^{a}	(1.80 ± 0.61)^{a}	(3.13 ± 1.33)^{b}	(3.50 ± 1.45)^{b}	(4.40 ± 0.81)^{c}	<0.001
Taste	(3.43 ± 1.47)^{a}	(2.30 ± 1.14)^{b}	(3.20 ± 1.27)^{a}	(2.20 ± 1.24)^{b}	(3.80 ± 1.27)^{a}	
Texture	(3.40 ± 1.38)^{a}	(2.43 ± 1.25)^{b}	(3.20 ± 1.27)^{a}	(2.13 ± 1.27)^{b}	(3.83 ± 1.26)^{a}	
Aroma	(3.53 ± 1.38)^{a}	(2.63 ± 1.56)^{bc}	(3.03 ± 1.24)^{abc}	(2.47 ± 1.13)^{c}	(3.33 ± 1.51)^{ab}	
Color	(3.63 ± 1.29)^{a}	(2.27 ± 1.38)^{b}	(3.30 ± 1.23)^{a}	(2.23 ± 1.07)^{b}	(3.57 ± 1.41)^{a}	

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 = like very much, 2 = slike slightly, 3 = neutral/like, 4 = dislike slightly, 5 = dislike very much.

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Table 4. Acceptance Testing Results of finger food products

Treatment Group	Acceptance Score	*P-value*
P1 (75%:25%)	$(1.80 \pm 0.42)^a$	0.020
P3 (75%:25%)	$(1.30 \pm 0.48)^b$	

DISCUSSION

Appearance Sensory Evaluation Test of Finger Food

Based on the preference test results, the panelists favored the appearance of finger food treated with 25% composite flour (P1), which was the most preferred product with an average value of 1.80 (like very much), and the 0% composite flour treatment (P0), with an average value of 2.17 (like slightly). Products using 50% composite flour (P2) and 75% composite flour (P3) were still preferred by the panelists, obtaining values of 3.13 (like slightly) and 3.50 (like/neutral), although these values decreased compared to samples P1 and P0. However, the sample using 100% composite flour (P4) received a significantly lower rating of 4.40 (dislike slightly).

The results of Duncan's analysis showed that the treatments using 25% composite flour (P1) and the control sample (P0) impacted the appearance of the finger food produced; both treatments were in the same notation and had a significant effect. Likewise, the treatment using 50% composite flour (P2) and 75% composite flour (P3) on the appearance of the finger food produced were in the same notation and had a significant effect. Meanwhile, the sample using 100% composite flour (P4) was at notation C with the lowest favorability value. Appearance is an important organoleptic parameter assessed by the panelists, which influences their assessment of other parameters like aroma, texture, and taste. Although appearance does not solely determine the absolute level of consumer preference, it does influence consumer acceptance. The uniformity and integrity of a product will certainly attract panelists and are preferable compared to products that are diverse and incomplete (22). The research indicates a strong preference among panelists for the sample treated with 25% composite flour (P1), with a value of 1.80, and for the 0% composite flour sample (P0) with a value of 2.70. This preference is attributed to the intact, flat, and brighter appearance of the P1 and P0 samples compared to samples P2, P3, and P4. This aligns with previous research, which noted that panelists generally preferred samples that were intact, even, and lighter in color.

Taste Sensory Evaluation Test of Finger Food

In the aspect of taste assessment, the results of variance analysis showed a significant impact of composite flour addition to finger food, with a p-value <0.05. Thus, the addition of composite flour influences the taste of the finger food produced. Based on the results of the taste preference test, the panelists favored the sample using 75% composite flour (P3) the most, with an average value of 2.20 (like slightly), followed by the 25% composite flour treatment (P1), with an average value of 2.30 (like slightly). While the panelists also expressed preferences for the samples treated with 50% composite flour (P2), 0% composite flour (P0), and 100% composite flour (P4), obtaining scores of 3.20 (like/neutral), 3.43 (like/neutral), and 3.80 (like/neutral), respectively, the preference for the taste of these three samples decreased compared to samples P3 and P1.

The results of Duncan's analysis showed that the treatment using 75% composite flour (P3) and samples treated with 25% composite flour (P1) significantly influenced the taste of the finger food produced; both treatments were in the same notation and had a significant effect on the preference value. Likewise, the samples in the treatment using 50% composite flour (P2), 0% composite flour (P0), and 100% composite flour (P4) on the taste of finger food produced were in the same notation, indicating a preference value of "like slightly". The taste of a product influences the level of consumer acceptance, even if the other parameters are good, an undesirable taste can lead to product rejection (23). The research results indicated that the panelists generally favored the taste of finger food made from a mixture of corn flour, green bean flour, and dragon fruit. The

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distinctive savory taste of green beans contributed to this positive assessment. The more protein a product contains, the more delicious the final product will taste. Corn flour basically has a very slightly sweet taste due to polysaccharides found in corn flour starch. The added granulated sugar serves as a sweetener, contributing to the overall sweetness of the finger food (24). According to Rustanti et al., brown sugar and granulated sugar have a sweet taste effect on the product and help form texture (25).

Texture Sensory Evaluation Test of Finger Food

The texture of food refers to the pressure experienced in the mouth or felt when touched with the fingers, sensations perceived during biting, chewing, swallowing, or holding, and also visually observed through the biscuit's form. The results of the variance analysis showed that the addition of composite flour to finger food affected the texture of the sample, as indicated by a p-value <0.05, so it can be concluded that the addition of composite flour influenced the texture of the finger food produced. Based on the results of the texture preference test, the panelists preferred the sample treated with 75% composite flour (P3) the most, with an average value of 2.13 (like slightly), and the 25% composite flour treatment (P1) with an average value of 2.43 (Like slightly). While the panelists also expressed preferences for samples treated with 50% composite flour (P2), 0% composite flour (P0), and 100% composite flour (P4), obtaining scores of 3.20 (neutral/like), 3.43 (neutral/like), and 3.83 (neutral/like), respectively, the panelists' preference for the texture of these three samples decreased compared to samples P3 and P1.

The results of Duncan's analysis showed that the treatments using 75% composite flour (P3) and 25% composite flour (P1) impacted the texture of the finger food produced; both treatments were in the same notation and had a significant effect on the preference value. Likewise, the treatment using 50% composite flour (P2), 0% composite flour (P0), and 100% composite flour (P4) on the texture of the finger food produced were in the same notation as the preference value. The P3 formulation was the most preferred by the panelists, due to its optimal biscuit hardness and the additional texture from corn flour and dragon fruit flour. In contrast, the P0 formulation, although preferred by panelists, exhibited a texture similar to typical biscuits, lacking the additional texture found in formulas P1, P2, P3, and P4. The difference in texture results from differences in the ratio of composite flour used in each treatment. This is also following the results of research on organoleptic tests of green bean biscuits and wake-up leaves on texture, which states that differences in the concentration of composite flour affect biscuit texture and crispness (25). According to Susiwi et al, assessing the texture of a food product involves tactile sensation or visual observation to determine whether the food is rough, smooth, hard, or soft (27).

Aroma Sensory Evaluation Test of Finger Food

The aroma of food is tied to the ingredients used in making biscuits. Results of the variance analysis showed that the addition of composite flour to finger food affected the aroma of the sample, as evidenced by a p-value of <0.05, suggesting that the addition of composite flour affected the aroma of the finger food produced. Based on the results of the aroma preference test, the panelists preferred samples treated with 75% composite flour (P3) the most, with an average value of 2.47 (like slightly), and 25% composite flour treatment (P1), with an average value of 2.63. (like slightly). While the panelists also expressed preferences for samples treated with 50% composite flour (P2), 0% composite flour (P0), and 100% composite flour (P4), obtaining scores of 3.03 (like/neutral), 3.53 (like/neutral), and 3.33 (like/neutral), respectively, the panelists' preference for the aroma of these three samples decreased compared to samples P3 and P1.

The results of Duncan's analysis showed that the treatments using 75% composite flour (P3) and 25% composite flour (P1) influenced the aroma of the finger food produced; both shared the same notation and had a significant effect on the preference value. Similarly, the samples in the treatment using 50% composite flour (P2), 0% composite flour (P0), and 100% composite flour (P4) on the aroma of finger food produced were in the same notation as the preference value. The organoleptic test results on the aroma of finger food in formulas P3 and

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P1 did not have a significant difference between the two treatments when smelled. This is due to the basic ingredients in making the two biscuits, where the distinctive aroma of both biscuit treatments is the aroma of green bean flour. Aroma is challenging to measure, which leads to different judgments or opinions regarding the quality of the aroma. These differences can be caused by individuals having different olfactory sensitivities and preferences (28).

Based on the results of research conducted by Siti Mardiyah et al, organoleptic testing of the aroma of biscuits with added green bean flour and wake-up leaves showed that the addition of 50% of green bean flour and 15% of wake-up leaves was more favored by the panelists. This preference is attributed to the dominant aroma influenced by the use of basic ingredients for making biscuits, which characterize the overall aroma of the biscuits (26).

Color Sensory Evaluation Test of Finger Food

The color of food significantly influences its visual appeal and taste. Food color is a complex pattern that is challenging to quantify, leading to varied assessments of color quality. These differences arise from individual perceptions of appearance and taste (29). The use of composite flour in finger food on the color of the sample, as indicated by a p-value <0.05, confirms that composite flour influences the color of the finger food produced. According to the results of the color preference test, the panelists favored the color of the sample treated with 75% composite flour (P3), scoring an average value of 2.23 (like slightly), and the 25% composite flour treatment (P1), with an average value of 2.27 (like slightly). Samples using 50% composite flour (P2), 0% composite flour (P0), and 100% composite flour (P4) were also still preferred by panelists, achieving scores of 3.30 (like/neutral), 3.63 (like/neutral) and 3.57 (like/neutral), respectively. However, the panelists' preference for the colors of these three samples decreased compared to samples P3 and P1.

The results of Duncan's analysis showed that the effects of treatments using 75% composite flour (P3) and 25% composite flour (P1) on the color of the finger food produced were in the same notation and had a significant effect on the preference value. Similarly, the samples in the treatment using 50% composite flour (P2), 0% composite flour (P0), and 100% composite flour (P4) on the color of finger food produced were in the same notation with the preference value of "like slightly". Color plays a crucial role in food, as it can stimulate appetite. Appealing food colors have the potential to enhance consumers' appetites and can serve as an indicator of food quality. Additionally, color contributes to the overall meaning and perception of food, influencing consumer acceptance. Foods that deviate from expected colors may be overlooked by consumers, despite being in good condition. However, color is not always synonymous with a particular taste (30). These research results are in line with the research by Togatorop et al., stating that the level of panelists' preference for the color of steamed red dragon fruit skin sponge cake influenced their interest in consuming the cake. The study demonstrated that the red color of the dragon fruit skin attracted panelists, contributing to their interest in consuming the steamed sponge cake (31).

Acceptance Testing of Finger Food

Testing the acceptability of finger food among infant participants involved assessing the most preferred formulas identified through the organoleptic tests, specifically formulas P3 and P1. The acceptability test for finger food, using P3 and P1 formulas, was conducted with 20 infants during *Posyandu* activities in Cinunuk Community Health Center Working Area. The evaluation of porridge acceptance included observing the reactions exhibited by the infants during the introduction of MP-ASI finger food by their mothers. These reactions were assessed at various stages, encompassing acceptance during the initial bite, within the mouth, during swallowing, and throughout subsequent bites until the completion of one portion of MP-ASI finger food. The acceptability assessment method was guided by previous research methodologies (32). If, during the first, second, or third feeding attempt, the infant displays refusal reactions, such as turning away, crying, closing the mouth, maintaining silence, clenching teeth, restlessness, vomiting, or an outright rejection of swallowing the provided food, it can be interpreted that the infant is not accepting the MP-ASI finger food. In instances where the

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infant exhibits initial dislike reactions, such as turning away, closing the mouth, vomiting, and refusing to swallow during the first bite, but subsequently, during the second bite, engages by chewing and swallowing without finishing half the portion of MP-ASI finger food, it can be interpreted that the infant either does not like or struggles to accept the MP-ASI finger food. Conversely, if the infant successfully swallows up to half of the MP-ASI finger food portion, it indicates that the infant likes or can accept the finger food MP-ASI.

Based on the results of the acceptability test conducted with 20 infants aged 6-12 months at *Posyandu* in Cinunuk Community Health Center Working Area, both P3 and P1 formulas showed good acceptability. However, P3 was more dominantly preferred than P1, as evident from the results obtained during the infant acceptability test. The outcomes of the infant acceptability test revealed that the P3 formula scored 1.3 (indicating good acceptability), while the P1 formula scored 1.8 (also indicating good acceptability). Observations of the response to the introduction of MP-ASI finger food using the P3 formula showed initial happiness and eagerness to consume more, which continued until the infant finished the portion. In contrast, when presented with MP-ASI finger food using the P1 formula, most babies exhibited initial refusal, looking away, possibly due to their first encounter with baby porridge. However, after trying subsequent bites, the babies showed a willingness to accept and swallow the food, although not one portion of MP-ASI.

CONCLUSION

The use of composite flour on the sensory evaluation test significantly influences the preference for the appearance, taste, texture, aroma, and color of finger food. Acceptability testing of finger food found that the most accepted treatment group was P3.

Author contributions

NFP: Data curation, investigation, validation, writing original draft, methodology; ASA: conceptualization, investigation, writing original draft, review, and editing; VA and RS: conceptualization, investigation, writing, review, and editing; RBSMZ and NT: Investigation, project administration, methodology, writing, review, and editing.

Declaration of Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Data availability

The data used and/or analyzed in the study are available from the corresponding author upon reasonable request.

Ethical clearance

This research has received ethical approval from the Alma Ata University Ethics Commission (KE/AA/VX/10626/EC/2021). Prior the study, the panelists had signed informed consent, and the researcher maintained the confidentiality of respondents' data.

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Improving the Knowledge of Health Cadres for Stunting Prevention through Emotional Demonstration Technique

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ABSTRACT

Stunting has become a dietary concern in Indonesia. Ogan Komering Ilir district of South Sumatra Province has a stunting prevalence exceeding 20%, highlighting a significant public health concern according to WHO. Addressing this challenge requires the active involvement of health cadres, who play a pivotal role in enhancing maternal and child health. This study aimed to enhance the knowledge of health cadres in stunting prevention through the application of the emotional demonstration method at the village level. A total of 23 active cadres from the healthcare system were purposefully selected to participate in this activity. The experiment group, consisting of 12 cadres, underwent training using the emotional demonstration method through interactive games, while the control group, totaling 11 cadres, followed conventional methods, such as lectures. The activity was held with separate sessions for each group. The participants' knowledge was measured using questionnaires covering the understanding of stunting, exclusive breastfeeding, complementary foods, anemia, and sources of nutrients. Data were analyzed using a dependent t-test. Average pre-post knowledge gains were 1.15 higher score for experiment groups compared to 0.19 higher score for control groups. Statistically significant changes in knowledge scores were observed in the experiment group ($p = 0.002$), while the control group showed insignificant changes ($p = 0.321$). Education activities employing emotional demonstration through interactive games are effective in increasing knowledge of stunting prevention.

Keywords: Cadres, Emotional Demonstration Techniques, Knowledge, Nutrition, Stunting

INTRODUCTION

Indonesia currently faces a double nutritional challenge indicated by both malnutrition and excessive nutrition across all age groups, including children. One of the nutritional problems in children under the age of five, which can be recognized through anthropometric measurements of length or height, is the incidence of stunting (z-score less than -2SD). This condition is attributed to deficiencies or excesses in nutrient intake, imbalances of essential nutrients, or impaired nutrient utilization. Stunting may be triggered by chronic nutrient intake malnutrition (protein energy deficiency) or recurrent chronic infectious diseases, which affect linear growth

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based on World Health Organization standards related to height for age (1,2).

Based on the results of the Basic Health Research (*Riskesdas*) in 2018, the national prevalence rate of stunting was 30.8%, and among the provinces with high rates of stunting, South Sumatra was one of those with an average prevalence of stunting above the national average (31.6%) (3). The nutrition monitoring results from the Indonesian Survey of Nutritional Status in 2021 revealed a stunting prevalence rate in South Sumatra, reaching 32.2%. Among the 17 districts in South Sumatra Province, Ogan Komering Ilir (OKI) District has the highest percentage of stunting incidence, exceeding 20% (4), placing it at the threshold of a health problem, though categorized as a "non-public health problem" based on WHO standards (5). From 2017 to 2018, the Faculty of Public Health selected S.P. Padang sub-district as one of the focus locations of Field Learning Experience, especially Problem-Based Learning (PBL) activities for students. The outcomes of these activities showed that one of the villages in S.P. Padang sub-district identified 23% of toddlers at risk of stunting (6).

Responding to the severity of the situation, the government has declared Ogan Komering Ilir district as an emergency area and a locus for stunting intervention. GAIN Indonesia (2017) has introduced the Emotional Demonstration Technique as a behavior change method for stunting prevention (7–9). Unlike typical health education methods such as lecturing or counseling, this method emphasizes the emotional impact on the education subject (promotion target) through real demonstrations and simulations designed using light-hearted concepts, including games. This technique, developed based on the Behavior-Centered Design (BCD) theory, serves as a reference for planning and testing imaginative and provocative behavior change interventions. Thus, it can encourage a strong response from participants to newly introduced information with challenging, surprising, or interesting packaging (10).

The Emotional Demonstration Technique is believed to enhance the capacity of health cadres in stunting prevention efforts. This is because health cadres serve as an extension of the government in addressing various health issues within the community, including the challenge of stunting, through Integrated Service Pos (*Posyandu*) in the village.

RESEARCH METHOD

Research Design

This study used a quantitative approach, employing a quasi-experiment design with a pre-test and post-test in both control and intervention groups. This study was carried out in S.P. Padang sub-district, Ogan Komering Ilir Regency.

Data Source

Primary data were collected using a questionnaire with a self-assessment method related to the knowledge of *Posyandu* cadres about stunting.

Target Group

The population in this study were *Posyandu* cadres in S.P. Padang sub-district, Ogan Komering Ilir Regency. The sample was taken using a purposive sampling method, resulting in a sample size of 24 health cadres from several villages, who were then divided into two groups. The intervention group received education using the emotional demonstration method. The emotional demonstration method involved activities such as building block games (to illustrate parenting/feeding patterns), filling in the infant and toddler feeding schedule, and filling "my plate" and snacks for toddlers. On the other hand, the control group was educated through the lecture method. This activity took place at the sub-district hall and was held on different days for both groups.

Instrument Development and Data Collection Techniques

The instrument aimed to measure respondents' knowledge related to the determinants of stunting, which consists of 12 questions. Before data collection, respondents were provided with informed consent explaining the purpose of the study. Data collection was carried out twice, before and after the intervention, both in the case and control group to measure the change in cadres' knowledge.

Data Analysis Technique

The data collected were further processed with statistical data processing software using the t-dependent test.

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RESULTS

Statistical Test Results of Intervention Activities

Measuring the effectiveness of interventions in the S.P Padang sub-district can be seen in the Table .1

Table 1. Distribution of Respondent Characteristics

Variable	Group			
	Experiment		Control	
	n	%	n	%
Length of time as a cadre				
≤ 5 years	7	53.9	5	45.5
> 5 years	6	46.1	6	54.5
Parity				
≤ 2 children	7	53.9	7	63.6
> 2 children	6	46,1	4	36.4
Job				
Working	9	69.2	2	18.2
Not Working	4	30.8	9	81.8
Marita Status				
Married	12	92.3	10	90.9
Living Divorce	1	7.7	1	9.1
Formal Education				
Completed Elementary School	2	15.4	2	18.2
Completed Junior High School	2	15.4	3	27.3
Completed Senior High School	7	53.8	6	54.5
Completed Diploma	2	15.4	-	-

Based on Table 1. It is known that in the intervention group, about 54% of respondents have been cadres for less than or a maximum of 5 years while in the control group, most of them have served as cadres for more than 5 years. In both groups, the majority of cadres were married, completed high school, and had at most 2 children. Most respondents in the treatment group did not work compared to the control group, while most had other jobs other than as cadres.

Table 2. The Average Knowledge Score between the Experiment and Control Groups

Group	Knowledge	Mean	SD	Median	Min-Max
Experiment (Emotional Demonstration Technique)	Pretest	7.77	1.36	8	6-10
	Posttest	8.92	1.49	9	6-11
Control (Conventional/Lecture Technique)	Pretest	8.45	1.86	8	6-12
	Posttest	8.64	1.43	9	6-10

Based on the results of the analysis as shown in Table 2, it is known that the average knowledge score of the treatment group increased from 7.77 with a standard deviation of 1.36 during

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the pre-test to 8.92 with a standard deviation of 1.49 during the post-test. Meanwhile, the Control Group's mean knowledge score also increased from pre to post, increasing by 0.19. The control group's knowledge increase tended to be lower than the treatment group's increase of 1.15.

Moreover, the results of the analysis shown in Table 3 indicate that the change in knowledge in the group trained using the emotional demonstration technique was statistically significant with a significance value of 0.002, while the change in knowledge in the group trained using the conventional technique (lecture) was not statistically significant with a significance value of 0.321. Thus, to increase the understanding of health cadres on issues related to the incidence of stunting, this educational technique can be used as an alternative.

Table 3. The Results of Mean Differences in Knowledge Scores Before and After Experiment

Group	Knowledge	Mean	$\Delta\bar{x} \pm SD$	p	Result
Experiment (Emotional Demonstration Technique)	Pretest	7.77	1,15 ± 0,98	0,002	Significant
	Posttest	8.92			
Control (Conventional/Lecture Technique)	Pretest	8.45	0,18 ± 1,94	0,321	Not Significant
	Pretest	8.64			

The effectiveness of interventions in S.P. Padang sub-district is presented in Table 1. Approximately 54% of respondents in the intervention group have been cadres for less than or a maximum of five years, while in the control group, the majority have served as cadres for more than five years. In both groups, the majority of cadres were married, completed high school education, and had at most two children. A larger proportion of respondents in the treatment group did not engage in other work compared to the control group, where the majority had additional occupations beyond their role as cadres.

Based on the analysis results as shown in Table 2, the average knowledge score of the treatment group increased from 7.77 (pre-test) with a standard deviation of 1.36 to 8.92 (post-test) with a standard deviation of 1.49. Meanwhile, the control group's mean knowledge score also increased from the pre-test to the post-test, by 0.19. The control group's knowledge increase tended to be lower than that in the treatment groups, by 1.15.

Moreover, the analysis results presented in Table 3 indicate that the change in knowledge within the group trained using the emotional demonstration technique was statistically significant, with a significance value of 0.002. In contrast, the change in knowledge within the group trained using the conventional technique (lecture) was not statistically significant, with a significance value of 0.321. Thus, to increase the understanding of health cadres on issues related to the incidence of stunting, the emotional demonstration technique can be used as an alternative.

DISCUSSION

Generally, defining and measuring stunting is well established, but its recognition at the community level is not immediate due to the prevailing societal norm that stunting is not a significant health concern. Additionally, the lack of routine anthropometry at the primary healthcare level complicates the visual identification of stunting (11). Stunted growth in children under five is closely linked to nutritional intake. According to Nurhasanah, Rachmawati and Sutejo (2021), severe energy and protein deficiencies are most common among stunted young children. Other contributing factors include inadequate intake of vitamin A, iron, fat, and carbohydrates (13). Furthermore, nutritional status and the incidence of infection are interrelated, in which stunted children have a different antibacterial immune function than children who are not stunted (1,2). This will influence the linear growth based on height-for-age (14,15).

Maternal nutrition and pregnancy conditions are crucial determinants of stunting risk. Therefore, detection and prevention efforts should begin from the first thousand days of

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life (1000DL) when the fetus is in the mother's womb. Getting pregnant at a young age is also a predictor of stunting. At a young age, the body's developmental needs are high, and pregnancy at this age increases the nutritional reserves' expenditure to meet the fetus's needs. This situation elevates the risk of low birth weight (16). For pregnant women, the intake of supplements, such as iron tablets and folic acid, is one of the most important issues in preventing anemia and supporting fetal growth to ensure a healthy childbirth (17). Multivariate analysis based on Basic Health Research (2013) data showed that 10% of pregnant women did not consume folic acid or iron tablets, and only one-third of the total respondents consumed 90 or more iron tablets during pregnancy (18). This is an indication that some pregnant women are not fully aware of the importance of iron and folic acid consumption. If unaddressed, this lack of awareness may contribute to increased anemia among pregnant women, increasing the risk of complications during childbirth, low birth weight, and stunting.

If the right health services had been used, the risks during pregnancy could have been prevented. A previous study found that approximately 12% of pregnant women had fewer than four antenatal care visits during their pregnancy, and about 4% had no antenatal care visits at all (18). It is crucial to inform pregnant women early on about the risks associated with pregnancy and childbirth and educate them about preventive measures through healthcare facilities (19).

The health of mothers and children should remain a priority, even after delivery. Exclusive breastfeeding for the first six months and continuing for two years postpartum are thought to be important to prevent stunting (20). In addition, providing young children with adequate nutrition, including the right frequency of feeding and the right portion, will support their physical and intellectual growth and development. However, social issues, such as economic welfare, pose challenges for communities to access sufficient food. Consequently, intervention processes must involve collaboration across various programs and sectors.

Health Cadres serve as an extension of the medical staff to educate the target population, including pregnant, lactating, and under-five mothers. There is a need to continually build the capacity of the health workforce to play an active role, particularly in reducing stunting. Training activities are instrumental in enhancing the capacity of health cadres, and it is believed that their knowledge can be enriched through training that integrates both theoretical material and practical application (21). The emotional demonstration method developed by GAIN Indonesia is the training model used in this community empowerment activity (7–9). To stimulate the rapidness of cognitive change in the target group, this method emphasizes role-playing, demonstrations, and interactive games. Using Edgar Dale's concept of the speed at which information is received, the use of increasingly realistic properties that involve thinking and movement aids in the transmission of information, ensuring better reception and understanding (22,23). The results indicated positive changes in knowledge scores for the emotional demonstration group.

The use of properties in interventions is believed to significantly enhance the understanding of the target group. The emotional demonstration method employs interactive media, including block layouts (to illustrate infant/toddler feeding patterns), posters depicting infant/toddler feeding schedules, and exhibits featuring "my plate" items and toddler snacks. The integration of visual aids, such as maps, proves effective as it facilitates easier comprehension and adds an element of interest. Learning about stunting becomes more accessible through the use of pictures and explanations, making the conveyed information clearer and more concrete (24). Researchers can use functional props for nutrition campaigns and fully engage stakeholders at all levels in designing and implementing effective behavior change communication interventions for target audiences (25). Building the capacity of *Posyandu*, the spearhead of efforts to improve maternal and child health, is the responsibility of village-level stakeholders.

Enhancing awareness of stunting prevention among mothers of infants and toddlers or expectant mothers can be achieved by augmenting the knowledge of *Posyandu* cadres. Cadres can provide information to this target group through the antenatal education program (26). Multimedia-based intervention

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media, such as videos, short messages on smartphones, public service announcements, or publications on other social media, can be designed to support the intervention process through direct interaction between cadres and target groups (25,26). All intervention efforts that have been carried out aim to achieve a significant reduction in stunting, especially in developing countries such as Indonesia (27).

CONCLUSION

The participants' knowledge of stunting prevention efforts is effectively increased through education using the emotional demonstration method through interactive games. This capacity-building program for health cadres aims to equip the target population, including pregnant women, infants, and mothers of toddlers attending *Posyandu*, with enhanced knowledge and skills. It is expected that this training will contribute to improved maternal and child health indicators, including the reduction of stunting among children under five, chronic energy deficiency, and anemia among mothers.

Author Contribution

In this study, FE, WL, EA, FR, NM, and AR contributed to designing the study. FE, AR, and WL performed data analysis. FE wrote the manuscript and made revisions for important content.

Declaration of Conflict of Interest

There are no conflicts of interest associated with this publication.

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Data availability

The data of this study are available from the corresponding author, upon reasonable request.

Ethical Clearance

This study has passed the ethical eligibility with the ethical clearance certificate number 394/UN9.1.10/KKE/2019.

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Original Research

Lekamer Fortir Cookies as Snack Alternative for Malnourished Toddlers

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ABSTRACT

Cookies serve as an alternative snack option and an additional food source for toddlers. This type of food is widely enjoyed due to the taste and texture. This study aimed to analyze the chemical and organoleptic quality of Lekamer Fortir cookies, made from local food ingredients consisting of catfish, forte, oyster mushrooms, and red beans. This study used an ANOVA test to analyze the chemical, physical, and sensory quality of cookies, exploring their potential to prevent malnutrition. The selected cookies, Formula D, consisted of 40 grams of red bean flour, 10 grams of oyster mushroom flour, 40 grams of catfish flour, and 10 grams of tempeh formula flour. Organoleptic test results showed an average score of 3.79, indicating a strong preference. Further examination of the nutritional composition of Formula D revealed that carbohydrates, protein, fat, and fiber were below 100% of the 2019 RDA requirement, whereas calcium, zinc, and iron content exceeded 100% of the RDA. The results of the panelists' preference for cookies using red bean flour, catfish flour, white oyster mushroom flour, and forte showed no significant differences in color, texture, and taste in each sample.

Keywords: Malnutrition, Cookies, Chemical Quality

INTRODUCTION

Toddlers, particularly within the vulnerable age range of 12-59 months, face a high risk of malnutrition, both wasting and stunting. This critical period is crucial for optimal nutritional intake to support brain growth and cognitive development, as it belongs to the first 1000 days of life (1). Malnutrition, due to a deficiency in macro and micronutrients, causes children under five susceptible to illnesses and, in severe cases, can lead to mortality. The results of Basic Health Research (*Riskesdas*) for North Sumatra in 2018 indicated a stunting prevalence of 32.4% among children under five, surpassing the national incidence of 30.8%. Additionally, the incidence of malnutrition in this age group was 19.6%, significantly higher than the national rate of 13.8% (2).

Malnutrition is characterized by deficiencies in essential macronutrients such as carbohydrates, proteins, and fats. It represents a state of nutritional disorders arising from diseases and insufficient food intake, as outlined by UNICEF. Addressing and preventing malnutrition requires supplementation activities, particularly through supplementary feeding, to fulfill the nutritional requirements of toddlers. Cookies serve as an alternative snack that can contribute to meeting these needs. Cookies, a popular type of biscuit enjoyed for their delightful taste, softness, and crunchiness, offer a palatable option for toddlers. These

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foods can play a role in supporting the growth and development of toddlers. The process of making cookies follows the principle of combining food ingredients with high energy, protein, and mineral content to enhance their nutritional value. This involves substituting and adding nutrient-rich foods during the cookie-making process. To make cookies into a high-energy and protein-rich food, it is crucial to replace and incorporate ingredients that are rich in nutrients. In Indonesia, the average annual per capita consumption of cookies is reported to be 0.40 kg (3).

The high level of consumption of cookies has prompted the substitution of traditional flour with red bean flour. This innovative approach involves combining red bean flour with other food ingredients that are high in protein, calcium, zinc, and other minerals. The selected ingredients, including catfish, oyster mushrooms, and tempeh, are processed into flour and mixed to create "Lekamer Fortir Cookies." Red bean flour, used as a wheat substitute, undergoes pregelatinization to eliminate the starchy taste commonly associated with cookies (4).

Red beans (*Phaseolus vulgaris l.*) are a widely recognized legume with significant potential as a basic ingredient for healthy snacks. Despite its inherent health benefits, red beans often face consumer aversion due to an unacceptable taste (5). However, red beans have an impressive nutritional profile, containing 22.3 g of protein per 100 g of material, especially the leucine protein content at 76.16 mg (6). Additionally, red beans are rich in essential minerals, providing 502 mg of calcium and 410 mg of phosphorus per 100 grams of material. This nutritional content makes red beans a valuable alternative in meeting the dietary needs of children under the age of five (7).

White oyster mushroom (*Pleurotus ostreatus*) has a higher nutritional content than other mushrooms. In 100 grams of dry weight, white oyster mushrooms provide 128 calories, with 27% protein, 1.6% fat, 58% carbohydrates, 51 mg of calcium, 6.7 mg of iron, and 0.1 mg of vitamin B. Notably, oyster mushrooms contain high protein, ranging from 10.5 to 30.4%, comparable to chicken meat. Oyster mushroom is a good source of minerals, such as potassium (K), sodium (Na), phosphorus (P), calcium (Ca), iron (Fe), and dietary fiber.

Catfish, widely cultivated in Indonesia with abundant production and affordable prices, can be processed into fish meal, serving as a protein fortification ingredient in various food products. Despite its high protein content of 17.5 grams per 100 grams and 14.5 grams of fat, the use of catfish flour is hindered by its strong fishy smell and taste. Nutritional content in 100 grams of catfish contains 17.5 g of protein and 14.5 grams of fat (8).

Tempeh is generally known in Indonesia, particularly tempeh from soybeans which is characterized by its yellow color, firm texture, and intricate structure, covered with a layer of white mycelium. This affordable and widely consumed tempeh variety has prompted the need for further development and diversification of tempeh products, including the creation of tempeh formulas in flour form. Typically, these formulas incorporate various food ingredients to enhance the overall quality of the end product. A tempeh formula is a processed food where tempeh serves as the primary ingredient, complemented by other supporting components to prolong its shelf life. Research conducted by the Nutrition Research and Development Center has successfully formulated tempeh into a processed food that has high energy and protein content, easy digestibility, and swallowability. Additionally, this tempeh formula has been used for feeding patients through a tube (9). Tempeh formula is also very good for children under five to improve their nutritional status.

This study aimed to assess both the chemical and organoleptic quality of Lekamer Fortir cookies, utilizing local food ingredients known for their potential to prevent malnutrition.

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METHOD

Research Design

Tool

The tools used in this study were flour-making tools, namely scales, knives, basins, cabinet dryers, millers, 80 mesh sieves, and plastic jars. The tools used for making cookies were mixers, ovens, baking sheets, basins, and cookie molds.

Material

The materials used for flour-making ingredients in this study were red beans, oyster mushrooms, catfish, and tempeh formula. The ingredients for the cookies were milk flour, powdered sugar, margarine, butter, baking powder, salt, egg yolks, and cornstarch.

This study is an experimental study with a completely randomized design (CRD). In this study, cookies were substituted using red bean flour for five treatments, taro flour for five treatments, catfish flour for five treatments, and tempeh formula flour for five treatments.

Research stages

Production of Red Bean, Oyster Mushroom, Catfish Flours, and Tempeh Formula

The selections of red beans, oyster mushrooms, catfish, and soybeans for the forte were chosen according to researcher specifications. After undergoing the process of sorting, cleaning, washing, boiling, and drying, the ingredients were subjected to food blending to obtain various flours for crafting Lekamer Forte cookies. Catfish, chosen for its stable availability and nutritional richness, is a freshwater fish with a composition of 413 kcal energy, 9 g fat, 56 g protein, and 27 g carbohydrates per 100 grams (10).

Cookies Making

The cookie recipe underwent modifications, starting with homogenizing 80 g powdered sugar, 35 g margarine, 20 g butter, 15 g milk flour, and 1 egg yolk using a mixer for approximately 5-10 minutes to form a dough. Red bean flour, oyster mushroom flour, catfish flour, and tempeh formula flour were then added in specified amounts. Following this, 15 g cornstarch, 1.4 g baking soda, and 2.4 g salt were added. The dough was shaped and baked in an oven for approximately 20-25 minutes at a temperature of around 100°C. This cookie recipe contains various ingredients that were previously processed into flour, including red bean flour, oyster mushrooms, catfish, and tempeh formula. The diverse flour additions are detailed in the table below.

Table 1. Distribution Of Ingredients And Grams In The Manufacture Of Cookies

Formulation	Material name			
	Red bean flour (g)	Oyster mushroom flour (g)	Catfish flour (g)	Tempeh formula flour (g)
A	25	25	25	25
B	30	20	30	30
C	35	15	15	15
D	40	10	40	10
E	45	5	45	5

Source : Food Technology Laboratory, Department of Nutrition, Poltekkes Kemenkes Medan

Kjedhal method of protein content testing

As much as 1 g of sample was placed into the Kjedhal flask, and the result in the form of a distillate was examined using titration with 0.1 N NaOH solution. Protein content was determined using the formula:

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$$\text{Protein content (\%}\ {}^{b}/_{b}) = \frac{V\ penitran\ (sample - blank)\ x\ N\ HCl\ x\ 14{,}008\ x\ 6{,}25}{sample\ weight\ \ x\ 1000}\ \text{x 100\%}$$

Soxhlet method of fat content testing

As much as 10 g of the sample was placed into a tin, and the final steaming with a rotary evaporator produced a heavy residue of fat. Fat content was calculated using the following formula:

$$\text{Fat level (\%}\ {}^{b}/_{b}) = \frac{fat\ weight}{sample\ weight}\ \text{x 100\%}$$

Carbohydrates Content Testing

Total carbohydrates were obtained using the formula below:

Carbohydrate content (% $^{b}/_{b}$) = 100% - % (content of protein, fat, ash, water)

Determination of the energy value of food

The energy value of food was determined through calculations according to the composition of carbohydrates, fats, and proteins. The determination of energy value was calculated using the following formula:

Energy = (4 Kcal/g × carbohydrate content) + (9 Kcal/g × fat content) + (4 Kcal/g × protein content)

Sensory Test

The sensory test evaluated cookies based on taste, aroma, color, and texture, employing a hedonic scale ranging from 1 (dislike very much) to 5 (like very much). The results of the sensory test determined the optimal formulation among the four flour ingredients. This determination was based on the average value and the percentage of acceptance from 50 trained panelists (11).

Analysis of Data

Data analysis was conducted using the latest version of the SPSS computer application, employing Analysis of Variance (ANOVA) followed by a Duncan test to recognize any significant differences among the formulations.

RESULT

Sensory Test

The results of the cookie sensory test with the varying proportions of red bean flour, oyster mushroom flour, catfish flour, and tempeh formula flour using the hedonic scale are presented in Table. 2

Table 2 shows that through sensory assessments on color, aroma, taste, and texture, Formula D received the highest preference from panelists, achieving an average value of 3.79. This particular cookie was formulated using 40 grams of red bean flour, 10 grams of oyster mushroom flour, 40 grams of catfish flour, and 10 grams of forte flour in its preparation.

Table 2. Distribution Of Organoleptic Test Result By Various Treatments

Sensory properties	Treatment					
	A	B	C	D	E	p-(value)
Color	3.38	3.54	3.32	3.76	3.39	0.007
Texture	3.33	3.28	3.36	3.83	3.51	0.001
Taste	3.51	3.78	3.50	3.94	3.50	0.007
Aroma	3.38	3.37	3.34	3.62	3.49	0.240
Average	3.40	3.49	3.38	3.79	3.47	

Source : Food Technology Laboratory, Department of Nutrition, Poltekkes Kemenkes Medan

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Chemical Quality and Nutrient Analyses and Compliance with 2019 RDA

The analysis of chemical quality involved various methods adapted to the examination of nutrient content, including carbohydrates, protein, fat, calcium, zinc, and iron. Table 3 illustrates the protein content analysis for Formula D.

Table 3 shows the results of the examination of Formula D in determining the nutrients it contains and the contribution of nutritional needs for children under five within the age range of 12-59 months. The contribution of minerals, calcium, zinc, and iron exceeded 100% of the 2019 Recommended Daily Allowance (RDA). Conversely, for macronutrients such as carbohydrates, protein, and fat, the contribution was below 100% of the 2019 RDA.

Table 3. Analysis of chemical quality and contribution of nutrients to cookies based on RDA 2019

Nutritional check	Unit/100g	Requirement	Nutrient content	%Akg
Carbohydrates	g	217.5	52.31	24,05%
Fat	g	22.5	13.46	59,82%
Protein	g	47.5	22.64	47,66%
Calcium	mg	825	6459.46	782,96%
Zinc	mg	4	19.07	476,75%
Fe	mg	8.5	57.87	680,82%
Fiber	g	19.5	6.44	33%

Source: M Brio Food Laboratory Bogor 2021

DISCUSSION

Color

Cookies with Formula D displayed a light brown color, which matches the standard color of cookies. The panelists evaluated the cookies visually, emphasizing the critical role of formulation in product development, as consumers often form their initial judgments based on visual appeal.

According to Winarno, as cited in Hapsari (2018), several factors contribute to the attractive color of food ingredients, including natural pigments such as chlorophyll, carotene, and myoglobin, as well as processes like caramelization and the Maillard reaction. Caramelization, initiated by heating sugar during the baking process, is a key contributor. The protein content in the red bean puree facilitates color changes in the cookies. The heating process activates amino acids in the protein, enabling them to react with the reducing sugar component, ultimately resulting in the formation of a brownish-yellow pigment (12). Moreover, the browning reaction in cookies can be influenced by organic compounds reacting with air, leading to an oxidation reaction. The use of high temperatures in oven processing opens the bonds in amino acids, enabling them to react with the reducing sugar component. This reaction is facilitated by the composition of the cookie ingredients.

Texture

The sensory test results for texture revealed a notable average score of 3.83, indicating a strong preference for Formula D. Cookies in Formula D exhibited a distinctive texture characterized by crispness and completeness, making them resistant to easy crushing (13). Texture creates a pressure sensation that can be felt when the cookie is introduced into the mouth, involving biting, chewing, and swallowing. Additionally, the assessment also involved the examination of hardness, elasticity, and crispness through touch (14). The crisp and crunchy attributes observed in Formula D cookies can be attributed to the presence of fiber in red beans, forte, and oyster mushrooms. These fibers can absorb water, disrupting the gelatinization process and preventing the cookies from becoming overly brittle. Consequently, the resulting product not only possesses a crunchy texture

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but also shows sturdiness and strength, enhancing its resistance to breakage and ensuring a prolonged shelf life (15)

Fiber, a polysaccharide known for its water-absorbing capacity, contributes to the firm and robust texture of the product, making it harder. As the fiber content increases, the product attains a greater degree of firmness and strength (16). Moreover, the notable levels of protein in red beans, catfish, and forte, coupled with the substantial carbohydrate content in oyster mushrooms, synergistically bolster the integrity of the cookies (17). Andarwulan et al (2011) stated that the crispness of cookies is influenced by the content of protein, amylose, and amylopectin (18).

Flavor

The sensory test results for taste indicated an average score of 3.78, signifying a strong preference for Formula D. Cookies in Formula D delivered a delectable combination of savory and slightly sweet flavors. Taste is an important element in gauging preference levels, where a good taste gains acceptance from panelists and consumers alike (10). The taste of food is a multifaceted aspect, intricately linked to its appearance. Visual stimuli from the presentation of the food activate nerves, inviting the appetite for a flavorful experience. Subsequently, the taste experience unfolds as a harmonious interaction between the stimulation of the sense of smell and taste. Flavor, as a crucial component, emerges from the collaboration of various senses, including sight, smell, hearing, and touch. According to Farida in 2021, taste is the most important factor in determining a decision for consumers to accept or reject a food product.

Aroma

Based on the sensory test on aroma acceptance, it is known that the average score of 3.62 indicates a strong preference for Formula D. The distinctive aroma of Formula D is attributed to the mix of eggs, margarine, and milk flour, which causes a fragrant and delicious aroma when baked at a high temperature.

Food aromas can also be generated using natural or synthetic aromas. According to Farida in 2021, aroma is an odor resulting from steam produced during food processing. It is influenced by volatile compounds and major components of ingredients, as well as cooking methods. Aroma serves as a critical parameter in determining the overall appeal and palatability of a food item. The Maillard reaction, a chemical reaction between amino acids and reducing sugars during heating, contributes to the aroma of food. This reaction involves the transformation of carbohydrates, free amino acids, peptides, nucleotides, and organic acids into flavorful and aromatic compounds, shaping the overall sensory experience of processed foods (13).

The distinctive aroma is attributed to the amino acids in white catfish flour, namely glutamic acid, lysine, aspartic acid, leucine, and alanine. These amino acids undergo reactions with sugar during the baking process at temperatures ranging from 190 to 210 °C, resulting in the development of a distinctive and appealing aroma.

Protein content

The protein content of Formula D, determined using the Dumas method, was found to be 13.4 grams. This protein content, originating from wheat flour, forte flour, and white oyster mushroom flour, constitutes 59.8% of the nutritional requirements for children under five. Protein, a vital macronutrient, plays a crucial role in the body, primarily serving as a building block for tissues. It is an essential component for daily bodily functions. Catfish protein can also produce antibodies, hormones, enzymes, and the formation of collagen needed for tissue repair in toddlers. Moreover, protein facilitates the transportation of bone growth hormone IGF-1 and enhances the potential for peak bone mass.

The combination of both vegetable and animal proteins positively influences the improvement of protein quality. These two types of proteins complement each other in terms of amino acid content, enhancing the overall nutritional profile (10). During the heating process, proteins undergo denaturation, resulting in changes to their molecular structure without breaking

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covalent bonds (10). However, heating during the production process can increase protein digestibility and protein storage capacity (20). Utilizing local food ingredients, such as catfish, in food processing not only increases the value of these ingredients but also improves the nutritional content of the final product. Oyster mushrooms, another component of Formula D, contain 19-35% protein, encompassing essential amino acids like lysine, methionine, tryptophan, thionine, valine, leucine, isoleucine, histidine, and phenylalanine (21). Proteins play a crucial role in maintaining tissues, influencing body composition, and facilitating the formation of new tissues.

Carbohydrate content

The carbohydrate content of Formula D was found to be 52.3 grams. This carbohydrate content, sourced from wheat flour, forte flour, and white oyster mushroom flour, constitutes 24% of the nutritional requirements for children under five (22). Adequate carbohydrate consumption as an energy source is crucial in preventing malnutrition in young children, subsequently reducing the risk of infectious diseases and averting issues like undernutrition and obesity. According to Hardinsyah, as cited in Katmawanti (2021), states that energy for growth and development can only be obtained from carbohydrates, proteins, and fats present in food and stored in the human body (23).

According to Sugito and Ari H in Nurlita (2017), the carbohydrate content is influenced by other nutritional components, the lower the other nutritional components, the higher the carbohydrate content, and vice versa. Meeting the carbohydrate intake requirement fulfills its crucial role as the primary energy producer, thereby preventing malnutrition, undernutrition, and obesity in children (24).

Lipid content

The lipid content of Formula D, determined by the Soxhlet method and chosen by the panelists, was 22.6 grams. This lipid content, sourced from red beans, catfish, margarine, butter, milk flour, forte flour, and egg yolks, constitutes 47.6% of the nutritional requirements for children under five. The fat content in cookies is a result of the composition of various food ingredients. Oyster mushrooms, for example, contain 86% unsaturated fat and 14% saturated fatty acids, while red beans contain 15.8% fat (25). Fat is an essential component needed by children under five as it serves the purpose of providing energy and contributing to the formation of fat cells crucial for a child's growth and development. Adequate fat intake ensures the maintenance of catabolic processes using energy sources other than noncarbohydrates (26).

Calcium content

The calcium content of Formula D, determined by flame atomic absorption spectrometry and selected by the panelists, was 6459.4 mg. This calcium content, sourced from wheat flour, catfish meal, milk flour, eggs, forte flour, and white oyster mushroom flour, contributes a significant 782.9% to the nutritional needs of children under five. Calcium plays a crucial role in mineralizing the new bone deposit matrix and supporting osteoblast function, thereby facilitating the process of height increase. Collaborating with vitamin D, calcium helps establish serum calcium homeostasis, maintaining extracellular calcium ion levels within the normal range and facilitating the transport of calcium to and from bone reservoirs.

Calcium deficiency will cause metabolic disorders, including inflammatory cytokine regulatory systems that directly affect chondrocytes and the process of bone formation (19). Calcium is also a major component of bone and tooth formation, playing an important role in regulating cell functions, such as nerve transmission, muscle contraction, and maintaining cell membrane permeability. Meeting calcium needs helps prevent malnutrition in toddlers, particularly in the prevention of stunting (26).

Zinc content

The zinc content of Formula D, determined using the flame atomic absorption spectrometry and selected by the panelists, was measured at 19 mg. This content,

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derived from wheat flour, flour, red beans, catfish, forte flour, and white oyster mushroom flour, fulfills 476.7% of the needs of toddlers. Zinc in cookies is essential for osteoblastic activity, collagen synthesis, and alkaline phosphatase function. As a component of the enzyme system in the body, zinc is also useful in the process of replacing the bone matrix (27). Additionally, zinc acts as a cofactor in stimulating protein synthesis, regulating cellular activity, and facilitating the impact of vitamin D on bone metabolism by promoting DNA formation in bone cells (19). Therefore, zinc is closely related to bone metabolism and becomes very important in the stages of growth and development (17).

Iron (Fe) content

The iron (Fe) content in Formula D, determined through flame atomic absorption spectrometry and selected by the panelists, was 57.8 mg. This iron content is sourced from wheat flour, red beans, catfish, forte flour, and white oyster mushroom flour, contributing significantly to 680.8% of the nutritional needs of children under five. Beyond its contribution, iron plays a crucial role in carrying oxygen and nutrients to cells throughout the body. In cases where iron intake is reduced, children under five may experience anemia, impacting their growth activities (28). Consuming Fe sources derived from animal foods will facilitate the absorption process thereby providing a faster contribution to the process of HB formation in children aged 5 years. Iron together with zinc has the potential to prevent children under five from infectious diseases (29).

Fiber content

The D formula chosen by the panelists contained 6.4 grams of fiber content sourced from wheat flour, red beans, catfish, forte flour, and white oyster mushroom flour and contributes 33% of the needs of children under five. The dietary fiber contained in cookies helps expedite the transit time process of metabolic results in the colon. Moreover, fiber has the capacity to bind excess fat and glucose, thereby helping toddlers avoid obesity (26). Higher fiber content is advantageous for digestion, as research developments indicate that, despite lacking nutrients, fiber performs a unique role in triggering physiological and metabolic conditions. This function is irreplaceable by other substances and provides protective benefits for the health of the digestive tract, particularly the small intestine and colon (30,31).

CONCLUSION

The analysis results of panelists' preference level for cookies composed of red bean flour, catfish flour, white oyster mushroom flour, and forte showed no significant differences in color, texture, and taste in each sample. However, a noticeable difference was observed in aroma across the samples. Formula D was selected and preferred based on color, taste, aroma, and texture, with an average value of 3.79 (like very much). Furthermore, Formula D showed a composition of 24.05% carbohydrates, 59.8% protein, 47% fat, and 33% fiber, all of which are below the Recommended Daily Allowance (RDA) requirements. Conversely, the nutritional contents of calcium, zinc, and iron (Fe) exceed 100% of the 2019 RDA requirements.

Author contributions

GS is responsible for writing articles, analyzing data, processing data, and correspondence with journal managers. NT did the data processing and helped to provide material input. IRS is responsible for finance and assisting in data processing.

Declaration of Conflict of Interest

There is no conflict of interest regarding this article.

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Data availability

The data used and/or analyzed in the study are available https://shorturl.at/aoNY0

Ethical clearance

This research has received ethical approval from the Health Polytechnic Ministry of Health Ethics Commission No.01.0184/KEPK/POLTEKKES KEMENKES MEDAN 2022

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Effect of UNAGI (Nutrition Snakes and Ladders Game) on Knowledge of Balanced Diet and Nutritional Intake in Adolescents in Bekasi

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ABSTRACT

Indonesia still faces the triple burden of malnutrition, which can impact the dietary choices of adolescents to balance their nutritional intake and, simultaneously, emphasize the need for effective nutrition education. This study aimed to determine the effect of nutrition education delivered through the UNAGI game and videos on the knowledge and nutritional intake of high school students. This quasi-experimental study was conducted with students from Public Senior High School 12 in Bekasi City, where the participants were divided into intervention and control groups. The intervention was provided once a week for two consecutive weeks. Knowledge was measured using a questionnaire, and food intake was assessed through 24-hour food recall. Data were analyzed using the Mann-Whitney test for the difference between groups and paired t-test/Wilcoxon for pre-post comparisons, with α significant level of 5%. Before the intervention, there was no significant difference in knowledge and dietary intake between the two groups. Post-intervention, a significant improvement in nutrition knowledge (p-value of 0.000) was noted in the intervention group exposed to the snake and ladder nutrition game. However, there were no significant changes in energy intake (p-value of 0.162), fat intake (p-value of 0.144), sugar consumption (p-value of 0.066), and salt consumption (p-value of 0.944). The findings support the recommendation of utilizing the UNAGI game for nutrition education in the digital era as a valuable alternative to visual media, effectively contributing to enhanced nutritional understanding among adolescents.

Keywords: Adolescent, Balanced Nutrition, Knowledge, Nutrition Intake, Snakes and Ladders Game

INTRODUCTION

Developing countries, including Indonesia, continue to face the triple burden of malnutrition, including underweight, excess nutrition, and micronutrient deficiency (1). Imbalanced nutrition exacerbates health issues and increases the risk of both non-communicable diseases and infectious diseases (2). In fact, one in six adolescents aged 10-19 years is overweight (3). In Indonesian adults, the obesity rate is at 21.8%, while adolescent obesity, based on BMI for ages 16-18, increased from 7.3% in 2013 to 9.5% in 2018. In another study, male adolescents have a higher obesity prevalence than their female counterparts (47% versus 24%)(4). The prevalence of obesity in West Java Province for adolescents aged 16-18 years increased from 6.2% to 10.9%, and from 7.5% to 11.28% in Bekasi City (5–7).

The consequences of limiting mobility during the COVID-19 pandemic in Indonesia led to decreased community activities, particularly among students (*citation here*). Most students

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experienced a decline in physical activity, with a shift from 46.6% light activity to 75.3%. This shift was accompanied by changes in energy density and high-fat food habits, which could increase the risk of excess weight (8,9). Direct contributors to nutritional problems include food intake and infectious diseases, while indirect causative factors include parental education and income factors, peers, school environment, mass media exposure, and genetics (10,11).

Poor knowledge of balanced nutrition is believed as one of the causes of the high prevalence of overweight (12). Nutritional problems can be corrected by providing knowledge and fostering awareness about healthy lifestyles and eating habits. Nutritional knowledge is significantly related to the nutritional status of adolescents, and dietary choices will impact their eating habits, which affect overall nutritional status (13,14). Nutrition education, emerging as a pivotal approach to increasing knowledge, can be done through health counseling using several methods and media. Educational media, including audio, visual, and a combination of the two, facilitate students to master educational modules that stimulate responses between educators and students (15). Media serves as a channel for conveying information, aiding in its acceptance and understanding among the audience (16).

Online education has gained popularity even before the pandemic. Using online media for nutrition education has proven effective and provides positive results in various treatments, as online media is an attractive medium for carrying out nutrition education for adolescents (17). In the digital age today, technology facilitates people to access information, including a source of learning for students, for example, educational game features (18). According to Nikiforidou (2018), digital educational games aim to acquire knowledge and foster understanding and habits of the surrounding environment (19).

Several studies state that educational games can enhance knowledge and attitudes (20,21). An intervention using the spin wheel game can significantly increase the understanding of balanced nutrition than the leaflet-based methods in school children, as seen from the difference in the average knowledge scores between the spin wheel group (score 2.4) and leaflets (score 1.0) (22). Additionally, Wijayanti et al. (2021) found a greater increase in the group exposed to a combination of lectures and a nutrition-based snakes and ladders game compared to the lecture group alone ($p < 0.001$) (23).

Snake and ladders game is widely recognized among children and adolescents. To adapt to the online environment, the author modified the game from a previous offline version created by Wijayanti et al. (24). The UNAGI game offers advantages, such as enhanced focus in small groups and accessibility through Android phones. Additional features, such as quizzes, can be incorporated to increase the interactive experience of playing and learning simultaneously.

A study by Yuniarsih (2021) revealed that 52.4% of adolescents at Public Senior High School 12 in Bekasi had low nutritional knowledge. This deficiency in knowledge, combined with inadequate nutritional intake, can elevate the risk of non-communicable diseases among adolescents (25). Consequently, interventions are important to enhance knowledge and nutritional intake among adolescents. Therefore, this study aimed to explore the impact of education using the UNAGI game on the knowledge and nutritional intake of adolescents at Public Senior High School 12 in Bekasi.

METHOD

Research design

This study is quasi-experimental with a pretest-posttest one control group conducted at Public Senior High School 12, Bekasi, between May and June 2022.

Research Subjects

Study participants were students from Public Senior High School 12 Bekasi aged 16-18 years who voluntarily participated as research samples by signing informed consent and had internet access. The sample size was determined following a study by Wijayanti, with a confidence level of 95%, a beta of 5%, an expected difference of 0.05 points, and a 10% loss to follow-up. The minimum sample

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size in each group was set at 34 samples or 68 subjects in total. The sample was calculated using the following formula (22; (26)):

$$n = \frac{2\sigma^2[Z_{1-\alpha}[Z_{1-\beta}]^2}{[\mu_1 - \mu_2]^2}$$

The recruitment of subjects used stratified random sampling, which represents each class students. Exclusion criteria for this study were students who were sick during this study, such as those hospitalized or unable to carry out normal activities, and students who did not participate in the intervention process or withdrew in the middle of the study.

Data Collection/Materials and Tools

Data were collected through an online questionnaire. Data on characteristics included age, class, allowance, parents' education, parents' occupation, parents' income, previous information exposure, information media, and nutritional status. The knowledge questionnaire consisted of 15 questions about balanced nutrition, with a validity assessment confirming the reliability of 10 out of the 15 statements, as indicated by a Cronbach's Alpha value of 0.815.

Food intake was assessed through non-consecutive 2x24-hour food recall, representing weekends and weekdays. Interview data on consumption were converted into intake using Microsoft Excel, which contained a table of Indonesian food composition. Intake data were then compared with individual needs calculated through the Harris-Benedict formula to determine adequacy percentages.

Interventions

Subjects were divided into two groups, i.e. the control group and the intervention group. The control group received education through video methods, while the intervention group was instructed using the UNAGI game. Each group underwent interventions twice a week at different times. Post-tests for knowledge were conducted immediately after the interventions, and post-tests for food consumption were carried out one week after the last intervention.

The design of UNAGI game media was created using the Canva application. As for an Android application, it was created with assistance from Abercode Software Developer. The game content included the pillars of balanced nutrition, "my plate", and adolescent recommendations for RDA and nutrients, which were formed into two sets of questions in the game.

The UNAGI game accommodated 5-6 players, each requiring an account in the UNAGI game application and participation in the same game room. The game board comprised 30 boxes, with 15 containing questions about balanced nutrition. Before initiating the game, players determined the order of dice rolling. Pawns advanced based on the dice outcome, and a game round lasted 15-20 minutes. During each round, 15 boxes contained questions about balanced nutrition. Correctly answering a question earned the player a bonus step forward, while an incorrect response resulted in a one-step penalty. Subsequently, other players resumed rolling the dice. The player achieved victory upon reaching the finish line. Upon answering all questions, a summary of the answers was provided.

The control group in this study received education on balanced nutrition using videos by Chandra et al. (27), with each video lasting 10-15 minutes and covering different topics in each session. The videos were displayed using a projector in the classroom monitored by a facilitator to maintain the class and to prevent sharing information between groups. After the video presentation, no further explanation of the topic was provided. Both interventions occurred at different times within the same week.

Data analysis

Data were processed using a statistical program. Univariate data were presented in frequencies and percentages to describe characteristics, knowledge, and nutritional intake (energy, fat, sugar consumption, and salt consumption). Knowledge scores were converted to percentages and categorized into good (76-100%), moderate (56-75%), or low (≤ 55%). The correlation between groups was assessed through chi-square analysis (α 5%).

The statistical test used was the paired samples/Wilcoxon test to analyze differences

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in changes in knowledge and nutritional intake between groups receiving nutrition education using video and the Snakes and Ladders nutrition application. The Mann-Whitney test was utilized if the data were not normally distributed, and the independent sample t-test was applied if the data followed a normal distribution. The confidence level was set at 95% and a significance limit of $p < 0.05$.

RESULT

Subjects Characteristics

Table 1 indicates that there were no significant differences in characteristics between the intervention group and the control group ($p > 0.05$). Of 72 subjects enrolled in this study, the majority were 17 years old in both groups, rather than those aged 16 years old. In the balanced nutrition video group, there was an equal proportion of subjects in year X and year XI (50%), while the subjects in year X were more in the intervention group (52.8%). Most subjects in both groups had a low monthly allowance, with 63.9% in the intervention group and 61.1% in the video group.

Based on the characteristics of the subjects' families, the education level of the fathers and mothers of subjects in the UNAGI game group was balanced, whereas, in the control group, the majority had secondary education (junior high school and high school). Entrepreneurs were the dominant occupation of the subjects' fathers in the intervention group, while in the control group, most worked as private employees. The occupation of the subjects' mothers in both groups was predominantly housewives. The income of the subjects' fathers in both groups was within the moderate-lower class category (< 3,000,000 IDR). Meanwhile, most of the mothers' income in both groups was classified as lower class (SD). Regarding exposure to information about balanced nutrition, most subjects stated that they had received information related to balanced nutrition, and most of them received information through social media. The nutritional status (BMI for age) of adolescents in both groups was generally in normal status.

Differences in the Impact of Education using UNAGI Game and Videos on Energy Intake, Fat Intake, Sugar Consumption, and Salt Consumption

Table 2 illustrates the changes in the average nutritional intake values within the intervention group after receiving education. Specifically, energy intake increased by an average of 4.56%, fat intake rose by 5.01%, sugar consumption decreased by 6.16 g, and salt consumption increased by 0.11 g. Conversely, the control group experienced a decrease in nutritional intake following education; energy intake decreased by 0.61%, fat intake decreased by 12.32%, sugar consumption decreased by 3.3 g, and salt consumption decreased by 0.12 g. There was a significant difference in the percentage of fat in the control group ($p=0.048$) but no significant difference in the intervention group.

Differences in Knowledge Before and After Intervention in the Control and Intervention Groups

Table 3 shows the difference in nutrition knowledge between the two groups ($p<0.001$). Both groups demonstrated a significant increase in nutrition knowledge after education. The difference in the average pretest-posttest scores was 2.86 in the intervention group, slightly higher than the control group (2.56). However, this increase did not show a significant difference with a score of 0.3 ($p = 0.485$).

Comparison of Differences in Knowledge and Dietary Intake between the Control and Intervention Groups

Table 4 shows no significant difference in the mean values for energy intake, sugar consumption, and salt consumption between the intervention group and control group, with p-values of 0.430, 0.464, and 0.839, respectively. However, there was a significant difference in the average value of fat intake between the two groups ($p = 0.021$).

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Table 1. Subjects' characteristics

Variable	UNAGI		Video		p-value
	n	%	n	%	
Age					
16 years old	15	41.7	15	41.7	1.000
17 years old	21	58.3	21	58.3	
Sex					
Female	29	80.6	27	75	0.571
Male	7	19.4	9	25	
Pocket money/month (.000)					
<Rp. 500	23	63.9	22	61.1	0.357
Rp. 500 – Rp. 1.000	13	36.1	12	33.3	
>Rp. 1.000	0	0	2	5.6	
Father's education					
Low	3	8.3	4	11.1	0.766
Moderate	23	63.9	20	55.6	
High	10	27.8	12	33.3	
Father's occupation					
Civil	3	8.3	3	8.3	0.909
Private	13	36.1	17	47.2	
Entrepeneur	14	38.9	11	30.6	
Retire	1	2.8	1	2.8	
Others	5	13.9	4	11.1	
Father's income (.000)					
<Rp. 1.000	8	22.2	7	19.4	0.426
Rp. 1.000 – Rp. 3.000	11	30.6	14	38.9	
>Rp. 3.000	17	47.2	15	41.7	
Mother's education					
Low	5	13.9	1	2.8	0.200
Moderate	24	66.7	21	69.4	
High	7	19.4	10	27.8	
Mother's occupation					
Civil	1	2.8	3	8.3	0.655
Private	6	16.7	4	11.1	
Entrepeneur	3	8.3	2	5.6	
Retire	0	0	0	0	
Others	26	72.2	27	75	
Mother's income (.000)					
<Rp. 1.000	21	58.3	22	61.1	0.459
Rp. 1.000 – Rp. 3.000	8	22.2	5	13.9	
>Rp. 3.000	7	19.4	9	25.0	
Nutrition information's exposure					
Yes	31	86.1	29	80.6	0.527
No	5	13.9	7	19.4	
Source of information					
Health worker	11	30.6	10	27.8	0.964
Parents/friends	3	8.3	4	11.1	
Book	1	2.8	1	2.8	
Web/social media	16	53.3	14	48.3	
Nutritional status					
Underweight	10	27.8	11	30.6	0.952
Normal	22	61.1	20	55.6	
Overweight	2	5.6	2	5.6	
Obesity	2	5.6	3	8.3	

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Table 2. Differences in Energy Intake, Fat Intake, Sugar Consumption, and Salt Consumption pre an post intervention between Intervention and Control Group

Variables	Mean±SD		$\Delta\bar{x}$	*p-value*
	Pre-test	Post-test		
UNAGI game				
Energy (%)	82.86±22.44	87,42±20,40	4.56	*0.162[a]
Fat (%)	91.53±35.25	96,54±27,28	5.01	*0.144[a]
Sugar (g)	26.38±22.69	20,22±15,86	-6.16	*0.066[a]
Salt (g)	1.26±0.43	1,37±0,96	0.11	*0.944[a]
Video				
Energy (%)	82.06±32.62	81.45±20.00	-0.61	*0.850[a]
Fat (%)	102.83±43.14	90.51±28.89	-12.32	*0.048[a]
Sugar (g)	21.88±18.15	18.58±15.16	-3.3	*0.418[a]
Salt (g)	1.25±0.52	1.13±0.46	-0.12	*0.418[a]

[a]Wilcoxon; [b]Mann-Whitney; *p-value < 0.05 (significant)

Table 3. Differences in Knowledge scores between Intervention and Control Group

Variables	Knowledge		$\Delta\bar{x}$	*p-value*
	Pre-test	*Post-test*		
UNAGI game				
Mean±SD	9.28±2.09	12.14±1.77	2.86	*0.000[a]
Video				
Mean±SD	9.08±1.99	11.64±1,82	2.56	*0.000[c]
$\Delta\bar{x}$	0.2	0.5	0.3	
p-value	*0.692[b]	*0.312[b]	*0.485[b]	

[a]Wilcoxon; [b]Mann-Whitney, [c]Paired Sample T Test *p-value < 0.05 (significant)

Table 4. Differences in the Increase of Energy Intake, Fat Intake, Sugar Consumption, and Salt Consumption between Intervention and Control Group

Variables	*UNAGI*	Video	$\Delta\bar{x}$ (*Game*-Video)	p-value
	$\Delta\bar{x}$	$\Delta\bar{x}$		
Energy (%)	4.56	-0.61	3.95	*0.430[a]
Fat (%)	5.01	-12.32	-7.31	*0.021[a]
Sugar (g)	-6.16	-3.3	-9.46	*0.464[a]
Salt (g)	0.11	-0.12	-0.01	*0.839[a]

[a]Mann-Whitney; *p-value < 0.05 (significant)

DISCUSSION

Differences in Adolescent's Knowledge between the Control and Intervention Groups

This study used two intervention methods, videos in the control group and the UNAGI game in the intervention group. Significant differences were found in adolescent knowledge about balanced nutrition before and after receiving education in both groups. The intervention group showed a higher increase in knowledge score compared to the control group, as seen from the post-test average score with a difference of 0.3. However, there was no significant difference

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between the increased knowledge in the intervention group and the control group. This lack of significance may be attributed to the media used in both groups, containing several components such as text, audio, graphics, and animation.

Both educational media have their advantages and disadvantages. The videos contain verbal explanations through a combination of pictures, text, and audio using easy-to-understand language so that the material can be received clearly and effectively. However, the disadvantage is the one-way nature of the educational method, causing no interaction during the education and one-sided understanding and perception. This statement aligns with research by Ramadhanti that video animation is a simple and enjoyable medium, delivering learning material in the form of moving images, visible, and audible (28). Secondly, game-based media has another attractiveness as it stimulates aspects of student development by fostering problem-solving skills without realizing it. In this study, subjects could try the UNAGI game with various questions from the game box to the finish line. In addition, another study highlights that educational games stand out among other visual media due to their direct engagement of players (29). Educational games are also presented with attractive and unique sound effects that can make students more enthusiastic about learning through playing games (30).

The disadvantages include the risk of subjects focusing solely on completing the games without catching the essence of the message. Also, it is stated that the learning process through game education needs advanced skills, such as technology learning curves, which require the accumulation of experience in some attempts (31). In this study, the limited research period may have hindered the skill development.

Differences in Dietary Intake between the Control and Intervention Groups

This study showed an increase in the average value of energy intake, fat intake, and salt consumption, but there was a decrease in sugar consumption in the UNAGI game group. The statistical test results indicated no significant changes before and after the intervention in both groups. The increase in energy intake, fat intake, and salt consumption may be attributed to understated information delivered through game education, making it challenging for participants to comprehend specific dietary recommendations, particularly regarding energy and fat content. It is important to note that the increased intake was still within normal limits as recommended by the Ministry of Health of the Republic of Indonesia (80-100%) (32).

The decrease in sugar consumption in the UNAGI game group can be attributed to the ease with which information on limiting sugar and salt consumption is accepted compared to other messages conveyed through the game. Additionally, many subjects had already been consuming sweet foods and drinks below the recommended levels of 50 g of sugar and 5 g of salt. Based on food recall data, they restricted their intake of sweet foods and drinks, such as milk, sweet tea, and packaged food and beverages. This behavioral pattern could be linked to economic factors, as most of their fathers' incomes were below 3,000,000 IDR, reflecting a lower economic status.

In the control group, there was a decrease in the average value of energy intake, fat intake, sugar consumption, and salt consumption, but only the decrease in fat intake showed a significant difference after the intervention. The decrease in the average value of energy intake, fat intake, sugar consumption, and salt consumption can be attributed to subjects reducing their consumption of fatty foods, particularly fried foods, resulting in a significant decrease in fat levels.

The video used in the control group has been tested in the previous study by Chandra et al., that the video used easy-to-understand language regarding recommendations for balanced nutrition for adolescents and the effects of diseases that occur when consuming excessive sugar, salt, and fat (33). In this study, subjects understood and were able to analyze that the food and drink consumed before education were inappropriate and could lead to health issues.

The statistical test results showed no significant difference between the two groups before and after the intervention, possibly due

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to the limited research time to monitor adolescent nutritional intake. Another study suggests that a nutrition education intervention carried out four times in one month increases nutritional intake by more than 50%, in line with the recommendations by the RDA (34). In another study, Mustika et al. stated that the provision of nutrition education may become apparent with a monitoring duration of at least six months (35). In this study, however, the period of intervention was only two weeks, which is shorter than other studies.

Besides predisposing factors, such as knowledge, attitudes, and perceptions, efforts to influence adolescent actions can also be affected by external factors including parents' role, mass media, and food supply in the family or environment (36). This result can make adolescents unable to achieve the correct action even after receiving education through the UNAGI game.

Nutrition education is one of the efforts to increase knowledge so that it can influence the actions of adolescents. This form of education can be implemented through various media. According to Notoatmodjo, the selection of media education is very important in information delivery (37). Although video and games can be alternative educational media, based on research results, this research indicates that the UNAGI game can increase respondents' knowledge more than video, as observed in the control group. Video could be a better medium to provide exact information through audio and visual, but in-game education, the message or information could be absorbed through repeated trials to complete the game and the learning curve process.

CONCLUSION

Knowledge increased both in the intervention group (UNAGI game) and control group, but this was not reflected in dietary intake, except for fat intake in the control group. There was no significant difference between knowledge, energy intake, fat intake, sugar consumption, and salt consumption between the game group and the video group. Videos still become a better medium for delivering messages without requiring extended comprehension, whereas game education requires accumulations of experience over time to accept the message. Thus, the UNAGI game is likely to increase respondents' knowledge more than video, as indicated by the average scores.

UNAGI game can be used to provide nutrition education in the digital era is recommended but it needs improvement in terms of procedures and methods. The UNAGI game led to an increase in nutritional intake after education, but it is necessary to implement interventions more frequently than four times in one month to observe significant changes in nutritional intake among students.

Author contributions

JE, conceptualized and designed the study, conducted the study, led the data collection and data analysis and interpretation, and prepared the draft of the research. FA, advised on the study design method, game's content, data analysis and interpretation, and prepared and reviewed the manuscript.

Declarations of Conflict Interest

There is no conflict of interest.

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Data availability

Must apply for access permission.

Ethical clearance

This research has received ethical clearance from the Health Research Ethics Committee of the FKM Muhammadiyah University Jakarta through the ethical clearance number 10.489B/KEPKFKMUMJ/V/2022 in May 2022.

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Original Research

Effects of Smoking Habits on Omega-3 Food Intake in Adults

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ABSTRACT

Smoking habits have been shown to impact omega-3 food intake, and cigarette smoke can increase lipid peroxidation through the induction of oxidative stress. Omega-3, an essential fatty acid, can be obtained through the consumption of fish, milk, eggs, and supplements. This cross-sectional research aimed to assess the relationship between omega-3 food intake and smoking habits. The research was conducted from March to June 2022 in Rungkut District, Surabaya, Indonesia. Data collected included the respondents' quantities and frequency of consuming foods containing omega-3, namely fish, milk, and eggs. Additionally, the level of nicotine dependence among smokers was evaluated using the Fagerstrom Test for Nicotine Dependence (FTND). The method for data analysis was the chi-square test. The total respondents in this study were 116 people, consisting of 41 smokers and 75 non-smokers. No significant differences were observed in the consumption patterns of omega-3-rich foods, including eggs, fish, and milk, between smokers and non-smokers ($p > 0.01$ for each food item). However, a significant difference was observed in the consumption of supplements containing omega-3 between the smoker and non-smoker groups ($p < 0.005$). However, the overall omega-3 intake did not exhibit a significant difference between smokers and non-smokers. Notably, a higher proportion of respondents who smoked reported consuming omega-3 supplements compared to the non-smoker group. Consequently, there is a need to conduct further research to identify the underlying factors that influence the habit of smokers toward consuming omega-3.

Keywords: omega-3 intake, omega-3 levels, smoking habit

INTRODUCTION

Smoking is a global health threat, carrying the risk of mortality (1). Indonesia is the sixth-largest producer of tobacco and the largest exporter of cigarettes in the world (2). Additionally, Indonesia is the third largest cigarette consumer in the world (3) and stands among the nations with the highest smoking prevalence (4,5). Despite government initiatives such as the implementation of Government Regulation No. 109, which aims to restrict cigarette advertising and curb smoking rates (6), efforts may be insufficient to deter the rising trend of young smokers. It is crucial to acknowledge that a burning cigarette releases numerous chemical compounds with harmful carcinogenic properties, and there is no safe minimum level of exposure to tobacco smoke (7).

Cigarettes consist of various kinds of chemicals that can harm health and pose significant health risks, with carcinogenic properties that contribute to the development of cancer. Some of the chemicals are nicotine,

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tar, carbon monoxide (CO), and various heavy metals (8). Nicotine, in particular, is very dangerous for health (9,10). Nicotine is addictive and is an indirect cause of decreased lung function as indicated by a gradual decrease in forced expiratory volume in one second (FEV1) values with increasing nicotine dependence (11,12).

Cigarette smoke, a source of exogenous free radicals, significantly contributes to the elevation of free radicals within the body (8). An increase in the number of free radicals in the body will trigger oxidative stress and cause peroxidation in cells, resulting in damage and death of body cells (13,14). Furthermore, the free radicals present in cigarette smoke, particularly reactive oxygen species (ROS), induce oxidative stress within the lungs (8). This oxidative stress triggers an inflammatory response, activating lung macrophages and facilitating neutrophil infiltration. Consequently, this process leads to the inactivation of the antiprotease α-AT1, an inhibitor crucial for regulating pulmonary proteases and preventing the production of pulmonary elastase (15,16,17).

Smoking habits have an impact on omega-3 levels. Cigarette smoke induces lipid peroxidation of polyunsaturated fatty acid (PUFA), which causes decreased PUFA concentrations and triggers oxidative stress (14). Low PUFA concentrations also cause dysfunction in the dopaminergic system associated with smoking dependence and craving (18,19). According to a previous study by Lorensia and Suryadinata (20), the drivers of online motorcycle taxi services or *ojek* were defined as individuals who utilize application technology in partnership with application-based transportation companies. These drivers face a potential risk of exposure to vehicle air pollution, especially considering their smoking habits. The results of the omega-3 intake assessment revealed an average total intake of foods containing omega-3 at 226.47 mg for all respondents, categorizing them into the group with insufficient omega-3 intake (<1,600 mg per day) (21,22). Cigarettes can also reduce appetite. Nicotine in cigarettes will have an effect on reducing appetite. Nicotine, rapidly absorbed into the lungs and bloodstream upon smoking, binds to nicotinic receptors in the brain, influencing ion channels and releasing various neurotransmitters, including catecholamines, dopamine, serotonin, norepinephrine, and GABA. This complex process in the central nervous system is linked to decreased appetite. The level of nicotine in the blood correlates with postsynaptic stimulation of nicotinic receptors, affecting neurotransmitter release. Previous studies have identified hormones such as dopamine, norepinephrine, and leptin as factors influencing appetite due to nicotine's impact (23). Therefore, this study explored the relationship between omega-3 food intake and smoking habits, accounting for the source and quantity of consumed foods. In addition, this study also evaluated the differences between intake of omega-3-rich foods among smokers and nonsmokers.

METHOD

This research used a cross-sectional design and was conducted in the area of Rungkut District, Surabaya, Indonesia from March to June 2022. The dependent variable was smoking habits, and the independent variable was intake of foods and supplements containing omega-3. The assessment of omega-3 intake involved evaluating the quantity and frequency of respondents' consumption of fish, milk, and eggs. The sample was active students from a private university, chosen through total sampling. Inclusion criteria included an age range of 17-30 years, no allergies to fish/milk/egg, and the absence of a special diet (vegetarian). The subjects were enrolled in health-related faculties (medicine and pharmacy) to ensure a homogeneous knowledge and lifestyle background (24). Students willing to participate were interviewed, and those meeting the research criteria became respondents after providing written informed consent.

Data collection involved interviewing respondents about the amount and frequency of fish dishes (regardless of processing method), milk, and eggs. The Fagerstrom Test for Nicotine Dependence (FTND) assessed the level of nicotine addiction in smokers, utilizing a 4-point Likert response sequence (0 = never, 1 = sometimes, 2 = most of the time, 3 = always) across six of the original FTQ

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(Fagerstrom Tolerance Questionnaire) scale items. (25).

The data were analyzed using the Statistical Package for Social Sciences (SPSS) version 24. Descriptive statistics were used to determine frequencies of distribution, percentages, means, and standard deviations. The relationship between omega-3 food intake and smoking habits was examined using the Spearman test, while associations between omega-3-rich food intake among smokers and nonsmokers were assessed using the chi-square test. The significance level was set at $p < 0.05$. The study protocols received approval from the Human Research Ethics Committee at the University of Surabaya, Indonesia through approval No. 016-OL/KE/III/2022.

RESULT

The total respondents in this study were 116 people, consisting of 41 smokers and 75 non-smokers. The respondents had an average age of 23 years (±2.11), and most respondents did not use drugs and did not have a history of illness. Most of the respondents had a normal Body Mass Index (BMI) (Table 1).

Table 1. Characteristics of Respondents

Characteristic	**Smoker (*n* = 41)**	**Non-smoker (*n* = 75)**
Gender		
Male	40	28
Female	1	47
Age (years)		
Late adolescence (17-25)	33	60
Early adulthood (26-35)	8	12
Late adulthood (36-45)	0	2
Early seniors (46-55)	0	1
Average age (years)	23.2 4± 2.11	23.99 ± 5.33
Medication history		
Not using drugs	32	30
Vitamin supplements	8	38
Indigestion medicine	0	5
Cardiovascular medicine	0	1
Endocrine medicine	0	1
Respiratory medicine	1	0
Disease history		
None	37	59
GERD (gastroesophageal reflux disease) – Gastritis	1	8
Asthma	1	2
Hypertension	0	2
Liver disease	1	0
Scoliosis	1	0
Sinusitis	0	1
nephrotic syndrome	0	1
PCOS (polycystic ovarian syndrome)	0	1
Anemia	0	1
Body mass index (BMI) (kg/m^2)		
Underweight (BMI ≤ 18.4 kg/m^2)	6	13
Normal (BMI 18.5-25.0 kg/m^2)	24	37
Overweight (BMI 25.1-27.0 kg/m^2)	5	9
Obesity (BMI > 27 kg/m^2)	6	16

kg/m2: BMI calculated by dividing a person's weight in kilograms by the square of height in meters

Source: Primary data, 2022

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Table 2 indicates that there were no significant differences in the consumption of omega-3-rich foods, including eggs, fish, and milk, between smokers and non-smokers ($p>0.05$ for each food item). However, a significant difference was observed in the intake of omega-3 supplements between the two groups ($p<0.005$).

Table 2. Intake of foods containing omega-3

Food containing omega-3	Number of subjects consumed foods containing omega-3 (%)		*p*-value
	Smoker (n = 41)	Non-smoker (n = 75)	
Egg	38 (92.68)	72 (96.00)	0.490
Fish	32 (78.05)	51 (68.00)	0.157
Milk	34 (82.92)	59 (6.67)	0.096
Supplement	11 (26.83)	40 (53.33)	0.000*

*$p < 0.01$

Source: Primary data, 2022

The normality test results on the omega-3 and smoking habit variables obtained p-values of 0.064 and 0.004, respectively. Therefore, the Spearman rank test was employed, revealing a non-significant relationship between omega-3 food intake (eggs, fish, milk, and supplements) and smoking habit, with a correlation coefficient (rs) of 0.05 and a p-value of 0.446.

Regarding smoking habits (Table 3), most smokers initiated smoking between the ages of 15-19 (53.66%), and the majority preferred filtered cigarettes (97.56%). The Fagerstrom Test assessed smoking dependence, as presented in Table 4. A significant percentage of respondents reported smoking their first cigarette within 60 minutes of waking up in the morning (63.41%) and did not find it challenging to smoke in prohibited places, such as churches, libraries, or cinemas (95.12%). Furthermore, the majority smoked ≤10 cigarettes per day (85.37%), with a higher frequency observed in the first hours after waking up (97.56%).

Table 3. Characteristics of smokers (*n* = 41)

Characteristics	Frequency *n* (%)
Age started smoking (years)	
10-14	5 (12.19)
15-19	22 (53.66)
20-24	13 (31.71)
30-34	1 (2.44)
Type of cigarette	
Filter	40 (97.56)
Non-filtered	1 (2.44)

Source: Primary data, 2022

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Table 4. Answer profile of Fagerstrom Test Questionnaire (*n* = 41)

Question of Fagerstrom Test Questionnaire	Frequency *n* (%)
1. How soon after you woke up did you smoke your first cigarette?	
In 5 minutes	4 (9.76)
6-30 minutes	6 (14.63)
31-60 minutes	5 (12.20)
After 60 minutes	26 (63.41)
2. Do you find it difficult to refrain from smoking in prohibited places (e.g., at church, in the library, at the cinema)?	
Yes	2 (4.88)
No	39 (95.12)
3. Which cigarette was the most difficult for you to give up?	
The first in the morning	6 (14.63)
Other	35 (85.37)
4. How many cigarettes per day do you smoke?	
≤10	35 (85.37)
11-20	5 (12.20)
21-30	1 (2.44)
5. Do you smoke more often in the first hours after waking up than at any other time?	
Yes	5 (12.20)
No	36 (87.80)
6. Do you smoke when you are so sick that you are in bed most of the day?	
Yes	1 (2.44)
No	40 (97.56)

Source: Primary data, 2022

Table 5 shows the classification of the Fagerstrom test, revealing that most of the respondents showed low dependence (46.34%) and very low dependence on cigarette addiction (41.46%). In addition, there were no respondents who experienced very high dependence.

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Table 5. Classification of smokers based on Fagerstrom test score

Category (Fagerstrom test score)	Frequency *n* (%)
Very low dependence (0-2)	71 (41.46)
Low dependence (3-4)	19 (46.34)
Medium dependence (5)	4 (9.76)
High dependence (6-7)	1 (2.44)
Very high dependence (8-10)	0

DISCUSSION

Smoking is a problem for those who are addicted to smoking cigarettes (26,27). Nicotine, the primary component in cigarettes, is responsible for causing dependence on cigarettes. Nicotine stimulates acetylcholine receptors on dopamine-containing neurons. This stimulation triggers a surge in dopamine within the brain's reward system. The pattern typically involves reaching peak nicotine levels, a transient activation of the brain reward system, followed by a gradual decline in nicotine levels leading to withdrawal symptoms that can only be alleviated by smoking another cigarette. Efforts to reduce or quit smoking often cause symptoms of anxiety and restlessness. Particularly, the longer nicotine remains in the body, the stronger the smoking behavior becomes, intensifying the challenge of stopping the habit (28).

Omega-3, an essential unsaturated fatty acid needed for the body's tissues, cannot be made by the body and requires external intake, commonly through the consumption of fish such as salmon, lobster, mackerel, herring, and cod (29,130). However, the utilization of omega-3 supplements is still limited due to factors such as cost, fishy odor, and the pill's size (31,32). The dopamine mesocorticolimbic pathway is affected by a deficiency in omega-3, that triggers dopamine withdrawal, leading to nicotine addiction (33). Intake of food and supplements containing omega-3 has an important role in reducing smoking habits, by normalizing the dopaminergic system and reducing the effects of addiction (34). Omega-3 can play a role in smoking termination since omega-3 fatty acids are effective in significantly reducing the desire to smoke.

The brain is vulnerable to oxidative stress due to high metabolic activity and the susceptibility of PUFA to free radical attack, so smoking can also reduce levels of omega-3 (PUFA) in brain tissue (345,356,367,37). In a cross-sectional study conducted by Scaglia *et al.* (35) at a Toronto Hospital, on 50 smokers and 50 non-smokers, it was found that smokers had lower levels of docosahexaenoic acid (DHA) than nonsmokers. Natural fatty acids including omega-3 fatty acids were EPA and DHA (389,39).

Cigarette smoke can increase lipid peroxidation from polyunsaturated fatty acid (PUFA) by triggering oxidative stress and resulting in a decrease in PUFA concentration. This elevation in nicotine levels further impedes efforts toward smoking cessation (34,36). An experimental study on animals has shown that both active smoking and exposure to secondhand smoke are linked to lower PUFA levels in mice and humans; however, an omega-3 index of approximately 8% in mice has vasoprotective and antioxidant properties (40). Previous research conducted by Scaglia *et al.*, which explored the association between omega-3 level in the body and smoking habit, showed that smokers ate less fish rich in omega-3 fatty acids than non-smokers, showing an inverse and significant relationship between omega-3 intake and smoking (35).

Omega-3 and smoking habits have a strong relationship. Considering that smoking habits can impact omega-3 levels and low concentrations of omega-3 polyunsaturated fatty acids (PUFA) may disrupt nerve

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transmission, leading to the hypofunction of the mesocortical system associated with dependency mechanisms, there is a potential for an increased desire to smoke; thus, in turn, hinders efforts to quit smoking (36). So, increasing consumption of omega-3 can be a perspective in the prevention or treatment of smoking. However, there is a lack of research on the role of omega-3 in assisting active smokers in quitting in Indonesia.

CONCLUSION

In short, there was no difference in eating patterns containing omega-3 between smokers and non-smokers, including the consumption of eggs, fish, and milk, with a p-value exceeding 0.05 for each food item. However, there was a difference in the intake of supplements containing omega-3 between the two groups. A higher proportion of smokers reported consuming supplements containing omega-3 compared to the non-smoker group. This causes an increased risk of impaired lung function due to smoking, which still needs further research.

Author contributions

Each author made equal contributions to this paper, including the conception and design of the study, literature review and analysis, drafting, critical revision and editing, and approval of the final version.

Declaration of Conflict of Interest

The authors declare no conflict of interest.

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Data availability

The data that support the findings of this study are available from the corresponding author.

Ethical clearance

The research protocols were approved by the Human Research Ethics Committee, University of Surabaya, Surabaya, Indonesia (approval No. 016-OL/KE/III/2022).

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Original Research

Risk Factors and Potential Economic Losses Associated with Stunting in Toddlers in Ogan Komering Ilir Regency

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ABSTRACT

Stunting, a chronic condition arising due to nutritional deficiencies during pre- and postpartum periods, is a significant public health issue in Indonesia, with a nationwide prevalence of 29.6% and approximately 22.6% in Ogan Komering Ilir Regency. This research aimed to identify the risk factors associated with stunting in toddlers aged 12-35 months and calculate the economic losses incurred by this condition. To achieve this, a cross-sectional design was employed. The population in this study were toddlers aged 12-35 months in Pedamaran sub-district, Ogan Komering Ilir Regency. A sample of 77 toddlers were selected through simple random sampling. Data were collected using questionnaires, and calculations based on the Konig 1995 and Horton 1999 formulas were used to analyze the Gross Regional Domestic Product (GRDP) per capita. The research found a stunting prevalence rate of 51.9% in toddlers. Additionally, dietary diversity emerged as a significant factor related to stunting (p-value of 0.0001) and was identified as the most dominant factor. In contrast, economic status, toddler participation, and history of infectious diseases were not significantly related to stunting (p-value > α). The estimated potential economic losses incurred by stunting amounted to IDR 170 billion and IDR 765 billion, respectively, or 0.67%-3.03% of OKI's GRDP, resulting from a 2% and 9% decrease in productivity. Hence, this research suggests that food consumption diversity is the most dominant factor significantly related to stunting in toddlers in Ogan Komering Ilir Regency.

Keywords: Economic Losses, Nutritional Status, Risk Factors, Stunting, Toddlers.

INTRODUCTION

Stunting is a long-term condition caused by poor healthcare and nutritional problems during the prenatal and postnatal periods (1). This cumulative impact can lead to increased mortality rates, motor development disorders, bodily function imbalances, and cognitive impairments in children (2). Children who experience stunting after the age of two have their body growth hindered, and their growth potential is not maximized until they reach adolescence or adulthood. Even when growth occurs, it tends to manifest in width rather than height. The impact of stunting extends beyond physical growth and can have detrimental effects on health resilience, development, and productivity due to linear growth disturbances (3).

According to World Bank estimates, malnutrition cases in the community result in a 2.5% loss in Gross Domestic Product (4). Furthermore, there is a negative correlation

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between the Gross Regional Domestic Product (GRDP) per capita and the prevalence of malnutrition in toddlers. This implies that areas with higher GRDP per capita values tend to exhibit lower rates of malnutrition (5). This correlation is because a large GRDP value indicates a large economic resource capacity and vice versa (6).

According to the 2017 Nutritional Status Monitoring (NSM), the prevalence of stunting in toddlers decreased from 37.2% in 2013 to 29.6% but increased from 27.5% in 2016. The prevalence of stunting in toddlers in South Sumatra province is 22.8%. Furthermore, the NSM report shows that 12 Sub-districts in South Sumatra province are categorized as acute-chronic, with more than 20% of toddlers experiencing stunting (7). Therefore, this research aims to identify the risk factors associated with stunting in toddlers aged 12-35 months in Pedamaran Sub-district and the economic losses incurred in Ogan Komering Ilir (OKI) Regency.

METHOD

Research Design

This research was conducted using a cross-sectional design. This research design was used to see the correlation or relationship between the independent variables (economic status, dietary diversity, toddler participation in integrated service post, and history of disease infection) and the dependent variable (stunting). The population in this study were toddlers aged 12-35 months who live in Pedamaran sub-district, Ogan Komering Ilir Regency.

Research Subjects

The sampling technique used was simple random sampling, with a sample selected based on inclusion and exclusion criteria. Inclusion criteria were toddlers aged 12 to 35 months, preference for the youngest toddler within the family, possession of a health card (KMS), and the willingness of the toddler's mother to participate as a respondent. Meanwhile, the exclusion criteria were toddlers whose measurement results were recorded in a different book and those with physical abnormalities. The sample consisted of 77 mothers who had toddlers aged 12-35 months. The sample size was calculated using the Lemeshow (1997) formula.

Data Collection/Materials and Tools

The variables in this research were stunting status, economic status, dietary diversity, toddler participation in integrated service posts, history of disease infection, and economic losses. The stunting variable was assessed by measuring the toddler's height based on age using a microtoise tool in a standing position. Based on the Ministry of Health (2014), children under five are considered stunted if their measurements are within the range of <-3 standard deviations to <-2 standard deviations, while measurements ≥-2 standard deviations are classified as normal (8). Economic status was measured using a questionnaire describing the household expenditure for food needs in one month. According to the Central Bureau of Statistics (2018), low economic status is indicated by quintiles 1, 2, and 3, whereas high economic status is indicated by quintiles 4 and 5 (9). To assess dietary diversity, a 3x24-hour food recall instrument was employed, and the gathered data were subsequently organized in an individual dietary diversity form that categorized foods into nine groups. The measurement results were seen from the results of the food consumed. According to FAO (2007), a diversity score below 4 is indicative of inadequate diversity, whereas a score equal to or exceeding 4 denotes a more diverse range of food consumption (10). In measuring toddler participation in integrated service posts, attendance was assessed using a questionnaire. As outlined by the Department of Health (2004), attendance of fewer than 8 times in a year is considered suboptimal, while attendance of 8 times or more within a year is regarded as satisfactory (11). Additionally, the history of disease infection in toddlers, particularly those experiencing diarrhea and acute respiratory tract infections, was determined based on the frequency over a defined period. This measurement utilized a questionnaire, indicating that a toddler was not considered to have a history of disease infection if they had not suffered from the disease in the preceding month; conversely, they were deemed to have a history of disease infection if they had experienced the ailment

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in the preceding month (11). In this research, to calculate the economic losses, secondary data were used including the Gross Regional Domestic Product per capita of Ogan Komering Ilir Regency by field of work in 2017 (12), the number of births and population by age group in 2017 in OKI Regency (13), the benchmark interest rate from Bank Indonesia, and the prevalence of stunting in Ogan Komering Ilir Regency. The data collected were then analyzed using the Konig and Horton formula with the Microsoft Excel program. The formula used for calculating the economic value of a child when they start to work is as follows:

$$FV_{[r,t]} = P_0 (1 + r)^t$$

The large economic value until the child enters the retirement period was calculated using the following formula:

$$FVA_{[r,t]} = \frac{(FV_{[r,t]})\ [(1+r)^t\ - 1}{r}$$

The potential economic value of a child at the age of 0 years was calculated using the following formula:

$$PV_{[0]} = \frac{FVA_{[r,t]}}{(1+r)^t}$$

The estimation of lost productivity cost due to stunting was calculated using the following formula:

$$P_{PEM} = Prev \times \sum BL\ \times\ PV_{[0]}$$

Calculation of the economic loss due to stunting with the correction factor from Horton, states that in actual conditions, the child can recover and still has a productivity value of less than 100%. Therefore, it will only experience a productivity loss of 2-9%. The following formula was used:

$$P_{PEM} = f_{(cor)} \times Prev\ \times \sum BL\ \times\ PV_{[0]}$$

Description:

a. FV[r,t] = Income in productive age (15-64 years old).
b. FVA[r,t] = Economic value until the child enters retirement age.
c. PV[0] = Child's economic potential at 0 years old.
d. P0 = PDRB per capita.
e. r = Annual interest rate.
f. t = Years in productive age.
g. PPEM = Potential economic loss due to stunting.
h. Prev = Prevalence of stunting.
i. ∑BL = Total births.
j. f(cor) = Correction factor (2% and 9%).

Data Analysis

The data analysis covered univariate, bivariate, and multivariate methods. Bivariate analysis involved the application of statistical tests, including the Chi-Square test. On the other hand, multivariate analysis utilized the predictive logistic regression model test.

RESULT

Family and Sample Characteristics

Family characteristics collected include details regarding parents' education, occupation, and average age. Meanwhile, the characteristics of the sample included gender distribution and the average age of the toddlers. The characteristics of the family indicate that the highest level of education was high school graduates, accounting for 33.8% for fathers and 39% for mothers. Based on parental occupation, the majority of fathers, at 58%, were engaged in self-employment or trading, while a substantial 77.9% of mothers identified as housewives or were not employed. The characteristics of the sample show that 50.6% were males and 49.4% were females. The average age of the toddlers collected was 22 months.

Characteristics of Respondents

In this research, Table 1 shows that more than 50% of the toddlers examined were under the category of stunted toddlers. Subsequently, almost 60% of participating families belonged to the category with low economic status. This research reveals a prevalence of limited dietary diversity among families, accounting for 61%, compared to those with diverse diets. Almost 80% of the toddlers in the families examined had good habits of attending integrated service post programs. The results show that 87% of toddlers had a history of infectious diseases.

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Table 1. Frequency Distribution of Univariate Results

No	Variable	N	%
1	**Stunting**		
	Stunting	40	51.9
	Normal	37	48.1
2	**Economic Status**		
	Low (< Rp 1.923.857,-)	46	59.7
	High (≥ Rp 1.923.857,-)	31	40.3
3	***Dietary Diversity***		
	Undifferentiated Consumption	47	61.0
	Diverse Consumption	30	39.0
4	**Toddler Participation in Posyandu**		
	Not Good (<8x)	16	20.8
	Good (≥ 8x)	61	79.2
5	**History of infection**		
	Yes	67	87.0
	No	10	13.0

Table 2. Bivariate Analysis

Variable	Category	TB/U Nutritional Status				N	p-value	PR 95% Cl
		Stunting		Normal				
		n	%	n	%			
Economic Status	Low	23	50.0	23	50.0	46	0.854	0.824 (0.330 – 2.053)
	High	17	54.8	14	45.2	31		
Dietary Diversity	Consumption does not vary	33	70.2	14	29.8	47	0.0001	7.745 (2.705 – 22.175)
	Various consumption	7	23.3	23	76.7	30		
Toddler participation in integrated service post	Not Good	9	56.3	7	43.7	16	0.916	1.244 (0.411 – 3.768)
	Good	31	50.8	30	49.2	61		
History of infection	Yes	36	53.7	31	46.3	67	0.637	1.742 (0.450 – 6.741)
	No	4	40.0	6	60.0	10		

Table 3. Final Multivariate Modeling Results (final model)

Variable	p-value	PR Crude	95% Cl	
			Min	Max
Dietary Diversity	0.00001	7.745	2.705	22.175

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Economic Losses

Based on the analysis results, it was found that among 46 toddlers from low-economic families, the distribution between stunted and normal statuses was roughly equal. The bivariate analysis, as presented in the table above, indicates that the economic status, as delineated by household food expenditure, is not significantly associated with the occurrence of stunting in toddlers (p-value > 0.05).

Table 2 shows that families with limited dietary diversity have the largest proportion of stunting in toddlers, accounting for about 70.2%. In contrast, families with diverse diets show a higher proportion influencing normal toddler height. The statistical results establish a significant relationship between the dietary diversity variable and the occurrence of stunting in toddlers in Pedamaran sub-district, with a p-value of 0.0001 (p-value < α). Subsequently, limited food diversity emerges as a risk factor: PR 7.745 CI 95% 2.706-22.175, signifying that families consuming a limited variety of foods are at a 7.745 times higher risk of stunting in toddlers compared to those with diverse food consumption.

Table 2 shows that some toddlers are still experiencing stunting, with the highest proportion occurring in the group attending integrated service posts less than 8 times, amounting to 56.3%. The p-value in the statistical results is 0.916 (p-value > α), indicating no relationship between toddler participation in integrated service posts and stunting.

Additionally, among the 40 toddlers experiencing stunting, 36 had a history of infectious diseases, constituting a proportion of 53.75%. The p-value generated from statistical calculations is 0.637, suggesting no relationship between the history of infectious diseases in toddlers during the previous month and stunting.

Final Modeling Results

From Table 2, the variable entering the final modeling is Dietary Diversity. The statistical results show a relationship between the diversity of food consumed in the family and stunting in toddlers. The calculated PR value of 7.745 indicates that a monotonous diet in the family can impact a toddler's height development and can cause the toddler to be classified as stunting 7.745 times more than families with a diverse food intake.

Calculation of Losses

The results of the calculations performed using the appropriate formula are presented in Table 4. The amount of income during the productive age (FV) is 128 million rupiahs. The economic value until the child reaches retirement age (FVA) is 9,402 billion rupiahs. The potential economic value of the child at the age of 0 (PV) is 2,284 billion rupiahs. The amount of productivity loss due to stunting (PPEM) is 8,498 billion rupiahs.

However, according to Horton (1999), individuals who experience malnutrition problems may encounter a decrease in productivity ranging from 2% to 9%. Therefore, in Table 8, the losses caused by a 2% to 9% decrease in productivity due to stunting range from Rp170 billion to Rp765 billion, calculated using the last formula.

DISCUSSION

Relationship between family economic status and stunting

In this research, the economic status was measured using the household expenditure indicator for food for one month. Previous research has shown that in developing countries, people typically allocate their income to buy food. Subsequently, family economic status is divided into two categories, namely low and high economic status (14).

The results of the statistical test showed that the economic status, as reflected by household food expenditure, was not significantly associated with the occurrence of stunting in toddlers in Pedamaran sub-district (p-value > 0.05). This result is different from previous research that also used household food expenditure as an indicator of economic status, where a significant relationship with stunting incidence was observed in toddlers in Palembang City, specifically at the 11th Public Health Center Ilir (p-value > 0.031) (15). Also, research conducted by Indrastuty and Pujiyanto reported a significant relationship between family economic status and stunting in toddlers (12,13).

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The difference observed between economic status and stunting suggests that the amount of money spent by households may not be optimally utilized to procure high-quality food ingredients. Although families with higher food spending may have more money, it does not necessarily mean the acquisition of a more diverse and higher-quality diet for their children. Both the quality and quantity of food required to meet nutritional needs might not be adequately addressed. Therefore, diversity is necessary as each food provides different chemical elements needed by the body for growth and health (18).

Diversity of Toddler Consumption (Dietary Diversity) with Stunting Incidents

Toddlers' food consumption quality can be assessed through the variety of menus and food ingredients they consume, which can be measured by the dietary diversity score (DDS). Subsequently, an individual's dietary diversity score aims to reflect their nutritional adequacy, and research across different age groups has shown that an increase in dietary diversity score is associated with an increase in the nutritional adequacy of the food consumed (19).

The chi-square test results showed a significant relationship between dietary diversity and the incidence of stunting in toddlers ($p \leq 0.05$). This result is consistent with a survey conducted by Ruel and Arimond in 11 countries, which shows a relationship between dietary diversity and nutritional status measured by weight-for-length/height in children aged 6-23 months. In addition to this research, other findings from Faiqoh, Suyatno, and Kartini indicate a significant relationship between dietary diversity and the incidence of stunting in toddlers aged 24-59 months (20).

Food consumption is a crucial factor in determining a person's nutritional status, as it involves the types and amounts of food an individual or a group consumes at a specific time (17,18). The quality of the diet is closely tied to the diversity of consumption, as various nutritional needs can be met through a variety of foods (23).

Relationship between Toddler Participation in Integrated Healthcare Center and Stunting

Madanijah and Triana categorized the participation of mothers in integrated health posts into four groups, considering factors such as attendance, activity level, utilization of the Health Card (KMS), and contributions to the development of integrated health posts, such as financial support, provision of facilities, personnel engagement, time commitment, and the provision of food or supplementary feeding (24).

The statistical test results showed no relationship between toddler participation in integrated health posts and the incidence of stunting in Pedamaran sub-district. This research is consistent with an investigation conducted by Wahyuningtyas, which found no relationship between maternal perception of Integrated Healthcare Center and toddler participation in Integrated Healthcare Center with the incidence of stunting in toddlers in Gilingan Surakarta (21). Similarly, research by Rarastiti found no relationship between the frequency of toddler visits to the Integrated Healthcare Center and their nutritional status (23). However, this present study contrasts with an investigation conducted by Anggraeni, which identified a significant relationship between family activity in Integrated Healthcare Center activities and the nutritional status of toddlers (25).

The lack of correlation between toddlers' participation in the Integrated Healthcare Center and the occurrence of stunting may be due to suboptimal utilization of the Integrated Healthcare Center. Additionally, Fitri stated that the Integrated Healthcare Center is considered a beneficial approach to reducing morbidity or mortality in children and improving the nutritional status of toddlers (26).

Correlation between History of Disease Infection and Incidence of Stunting

Infectious disease is a direct cause of nutritional problems, and its presence in a child's body can have an impact on the nutritional status. The results of statistical tests conducted showed no relationship between the history of infectious diseases and

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the occurrence of stunting in children in Pedamaran Sub-district. This research is different from the results of the previous investigation conducted by Soekirman, which identified infectious diseases as one of the factors associated with stunting (5). Also, diarrheal diseases among children contribute to the incidence of stunting in some African countries, such as Libya (27).

These findings revealed a negative correlation, possibly attributed to the fact that the survey on infectious diseases only encompassed the past month, not fully representing the infectious diseases the children in Pedamaran had experienced. Additionally, Nirmalasari stated that stunting is the result of a combination of poor quality consumption, morbidity, infectious diseases, and environmental problems over a long or chronic period (28).

Potential Economic Losses Due to Stunting

The loss of economic potential due to stunting in toddlers in Ogan Komering Ilir Regency, projecting a 2% productivity decrease in adulthood, is estimated at IDR 170 billion, and with a 9% productivity loss, this figure rises to IDR 765 billion. Looking at this as a percentage of GDP, the loss of economic potential due to a 2% and 9% drop in productivity is about 0.67%-3.03%.

Renyoet stated that the economic losses caused by stunting in toddlers cannot be fully calculated as the calculation does not include the cost of treatment due to infectious diseases that occur in stunted toddlers, as well as the cost of premature death caused by non-communicable or other diseases caused by stunting (5).

Every newborn baby is a potential human resource with inherent economic productivity value. Meanwhile, high birth rates and increasing numbers of stunted children can lead to high potential economic losses as well. According to Freijer, the total additional cost for malnutrition-related adult patients was estimated at 1.9 billion euros in 2011, equivalent to 2.1% of the total national healthcare expenditure in the Netherlands and 4.9% of the total healthcare sector costs (27). A meta-analysis of 45 longitudinal studies in the United States shows a significant relationship between height, career success, and salary in the work environment. On average, a person who is six feet (1.82 m) tall earns approximately $166,000 more over a 30-year career than an individual who is five feet five inches (1.55 m) tall. This shows that a person's height affects the type of work, income, and work productivity (5,25).

CONCLUSION

In summary, this study revealed a significant prevalence of stunting, affecting 51.9% of toddlers aged 12-35 months. Meanwhile, the results showed a relationship between dietary diversity and the incidence of stunting (p-value = 0.0001; PR = 2.705-22.175). Conversely, no statistically significant relationships were observed between stunting and other factors, including economic status (p-value = 0.854), participation of toddlers in integrated health posts (p-value = 0.916), and history of infectious diseases (p-value = 0.637) and the relationship with the incidence of stunting. Therefore, the most dominant factor related to stunting was dietary diversity. Economic losses due to a 2% and 9% decrease in productivity resulting from stunting were estimated at IDR 170 billion and IDR 765 billion, respectively, representing 0.67% to 3.03% of the 2017 OKI GRDP.

Author Contributions

ANR and AR in this study have a role in designing research and data analysis. Then, ANR and AR also have the role of writing manuscripts and revisions for important content.

Declaration of Conflict of Interest

There are no conflicts of interest associated with this publication.

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Data availability

Must apply for access permission.

Ethics clearance

This study was ethically approved by the Health Research Ethics Committee Faculty of Public Health Sriwijaya University, with clearance number: 75/UN9.1.10/KKE/2019.

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Review Research

Impact of Mobile Applications on Improving Healthy Lifestyle of Patients with Metabolic Syndrome: A Systematic Review

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ABSTRACT

Metabolic syndrome (MetS) generally occurs in adults and becomes more prevalent with age. Most e-health tools are often described as web-based platforms or applications designed for the general public, rather than specifically for MetS patients. Mobile applications, however, have great potential in providing internet-based health education and supporting the self-management of MetS patients, particularly in diet management and physical activity. This study aimed to consolidate the findings on the impact of mobile app interventions in enhancing self-management practices among MetS patients. A comprehensive literature search covering the years 2019 to 2023 was conducted across Science Direct, ProQuest, and PubMed databases. From 16,628 articles analyzed, 11 were selected for review. The interventions were categorized into short-term (> 12 months) and long-term (≥ 12 months). Eleven mobile applications were identified. These applications were primarily free and designed to facilitate the management of diet and physical activity. The study observed significant changes in the components of metabolic syndrome, including weight, blood pressure, waist circumference, body mass index, fasting blood sugar, triglycerides, and High-Density Lipoprotein cholesterol. Furthermore, these mobile applications demonstrated a positive impact on the lifestyle of MetS patients, influencing factors such as eating behavior, physical activity, self-efficacy, sleep quality, and sleep duration.

Keywords: Mobile Application, Metabolic Syndrome, Lifestyle, Self-Management

INTRODUCTION

Metabolic syndrome is synonymous with a group of cardio-metabolic risk factors, including abdominal or visceral obesity, hypertension, insulin resistance or blood glucose intolerance, elevated triglycerides, and low levels of High-Density Lipoprotein Cholesterol (HDL-C) (1). Heart disease, stroke, and death are twice as likely in individuals with metabolic syndrome (2). Currently, the global prevalence of metabolic syndrome has reached epidemic proportions, affecting approximately 25% of the population worldwide, with its occurrence escalating with age (3). Indonesia, with a prevalence of metabolic syndrome at 21.6%, ranks 5th among Asian countries (4).

Metabolic syndrome has not been treated clinically as a whole. Instead, the focus is on managing each cardio-metabolic risk factor separately. Treatment recommendations include lifestyle modifications, such as adopting a healthy diet and engaging in

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regular exercise, as well as pharmacological and surgical interventions, particularly bariatric surgery if needed (5). However, the conventional approach to managing metabolic syndrome is resource-intensive, involving consultations with doctors or nutritionists at public health centers or private practices, and the effects of these interventions tend to diminish over time due to the challenges of sustaining lifestyle changes (6).

The interventions can be improved by incorporating e-health technology, which refers to using information and communication technology to improve healthcare (7). Information technology alternatives, such as telehealth using smartphones, have an essential role in many aspects of human life, including health services. The integration of information and communication technology can assist in the diagnosis, prevention, and provision of advice concerning health issues. Using telehealth with smartphones can positively affect patient health and the relationship between health workers and patients (8).

This research focuses on the utilization of mobile applications for the lifestyle management of patients with metabolic syndrome. Lifestyle management using mobile applications is defined as applications that can be included in health promotion programs to support sports maintenance and a healthy diet for people with metabolic syndrome in the community (9). Lifestyle management using a mobile application is an intervention that can be used as a promotive-preventive effort related to metabolic syndrome (10) and offers an independent management option, presenting an alternative application-based intervention (11). In addition, mobile applications can also be used to prevent the risk of type 2 diabetes mellitus, stroke, cardiovascular disease, and death in an easier way using information technology (2).

Based on the results of a literature review, interventions that focused on regular exercise for six months facilitated by a telemonitoring system could reduce the prevalence of metabolic syndrome (3). Research by Kim et al. indicated that applications developed for managing metabolic syndrome could improve behavioral skills in performing exercise self-management and dietary habits (12). However, Matsuhisa et al. reported no significant difference in weight loss between the group using the application and the group receiving usual care (13). Existing literature reviews on the effectiveness of using mobile applications for promoting healthy lifestyles show conflicting and inconclusive results, with some studies showing positive outcomes while most recommend further research. In addition, various factors that facilitate or hinder the use of mobile applications have been identified among the population using mobile applications. Previous studies have shown that the accessibility and acceptability of mobile applications are not universal.

This review aims to provide a comprehensive overview of the impact of mobile app interventions in improving self-management among patients with Metabolic Syndrome. Specifically, this review aims to answer the question: Are lifestyle-related mobile applications effective for improving the self-management of adult patients with metabolic syndrome?

METHOD

Data Sources and Search Strategy

Literature sources were systematically searched through Science Direct, ProQuest, and PubMed, using the keywords “Metabolic Syndromes” OR “metabolic syndrome” OR “syndromes, metabolic” OR “syndrome, metabolic” OR “MetS” AND “mobile app” OR “mobile apps” OR “mobile application” OR “mobile applications” OR “m-health” OR “mobile health” documented with Mendeley.

Eligibility Criteria

Research titles and abstracts were screened to identify research that meets the requirements by a separate review team. Within the research team, the authors identified research that meets the eligibility standards and accessed the full text of that systematic review. Any differences in views were resolved through discussion between the authors and other reviewers.

The inclusion criteria in this review were:

1. Type of Study: Pre-post study, quasi-experimental study, randomized

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controlled trial, and cohort published in 2019-2023.
2. Population: Individuals with metabolic syndrome and central obesity (men with a waist circumference of more than 90 cm, women with a waist circumference of more than 80 cm) and meeting one of the following two criteria (7):
    a. Triglyceride concentration is greater than 150 mg/dL (1.7 mmol/L) or on triglyceride therapy.
    b. HDL cholesterol in men is not more than 40 mg/dL (1.03 mmol/L), or in women, is not more than 50 mg/dL (1.29 mmol/L) or on HDL therapy.
    c. Fasting blood sugar level is over 100 mg/dL (5.6 mmol/L) or previously diagnosed with type 2 diabetes mellitus.
    d. Systolic blood pressure is more than 130 mmHg, or diastolic blood pressure is more than 85 mmHg, or taking antihypertensive medication.
3. Intervention: Using any application to help individuals with metabolic syndrome improve self-management in a healthy lifestyle. Mobile apps can be used exclusively or combined with other interventions. Research on the use of different technologies was excluded.
4. Comparison: The control group should receive regular healthcare and did not use mobile applications to live a healthy lifestyle.
5. Outcomes: Covering components of the metabolic syndrome (weight, blood pressure, waist circumference, body mass index, fasting blood sugar, triglycerides, High-Density Lipoprotein cholesterol)
6. Time: Long-term (≥ 12 months) and short-term (< 12 months) effectiveness.

Data Extraction

Data from the included articles were extracted using the standard extraction form. The extracted data included the primary author, year, source, study population, study site, study design, interventions, comparisons, and findings. Details of the data extraction results are presented in Table 1. This systematic review adheres to the PRISMA recommendations. Figure 1 illustrates the article selection process based on the PRISMA flowchart scheme. To evaluate the quality of nonrandomized studies, the Newcastle Ottawa Scale Analysis (NOS) was employed.

RESULT

Eleven different applications related to diet and physical activity management were assessed. The interventions conducted through these mobile applications ranged in duration from 1 to 12 months. The primary outcomes from the review were weight loss and the prevalence of metabolic syndrome. At the same time, secondary results found from the study were Body Mass Index (BMI), waist circumference, blood pressure, fasting blood sugar, triglycerides, HDL-C, eating behavior, physical activity, self-efficacy quality, and sleep duration.

Search Summary

Based on a literature search through three databases for articles published between 2019 and 2023 and employing search terms adapted according to Medical Subject Headings (MeSH), researchers identified 16,628 articles that matched these keywords. After removing duplicate articles, the dataset was refined to 10,339 articles. Subsequent screening based on titles yielded 72 articles, from which researchers excluded those with one or two cardio-metabolic risk factors, resulting in a final set of 22 articles.

An additional assessment was conducted based on inclusion criteria (articles published between 2019 and 2023, must be complete full papers, and written in English) and based on exclusion criteria (articles inaccessible without payment, not full papers, reviews, draft designs applications, and articles using other technological interventions), resulting in 11 articles used in the literature study and documented with Mendeley. The Newcastle Ottawa Scale (NOS) was employed to assess the quality of the 11 reviewed articles, revealing an average score categorizing them in the “good quality” category. The detailed NOS analysis table is available in Table 2.

Narrative Review Result

Mobile Application and Intervented Lifestyle

Table 3 describes the mobile applications and corresponding lifestyle patterns in detail.

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Eleven applications were identified: one related to diet, five related to sports and physical activity, and five combining these two components. The mobile applications examined in this review include Dr. Healthing, Yonsei Health, EMPOWER SUSTAIN, Mindfulness Mobile Application (MMA), e-Motivate4Change App, and Noom. These applications focus on lifestyle interventions, including management of diet and physical activity to improve self-management of MetS patients, and offer free access for all mobile devices.

1. Dr. Healthing. This application provides information about personal health conditions by analyzing information from health checks and average daily step data recorded in the application. Health training content on Dr. Healthing is provided three times a week, covering training related to nutrition/physical activity/mental health, general medical knowledge, and individual health report for one week (15).
2. Yonsei Health. This mobile app allows users to access text messages, phone contacts, videos, and health education materials tailored to prevent and treat metabolic syndrome. Users also wear a wearable device (Galaxy Watch Active1) to monitor changes in physical activity and obtain feedback regarding physical activity, in the form of appreciation or encouragement based on activity levels. The health information provided contains guidance on lifestyle and physical activity to prevent and reduce metabolic syndrome risk factors across cognitive, lifestyle, exercise, nutrition, and medical categories (18).
3. EMPOWER-SUSTAIN. This self-management app facilitates metabolic syndrome patients to review their progress at home, including self-monitoring blood pressure, weight, and blood glucose, and record their diet and physical activity. Special attention is paid to the application pages that summarize the patient's clinical outcomes and the self-management carried out. Users' achievements are rewarded with star ratings on the application following the theory of persuasive technology. The nurses monitor the patient's login frequency and duration of application use via a separate web and discuss the patient's achievements during follow-up visits (19).
4. Mindfulness Mobile Application (MMA). MMA is a program for weight loss for metabolic syndrome patients. This application provides daily reminder notifications for users to practice mindfulness breathing exercises via audio instructions in Japanese. Users also receive comprehensive lifestyle intervention (CLI), such as health education and nutritional guidance by public health nurses and nutritionists and sports education and guidance by health sports instructors. Subsequently, nutritionists and public health nurses conducted telephone counselling every four weeks to check the metabolic syndrome patient's adherence to diet and exercise programs and the consistent use of MMA (13).
5. e-Motivate4Change. This application facilitates users in obtaining information related to MetS, explanations on health programs provided, types of MetS, and its risk factors. The app also links users to websites, including YouTube, about practical exercises for preventing MetS. Users can self-diagnose their health status and check their metabolic syndrome risk factors (diet, disease, and lifestyle). Nurses routinely assess users' health information (obesity level, weight, fasting cholesterol, and body fat) to provide health recommendations for physical activity, diet, and sleep management. The app also facilitates a group messaging feature via the network so that users are actively involved in sharing information about their health status. In addition, users can choose their preferred health

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management method and obtain rewards for their achievements (20).

6. Noom. This application focuses on behavior change for weight loss and developing healthy living habits. Noom allows users to track food intake, daily activities, blood sugar, and blood pressure, logging their diet and physical activity within the app. Through mobile messages sent through the Noom app, users receive feedback and health education from a coach (trained nutritionist) three times a week. Feedback is provided to users, offering insights on successes and areas for improvement, along with articles or videos related to healthy lifestyle management (22).

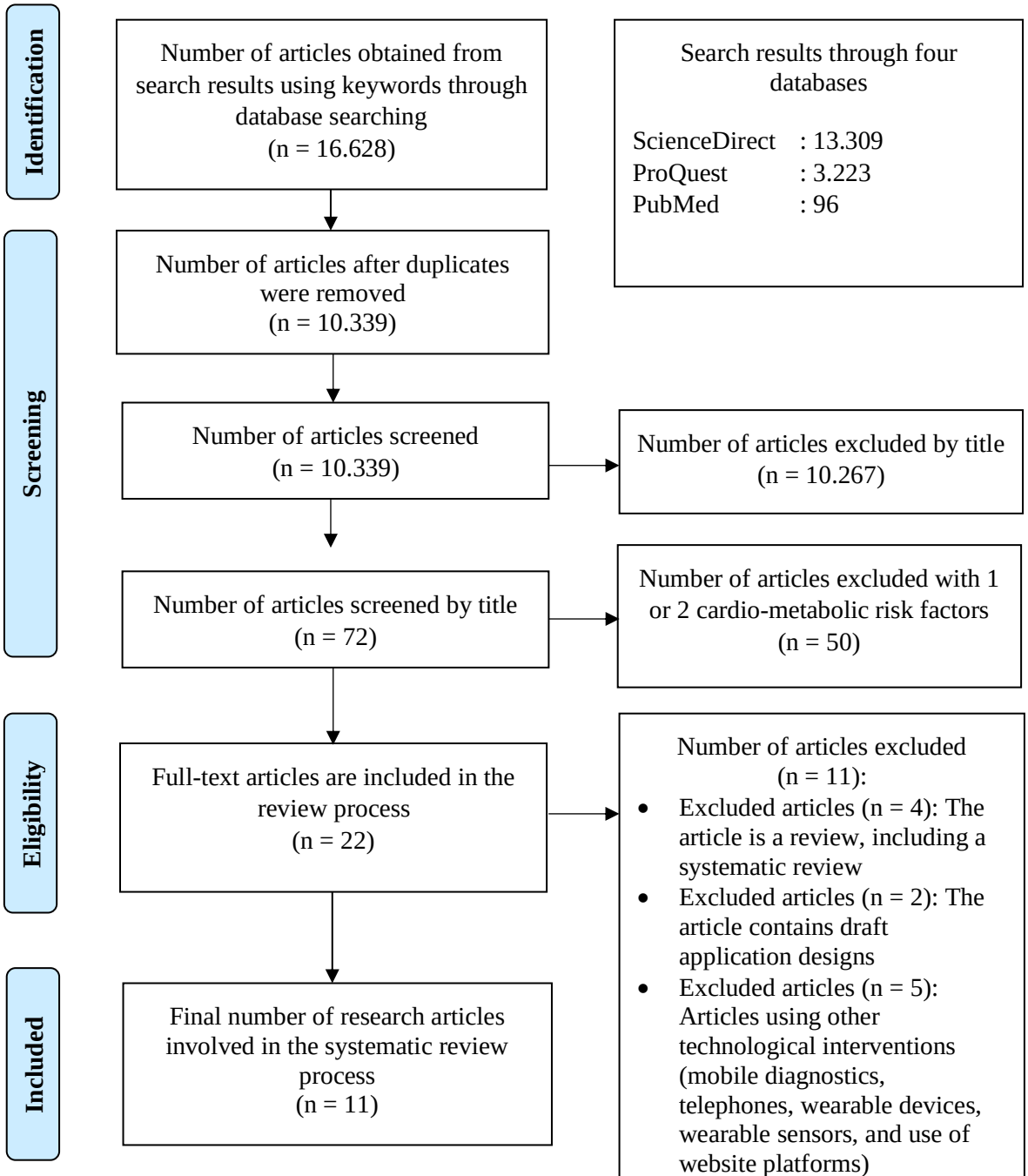

Figure 1. PRISMA Flow Diagram

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Table 1. General Characteristics of a Systematic Review

First author, year/source	Study Population and Site	Study Design	Intervention	Comparison	Duration	Outcome
Sharma, 2021/Diabetes & Metabolic Syndrome: Clinical Research & Reviews (14)	286 adults aged 20-60 years with metabolic syndrome; 10 villages in Jaipur district, India Community	Randomized Controlled Trial	Apps to help patients acquire knowledge regarding healthy eating, smoking/tobacco cessation exercise and physical activity, and promotion of hypertension and other risk factor management with medication adherence	Usual care	12 months	*Primary:* Prevalence of metabolic syndrome *Secondary:* Diet, physical activity, tobacco consumption, waist circumference, body mass index, systolic blood pressure, fasting glucose levels, cholesterol, and triglycerides
Bae, 2023/JMIR Formative Research (15)	63 Korean adults aged ≥ 20 years; National Health Insurance Service Ilsan Hospital (NHIS) *Secondary care*	Pre-Post Study	Apps provide information regarding the health status and health coaching contents (exercise/ nutrition/ mental coaching, general medical knowledge, and individualized weekly health report)	-	Three months	*Primary:* Body weight *Secondary:* Waist circumference, triglycerides, HDL cholesterol, and blood pressure
Huh, 2019/ JMIR Mhealth Uhealth (16)	20 patients with metabolic syndrome aged between 36 and 50 years; Health promotion center Pusan National University Hospital (Busan, South Korea) *Secondary care*	Pre-Post Study	Apps to help track physical activity, number of steps, and calories consumed	-	Three months	*Secondary:* Blood pressure and physical activity

Wong, 2022/ Int. J. Environ. Res. Public Health (17)	118 participants with hypertension and metabolic syndrome; Hong Kong Community	Randomized controlled trial (RCT)	Apps provide knowledge content, personal health monitoring tools, the ability to set exercise goals, and an exercise recording system.	• Booklet group: Receive a booklet • Control group: Receive a leaflet	Six months	*Primary:* Body weight *Secondary:* Waist circumference, exercise, and self-efficacy
Kim, 2022/JMIR Mhealth Uhealth (18)	Two hundred twenty-one adults aged 40–80 with metabolic syndrome; Wonju-Pyeongchang countryside, South Korea. Community	Randomized Controlled Trial	Apps to help track physical activity and provide health information contain guidance on lifestyle and physical activity	Digital device (GalaxyWatch Active1)	Six months	*Primary:* Body weight *Secondary:* Body mass index, blood pressure, waist circumference, glycated hemoglobin A1c (HbA1c) levels, and physical activity
Daud, 2020/Trials (19)	232 patients aged 18-60 years with metabolic syndrome; University Primary Care Clinic, State of Selangor, Malaysia Primary care	Randomized Controlled Trial	Apps for self-monitoring blood pressure, weight, blood glucose and recording diet and physical activity	Usual care	Six months	*Secondary:* Body mass index, waist circumference, blood pressure, eating behavior, and physical activity
Wong, 2021/ Clinical Interventions in Aging (7)	77 individuals aged ≥ 50 years with metabolic syndrome; Two Hong Kong community centers Community	Randomized Controlled Trial	Apps to help behavioral changes, such as self-observation and monitoring of body weight, waist circumference, and goal setting, recording and providing feedback on the pattern and amount of exercise	Receive a booklet	Three months	*Primary:* Body weight *Secondary:* Body mass index and exercise

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Matsuhisa, 2023/International Journal of Behavioral Medicine (13)	32 adults aged 20-75 years with metabolic syndrome; Public Health Center, Kasugai City, Japan Primary care	Randomized Controlled Trial	Apps provide daily reminder notifications, mindfulness breathing exercises, and comprehensive lifestyle intervention (health education and nutritional guidance, sports education and guidance)	Usual care	Six months	*Secondary:* Eating retention
Lee, 2020/ Journal of Medical Internet Research (20)	59 nursing students with metabolic syndrome; Daegu University and Keimyung University, Daegu, Korea Community	Quasi-experimental study	Apps for self-monitoring metabolic syndrome risk factors (diet, disease, and lifestyle) and providing information related to MetS, explanations of health programs, and exercises for preventing MetS	Receive a pamphlet	Four months	*Secondary:* Self-efficacy, body mass index, and cholesterol levels
Lee, 2022/ Diagnostics (21)	106 adult individuals aged 40-80 years with pre-metabolic syndrome and metabolic syndrome; Wonjun, Korea Community	Cohort study	Apps for self-monitoring blood pressure, weight, and blood glucose.	Usual care	Four months	*Primary:* Body weight *Secondary:* Waist circumference and blood pressure, body mass index, waist circumference, and fasting blood sugar levels
Ju, 2022/JMIR mHealth and uHealth (22)	110 patients aged ≥ 19 years with hypertension, diabetes, dyslipidemia, or metabolic syndrome; South Korea Primary care	Cohort study	Apps provide health education and help track food intake, daily activities, blood sugar, blood pressure, diet, and physical activity.	Traditional care (counseling sessions and receiving a booklet)	Four months	*Primary:* Body weight *Secondary:* Sleep quality and duration

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Table 2. Quality Assessment of Included Articles (Newcastle-Ottawa Quality Assessment Scale Randomized and Nonrandomized)

Article	Selection Grade	Comparability Grade	Exposure/Outcome Grade	Category
Randomized Controlled Trial	Max 4	Max 2	Max 3	
Sharma, 2021 (14)	3	2	3	Good Quality
Wong, 2022 (17)	3	1	3	Good Quality
Kim, 2022 (18)	3	2	3	Good Quality
Daud, 2020 (19)	2	2	3	Fair Quality
Wong, 2021 (7)	3	2	3	Good Quality
Matsuhisa, 2023 (13)	2	2	3	Fair Quality
Nonrandomized Controlled Trial (Cohort)	Max 4	Max 2	Max 3	
Lee, 2022 (21)	4	1	3	Good Quality
Ju, 2022 (22)	4	1	2	Good Quality
Bae, 2023 (15)	3	1	2	Good Quality
Huh, 2019 (16)	3	1	2	Good Quality
Lee, 2020 (20)	4	1	3	Good Quality

Table 3. Identified Mobile Applications and Lifestyle

First author, year	Application Name	Identified Lifestyles	Cost
Sharma, 2021 (14)	Not identified	Healthy diet, exercise, and physical activity	Free
Bae, 2023 (15)	Dr. Healthing	Exercise, sleep duration, and eating habits	Free
Huh, 2019 (16)	Not identified	Exercise and physical activity	Low payment
Wong, 2022 (17)	Not identified	Exercise and physical activity	Free
Kim, 2022 (18)	Yonsei Health	Physical activity	Free
Daud, 2020 (19)	EMPOWER SUSTAIN	Eating behavior and physical activity	Free
Wong, 2021 (7)	Not identified	Exercise	Free
Matsuhisa, 2023 (13)	Mindfulness Mobile Application (MMA)	Eating behavior	Free
Lee, 2020 (20)	e-Motivate4Change App	Exercise, sleep duration, and eating habits	Free
Lee, 2022 (21)	Not identified	Physical activity	Free
Ju, 2022 (22)	Noom	Diet, exercise, sleep quality, and sleep duration	Free

Primary Outcome

The primary outcomes in this review are body weight and the prevalence of metabolic syndrome. Five articles reported a significant weight loss change; one showed a statistically insignificant difference ($p = 0.924$) (13). Huh et al. reported that the resolution of the metabolic syndrome was the primary outcome, with metabolic syndrome resolved in 9 of 20 participants (45%) after 12 weeks (14). Sharma et al. also reported a decrease in the prevalence of metabolic syndrome 12 months after the intervention (15).

Body Weight

The use of the application impacts the weight of MetS patients. Wong et al. reported a significant weight loss in the application group compared to the booklet group ($\beta = -1.069$, $p = 0.012$) (7). Additionally, significant weight loss in the application group was observed at weeks 12 (T3) and week 24 (T4) compared to the control group (T3, $\beta = -0.913$, $p = 0.040$; T4, $\beta = -1.254$, $p = 0.007$) (17). Ju et al. reported that the application user group experienced a substantially greater weight loss compared to the control group, with a decrease of 1.43 kg in the application user group and 0.13 kg in the control group (22).

Prevalence of Metabolic Syndrome

Interventions using mobile applications contribute to reducing the prevalence of metabolic syndrome. Huh et al. reported that by week 12, the metabolic syndrome resolved in 9 of 20 (45%) participants, and the number of metabolic abnormalities decreased in 11 of 20 (55%) participants (16). Meanwhile, Sharma et al. reported that the prevalence of metabolic syndrome was significantly reduced in the intervention group (-22.3%) compared to the control group (-3.9%) ($p < 0.001$) (14).

Secondary Outcome

The secondary results of this review cover several aspects. Regarding body mass index (BMI), four articles reported significant reductions. Research by Kim et al. showed a reduction in BMI of 0.21 (SD 0.76) kg/m^2 after a six-month intervention ($p \geq 0.001$) (16). As for waist circumference, seven articles observed a significant decrease, as seen in the study by Sharma et al., where waist circumference decreased by 85.7 ± 6.3 cm, equivalent to a 2.9% decrease (-5.5 to -0.3) ($p = 0.026$) (15). Positive changes in blood pressure were evident in eight articles, reporting significant reductions in blood pressure. Research by Huh et al. found that the mean systolic and diastolic blood pressure decreased from an average of 136.6 (SD 18.5) mm Hg to an average of 127.4 (SD 19.5) mm Hg and from an average of 84.0 (SD 8.1) mm Hg to a mean of 77.4 (SD 14.4) mm Hg, respectively (both $p = 0.02$) (14). Concerning fasting blood sugar, four articles noted significant reductions. The study by Kim et al. reported a decrease in glycated hemoglobin A1c (HbA1c) ($p < 0.001$) (16). Four articles reported significant changes in triglyceride reduction, as observed in the study by Sharma et al., where triglycerides decreased by 147.6 ± 48.3 mg/dL, i.e., decreased by 11.9 (-25.0 to -1.2) mg/dL ($p = 0.070$) (15). In terms of HDL-C levels, two articles reported a significant decrease. The study by Bae et al. reported that before the intervention, HDL-C was 46.57 (SD 19.02) mg/dL, and after the intervention, HDL-C decreased to 45.19 (SD 18.09) mg/dL (17). Meanwhile, research by Kim et al. showed that in the intervention group before the intervention, HDL-C was 50.5 (SD 10.1) mg/dL, and after the intervention, HDL-C decreased to 49.6 (SD 10.6) mg/dL (16).

In addition, there are changes in eating behavior, physical activity, and self-efficacy. Two articles reported significant increases in eating behavior, as in the study by Matsuhisa et al., where the Dutch Eating Behavior Questionnaire (DEBQ) score increased in the CCI+MMA group ($p = 0.033$) (13). Five articles observed a significant increase in physical activity, similar to that of Kim et al., which showed differences in physical activity between the standard and enhanced intervention groups. The total number tended to be about 2.8 times lower in the standard intervention group, 44.47 ± 224.85 minutes/week, compared to the enhanced intervention group, 124.36 ± 570.0 minutes/week (16). Furthermore, three articles noted increased self-efficacy, for example, in the study of Wong et al., where self-efficacy for exercise increased

significantly in the application group at T3 (β = 1.043, p = 0.037) and T4 (β = 1.170, p = 0.031) (18). Finally, in the aspect of sleep quality and sleep duration, one article reported significantly better changes in patients in the intervention group. Patients in the intervention group reported better sleep quality (p = 0.04) and better sleep duration (p = 0.004) compared to the control group (19).

Body Mass Index (BMI)

The use of mobile applications in patients with metabolic syndrome has the effect of reducing body mass index. Ju et al. reported that BMI in the application user group decreased at week nine or more (22). Lee et al. similarly noted a reduction in BMI in the intervention group at 4, 8, and 12 weeks (20). In addition, Kim et al. reported that in the intervention group, BMI decreased by 0.21 (SD 0.76) kg/m^2 (p < 0.001) at six months (18).

Waist Circumference

Mobile applications impact the waist circumference of MetS patients. Sharma et al. reported a more significant change in waist circumference in the intervention group vs the control group at 12 months (85.7 ± 6.3 cm vs 88.6 ± 14.0 cm) (14). Research by Bae et al. also reported that after using the application for three months, the mean waist circumference decreased from 79.65 cm to 79.34 cm (15). Meanwhile, Wong et al. reported that the booklet and application group showed more significant reductions in waist circumference than the control group. However, statistically, the decrease in waist circumference in the application group differed from that in the control group at week 24 (β = -3.842, p < 0.001) (17).

Blood Pressure

Mobile applications affect the blood pressure, which is an indicator of metabolic syndrome. Huh et al. reported that the mean systolic and diastolic blood pressure decreased from an average of 136.6 (SD 18.5) mm Hg to an average of 127.4 (SD 19.5) mm Hg and from an average of 84.0 (SD 8.1) mm Hg to a mean of 77.4 (SD 14.4) mm Hg (both p = 0.02) (16).

Fasting Blood Sugar

The mobile applications impact another indicator of metabolic syndrome, namely fasting blood sugar. Huh et al. reported that using the application for 12 weeks led to a reduction in fasting blood sugar (16). In addition, the study of Kim et al. also noted that the use of mobile applications caused a decrease in glycated hemoglobin A1c (HbA1c) (p < 0.001) (18).

Triglycerides

The use of mobile applications has an impact on the triglycerides of patients with metabolic syndrome. Sharma et al. reported that triglycerides decreased by 147.6 ± 48.3 mg/dL, representing a reduction of 11.9 (-25.0 to -1.2) mg/dL (p = 0.070) (14). Bae et al. also reported a decrease in triglycerides of 129.68 (SD 101.69) mg/dL after using the application for three months (15).

High-Density Lipoprotein Cholesterol (HDL-C)

The use of mobile applications affects HDL-C. Bae et al. reported that before the intervention, HDL-C was 46.57 (SD 19.02) mg/dL, but after the intervention, HDL-C decreased to 45.19 (SD 18.09) mg/dL (15). Meanwhile, Kim et al.'s research showed that in the intervention group before the intervention, HDL-C was 50.5 (SD 10.1) mg/dL, and after the intervention, HDL-C decreased to 49.6 (SD 10.6) mg/dL (18).

Eating Behavior

The mobile application helps individuals with metabolic syndrome change their eating behavior. Daud et al. reported a change in eating behavior among individuals with metabolic syndrome (19). Research by Matsuhisa et al. also showed an increase in eating behavior, with a significant interaction for the DEBQ Dutch Eating Behavior Questionnaire (DEBQ) scores between the CCI and CCI+MMA groups (p = 0.033) (13).

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Physical activity

Mobile applications help increase physical activity for MetS patients. Daud et al. reported that mobile applications can elevate the physical activity level of patients with metabolic syndrome (19). Kim et al. highlighted the main result of the study, indicating differences in physical activity. The total number was approximately 2.8 times lower in the standard intervention group, 44.47 ± SD 224.85 minutes/week, compared to the enhanced intervention group mean of 124.36 ± 570.0 minutes/week (18).

Self-Efficacy

The use of mobile applications has an impact on the self-efficacy of patients with metabolic syndrome. Wong et al. reported a significantly more significant increase in exercise self-efficacy in the application group after one month ($\beta = 7.919$, $p = 0.002$) and three months ($\beta = 10.62$, $p = 0.001$) compared to the booklet group (7). Wong et al. also reported that exercise self-efficacy in the application group increased significantly compared to the control group at week 12 ($\beta = 1.043$, $p = 0.037$) and week 24 ($\beta = 1.170$, $p = 0.031$) (17).

Sleep Quality and Duration

Mobile applications help improve sleep quality and duration in patients with metabolic syndrome. One article reported significant changes in improved sleep quality and duration. Patients in the intervention group reported better sleep quality ($p = 0.04$) and better sleep duration ($p = 0.004$) than the control group (22).

DISCUSSION

This systematic review provides an overview of the impact of mobile app interventions in improving the self-management of MetS patients. The findings support that the mobile app intervention produced significant changes in metabolic syndrome components and lifestyle changes in MetS patients.

Impact of Mobile Application on Metabolic Syndrome Components

Mobile applications are effective in improving various components of metabolic syndrome. The findings show that mobile applications can improve patients' metabolic syndrome, body weight, and body mass index. The interconnectedness of overweight conditions and metabolic syndrome escalates the susceptibility to vascular events and the onset of type 2 diabetes mellitus (25). In patients with metabolic syndrome, excess energy accumulated in fatty tissue will be ectopically deposited in non-adipose tissues, such as the liver, causing metabolic disturbances, including increased blood pressure, blood glucose, and triglycerides (25). The most common dietary interventions focus on energy restriction to target weight loss, which generally increases cardiometabolic risk factors. Recent research has shifted focus towards macronutrient combinations, particularly low-carb diets. Several studies have shown that low-carbohydrate diets improve glucose, insulin sensitivity, triglycerides, and High-Density Lipoprotein Cholesterol (HDL-C), which affect weight loss (24). Mobile applications play a transformative role in altering the Body Mass Index (BMI) of individuals with metabolic syndrome because the users are required to record their daily activities, and the application will display the user's goals and achievements every day (20).

Implementing mobile applications efficiently can help people identify risk elements for disease, prevent their onset, and support preventing the development of complicated situations and worsening symptoms (15). Mobile applications help increase motivation, foster adherence to lifestyle changes, and exert a positive influence on indicators of metabolic disorders, including waist circumference (27). The mHealth application also promotes a healthy lifestyle for individuals with dyslipidemia and has proven to improve lipid profiles and body composition (27). Mobile application interventions help control risk factors for metabolic disorders that can be accepted by patients with metabolic syndrome, including dyslipidemia and hyperglycemia (29). Mobile self-management healthcare applications integrated with human coaching in current primary care systems for patients with metabolic syndrome improve cardiovascular risk factors, such as blood lipid levels, including HDL-C (22). Furthermore,

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intervention using the application also can produce triglyceride improvements (28).

Self-management interventions using mobile applications improve the outcome of individuals with metabolic syndrome, including decreasing fasting blood sugar (27). Using mobile applications to enhance a healthy lifestyle to prevent metabolic syndrome has benefits in disseminating health education more efficiently, quickly, and effectively. This approach can be accepted by many users (7). MetS applications can potentially reduce the risk of cardiovascular problems among patients with hypertension and Mets. Guidelines for managing high blood pressure indicate that patients with hypertension should maintain their blood pressure below 140 mmHg for systolic pressure (SBP) and below 90 mmHg for diastolic pressure (DBP) during treatment (17). The mobile app helps improve various components of metabolic syndrome and continuing interaction between the healthcare provider and the user via the app. This interaction can produce beneficial results by increasing user adherence to recommendations and directions provided (15).

Impact of Mobile Application on Metabolic Syndrome Patient Lifestyle

A healthy lifestyle is a first-line intervention for preventing and managing metabolic syndrome, with a focus on dietary choices and regular exercise according to clinical guidelines (23). The combined diet intervention and regular physical activity led to a twofold reduction in the prevalence of metabolic syndrome compared to the placebo and metformin groups (24). Mobile health technology can potentially improve the self-management behavior of individuals with chronic illnesses, including those with metabolic syndrome (10).

Metabolic syndrome can be managed effectively using mobile applications (12). Mobile applications, acting as effective tools for behavior modification, enable sustained healthy living. Patients utilizing mobile self-management health apps demonstrate continued commitment to a health-conscious lifestyle, encompassing dietary practices, physical activity, sleep quality, and duration over a span of 12 months (22). Self-management in health care can enable patients to manage their health data anytime and anywhere for the independent prevention of chronic diseases (11). Mobile apps can alleviate difficulties associated with continuous self-monitoring, providing patient education, customizing feedback, and managing physician appointments (22).

Applications developed to address metabolic syndrome can improve behavioral skills in exercise self-management and dietary habits. Increased physical activity, motivation to change to a healthier lifestyle, and understanding of healthy dietary options collectively contribute to transformative changes in the health status of metabolic syndrome (6). Several studies have examined evidence of the effectiveness of health-related apps when targeting one specific behavior, such as physical activity or a particular condition, with a notable impact on the activity levels of MetS patients (30). The findings show that exercising 150 minutes per week can reduce metabolic syndrome severity (3).

Mobile applications are an ideal platform for delivering simple yet effective interventions. Mobile applications are practical for achieving health-related behavior change on various health problems. Previous research stated that these applications effectively influence the eating behavior of application users (30). This is because mobile application interventions are designed to help improve goal setting, problem-solving, and self-monitoring of patients with metabolic syndrome (16).

In addition, mobile applications can increase self-efficacy in metabolic syndrome patients. Recognizing the integral role of self-efficacy in behavior control and modification, previous research highlights health-related self-efficacy as a primary motivator for instigating behavioral changes conducive to a healthy lifestyle. Therefore, to motivate application users and foster active participation, increasing user self-efficacy is necessary to provide significant intrinsic motivation (20).

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CONCLUSION

The findings from this review support the application of mobile applications as effective tools to improve the self-management capabilities of individuals with metabolic syndrome, with a specific emphasis on promoting a healthy lifestyle. However, higher quality and quantity research is still needed to better understand the impact of using applications in controlling the lifestyle of individuals with metabolic syndrome, especially in the long term, considering their risk of cardiovascular disease, type 2 diabetes mellitus, and death. Most analyzed applications can be downloaded for free, guaranteeing good accessibility. Since the applications reviewed in the review focus on diet management and physical activity, it is necessary to know the effectiveness of this tool in overcoming other unhealthy habits, such as smoking, drinking alcohol, sleep quality, and duration because there is little literature on this matter.

Author contributions

NA is screening research titles and abstracts as part of a separate review team to identify research that meets the requirements. The authors and other reviewers hold discussions to resolve any differences in views in the study (NA and YS).

Declaration of Conflict of Interest

There is no conflict of interest in this research.

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Data availability

All available data can be accessed in this article.

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Original Research

Exploring Organoleptic, Chemical, and Physical Properties of Foxtail Millet (*Setaria italica*) and Snakehead Fish (*Channa striata*) Cookies as Emergency Food Alternatives

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ABSTRACT

High disaster risk in Indonesia necessitates the development of emergency food products (EFP). One potential EFP is cookies made from foxtail millet and snakehead fish. This study aimed to examine the sensory, chemical, and physical properties of EFP cookies with different formulations. This research used a completely randomized design. Variations in the composition of wheat flour, foxtail millet flour, and snakehead fish flour were P0(100:0:0), P1(8:76:16), P2(8:66:26), and P3(8:56:36). All treatments were analyzed for organoleptic quality using hedonic tests and proximate analysis, water activity analysis using an aw meter, and physical quality analysis using tensile strength. The Zeleny method was applied to identify the most optimal treatment, revealing that P1 emerged as the best formulation. P1 has the color, aroma, and taste that the panelists like, while maintaining a neutral rating in texture. P1 contains 241.51 kcal/50 grams of energy, 10.97% protein, 41.16% fat, 47.86% carbohydrates, 1.93% ash content, 4.93% water content, 0.55 water activity, and 17.16 N breaking strength. These results are in accordance with EFP and SNI 2973:2011 standards. The recommended daily consumption is 18 pieces (each piece weighing 25 grams) if not accompanied by any other food, or only 4-5 pieces if consumed as a snack.

Keywords: Emergency Food Product, Foxtail Millet, Snakehead Fish, Cookies

INTRODUCTION

Indonesia faces a relatively high disaster risk. This condition can occur because Indonesia is located at the confluence of four major plates, the confluence of two oceans and two continents, and its positioning in a tropical zone (1). Beyond natural phenomena, non-natural events, including epidemics, technological failures, disease outbreaks, and social disasters such as conflicts and acts of terror, contribute to the complex disaster landscape in Indonesia (2). Additionally, human activities that inadequately manage nature can exacerbate the occurrence of natural disasters (3).

During a disaster phase or emergency response phase, various health problems, such as starvation and decreased nutritional status, can arise during evacuation. So, in the initial emergency response stage, a maximum of three days post-disaster, the primary goal of providing food is to prevent starving and maintain nutritional well-being (4). One alternative that can be done is providing Emergency Food Products (EFP).

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EFP serves as a high-energy and nutrient-dense food, designed for immediate consumption during emergencies. The recommended usage period for EFP ranges from 3 to 7 days, with a maximum extension of up to 15 days. The primary objective of providing EFP is to reduce morbidity and mortality among refugees. The five key characteristics of EFP are safety, palatability, ease of distribution, simplicity of use, and complete nutritional content. EFP is suitable for individuals ranging from babies older than 6 months to the elderly, with the exception of being unsuitable as a substitute for breast milk and not recommended for malnourished individuals requiring medical attention. Since EFP is expected to be the main energy source for a maximum of 15 days, EFP must be able to meet the energy and nutritional needs of natural disaster victims, by providing 2100 kcal/day, 10-15% protein, 35-45% fat and 40-50% carbohydrates. EFP can be divided into 9 parts in the form of bars, each weighing 50 grams, and produce 2 equal portions. Consequently, each portion contains 116 kcal, and the total weight in a day is 450 grams (50 grams/bar) to meet the needs of 2100 kcal.

One potential product that can be developed as EFP is cookies made from a combination of foxtail millet and snakehead fish. Cookies offer simplicity in preparation, prolonged shelf life, and a wide variety of flavors (6). To meet EFP nutritional standards, the cookies are enriched with foxtail millet and snakehead fish. Foxtail millet contributes abundant carbohydrates, protein, vitamin E, and fiber, while maintaining low-fat content (7). Snakehead fish, on the other hand, surpasses chicken, eggs, and beef in protein content (8). Furthermore, snakehead fish is a rich source of essential and non-essential amino acids, along with albumin, which can be used in wound healing (9).

To create high-quality cookies suitable for Emergency Food Products (EFP) and in adherence to the standards outlined in SNI 2973:2018, as detailed in Table 1, it is imperative to tailor their composition to meet the specified requirements. Based on this context, this research aims to determine the sensory, chemical, and physical properties of EFP cookies across various formulations.

METHODS

Research Design

This research is a true experimental study employing a completely randomized design with four distinct formulations for comparative analysis. The research began with the production of foxtail millet flour, followed by the creation of cookies using a composition ratio of wheat flour, foxtail millet flour, and snakehead fish flour in EFP cookies as P0 (100:0:0), P1 (8:76:16), P2 (8:66:26), and P3 (8:56:36). Determination of the formulation was based on EFP energy and nutrient content standards (5), proximate test results of foxtail millet flour and snakehead fish flour, modifications from research of biscuit proso millet and koya (10), and preliminary tests.

This research analyzed the organoleptic, chemical, and physical quality of EFP cookies. The organoleptic assessment involved hedonic tests where 25 semi-trained panelists evaluated the color, aroma, taste, and texture of the cookies. These tests were conducted following the Ethics Approval from the Health Research Ethics Committee, Faculty of Health Sciences, Universitas Brawijaya, with reference number 5047/UN10.F17.10/TU/2022. Chemical quality analyses encompassed total energy (empirical calculation (11)), protein (Kjeidal method (12)), fat (direct extraction method using a Soxhlet apparatus (12)), carbohydrates (by difference method (12)), water (thermogravimetric method (12)), ash (thermogravimetric method (12)), and water activity (measured using an aw meter with a retronic hygropalm device (13)). The physical quality was assessed through breaking strength utilizing the tensile strength method (14).

Data Collection/Materials and Tools

The equipment used in this study consisted of a food dehydrator, grinder, baking sheet, plastic gloves, digital scales, baking paper, drainer, 80-mesh sieves, basin, spoon, plate and measuring cup, digital scales, basin, mixer, electric oven, baking sheet, spatula, spoon, plastic gloves, cake mold, fork, non-stick baking paper, and plate.

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The raw material used included "Segitiga Biru" medium protein wheat flour obtained from the traditional market of Malang City, sosoh foxtail millet obtained from Waimangit Village, Air Buaya District, Buru Regency, and snakehead fish flour obtained from CV. Striata, Singosari District, Malang Regency.

Foxtail Millet Flour Production

The procedure of foxtail millet flour production was a modification from the research of foxtail millet variety using majene flour (15). The foxtail millet was washed until the water ran clear. The cleaned foxtail millet was then soaked for 4 hours and drained. Next, foxtail millet was dried using a food dehydrator for 2 hours at a temperature of 60°C. Once dried, the foxtail millet was finely ground using a grinder and subsequently sieved using an 80-mesh sieve. Foxtail millet flour was carefully packed in aluminum foil packaging and stored in a dry place.

Cookies Production

The procedure of cookie production was adapted from research on proso millet and koya biscuit (10). All ingredients were precisely weighed according to the formulation (Table 2). Egg yolks, powdered sugar, vanilla, salt, full cream milk powder, and margarine were mixed using a mixer. The flour was mixed into the mixture by sifting, with continued stirring until evenly distributed. The oven was heated to a constant temperature of 120°C. Each portion of 28 grams of dough was shaped into a square and decorated with a fork impression. The dough was baked for 45 minutes at 120°C. Following baking, the cookies were left to cool before being packed in a tightly closed container.

Data Analysis Technique

The instruments used for data analysis were Microsoft Word, Microsoft Excel, and SPSS 25. Organoleptic test data were analyzed using the Kruskall-Wallis statistical test, while chemical and physical data were subjected to the One-way ANOVA statistical test. Determining the best treatment level was carried out using the Multiple Attribute Zeleny method, based on organoleptic, chemical, and physical assessments of the cookies (16).

RESULTS

This research aims to determine the sensory, chemical, and physical properties of EFP cookies with different formulations. The research results are presented in Table 3.

Sensory Properties

The treatment cookies (P1, P2, and P3) had different organoleptic characteristics compared to the control cookies (P0). These cookies had a darker brown color, a distinctive fish aroma, a distinctive blend of foxtail millet and fish taste, and a slightly crunchy, slightly breakable, and rough texture. These differences contributed to a decrease in the overall liking level compared to the control cookies, as presented in Figure 1.

Detailed results of the organoleptic assessment are provided in Table 2. The highest preference for the color of the treatment cookies was observed in P1 (liked) and the lowest was in P3 (neutral). Regarding aroma, P1 received the highest liking rating (liked), while both P2 and P3 received a neutral assessment. In terms of taste, P1 obtained the highest liking rating (liked), whereas P3 received the lowest (disliked). All treatment cookies received a neutral assessment for texture parameters.

Statistical analysis using the Kruskal-Wallis test at a 95% confidence level revealed significant differences between treatments in the parameters of color ($p = 0.000$), taste ($p = 0.000$), and texture ($p = 0.001$). However, no significant difference was found for the aroma parameter ($p = 0.260$). Subsequent Mann-Whitney tests indicated a significant distinction between control cookies and treatment cookies in each parameter, except for the aroma of P0 and P1.

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Table 1. The criteria for cookies as EFP based on EFP requirements and SNI 2973:2018 standards

Criteria	EFP Requirements (5)	SNI 2973:2018 Standards (17)
Color	Depend on the ingredients and processing method	Normal
Aroma	Free from foreign odors	Normal
Flavor	Free from foreign flavors	Normal
Texture	Depend on the ingredients and processing method	-
Total Calories (kcal/50 gr)	233 - 250	-
Protein (%)	10 - 15	Min. 4,5
Fat (%)	35 - 45	-
Carbohydrate (%)	40 - 50	
Ash Content (%)	-	Max. 0,1
Water Content (%)	≤ 9,5	Max. 5
Water Activity	≤ 0,6	-
Breaking Strength (N)	-	-

Chemical Properties

All cookies met the EFP requirements, containing 233-250 kcal/50 grams of energy. Among the cookies, P1 had the highest energy content at 241.51 kcal/50 grams, while P0 was the lowest at 237.39 kcal/50 grams. The statistical analysis using the One-way ANOVA test at a 95% confidence level showed no significant difference in energy levels between treatments ($p = 0.213$).

In terms of protein content, EFP requires 10-15%. P1 met this requirement with 10.97% protein, and P2 surpassed it with 13.42% protein. The statistical analysis using the One-way ANOVA test at a 95% confidence level showed a significant difference in protein levels between treatments ($p = 0.001$). The results of further tests using the Bonferroni test showed significant differences in all treatments.

All cookies met EFP requirements, by containing 35-45% fat. P0 had the highest fat content at 42.24%, while P1 was the lowest at 41.16%. The statistical analysis using the One-way ANOVA test at a 95% confidence level showed no significant difference in fat content between treatments ($p = 0.292$).

The requirement for carbohydrate content in EFP is 40-50%. Cookies that met the requirements for carbohydrate content were P1 at 47.86%, P2 at 45.42% and P3 at 41.50%. The statistical analysis using the One-way ANOVA test at a 95% confidence level showed that there were significant differences in carbohydrate levels between treatments ($p = 0.001$). The subsequent Bonferroni tests showed significant differences between P0 and P1, P0 and P2, P0 and P3, P1 and P2, P1 and P3, and P2 and P3.

The highest ash content was in P3 at 2.15%, while the lowest was in P0 at 1.71%. The statistical analysis using the One-way ANOVA test at a 95% confidence level showed a significant difference in ash content between treatments ($p = 0.002$). The

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subsequent Bonferroni tests showed significant differences between P0 and P2, and P0 and P3.

All cookies met EFP requirements, by containing water content below or equal to 9.5%. P0 had the highest water content at 7.45%, while the lowest was P1 at 4.93%. The statistical analysis using the One-way ANOVA test at a 95% confidence level showed no significant difference in water content between treatments ($p = 0.079$).

The requirement for water activity in EFP is ≤0.6. Cookies that met these requirements were P1 at 0.55 and P2 at 0.59. The statistical analysis using the One-way ANOVA test at a 95% confidence level showed no significant difference in water activity between treatments ($p = 0.088$).

Table 2. Cookies Formulation

Ingredients	P0	P1	P2	P3
Wheat flour (%)	43,86	3,51	3,51	3,51
Foxtail millet flour (%)	0,00	33,33	28,95	24,56
Snakehead fish flour (%)	0,00	7,02	11,40	15,79
Margarine (%)	22,81	22,81	22,81	22,81
Egg yolk (%)	8,77	8,77	8,77	8,77
Full cream milk powdered (%)	5,26	5,26	5,26	5,26
Powdered sugar (%)	17,54	17,54	17,54	17,54
Salt (%)	0,88	0,88	0,88	0,88
Vanilla (%)	0,88	0,88	0,88	0,88
Total (%)	**100,00**	**100,00**	**100,00**	**100,00**

Notes

- P0 = 100% wheat flour, P1 = 8% wheat flour : 76% foxtail millet flour : 16% snakehead fish meal, P2 = 8% wheat flour : 66% foxtail millet flour : 26% snakehead fish meal, P3 = 8% wheat flour : 56% foxtail millet flour : 36% snakehead fish meal

Physical Properties

The physical property observed in this research is the breaking strength of cookies. The highest breaking power was P1 at 17.16, while the lowest was P0 at 12.53. The statistical analysis using the One-way ANOVA test at a 95% confidence level showed no significant difference in breaking strength between treatments ($p = 0.722$).

Determination of the Best Formula

To determine the best treatment, the Multiple Attribute Zeleny method was used. The calculation covered organoleptic (color, aroma, taste, and texture), chemical (energy, protein, fat, carbohydrate, ash, water, and water activity), and physical (breaking strength) assessments. The calculation results showed that the best treatment in this study was P1, followed by P2, P3, and lastly, P0, as presented in Table 4.

DISCUSSION

The results showed significant differences in almost all parameters when combining foxtail millet flour and snakehead fish flour into cookies, excluding total calories, fat content, water content, water activity, and breaking strength. The subsequent section provides a detailed explanation of each parameter.

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Table 3. Results of Organoleptic, Chemical and Physical Analysis of Cookies

Parameter	Research Result				p-value	Standard	
	P0	P1	P2	P3		EFP (5)	SNI 2973:2018 (17)
Sensory Properties							
Color	5,00 (3;5)[a]	4,00 (3;5)[b]	4,00 (2;5)[b]	3,00 (2;5)[c]	0,000 *	Depend on the ingredients and processing method	Normal
Aroma	4,00 (2;5)[a]	4,00 (2;5)[ab]	3,00 (1;5)[b]	3,00 (1;5)[b]	0,026 *	Free from foreign odors	Normal
Flavor	4,00 (2;5)[a]	4,00 (1;5)[b]	3,00 (1;5)[b]	2,00 (2;4)[c]	0,000 *	Free from foreign flavors	Normal
Texture	4,00 (3;5)[a]	3,00 (2;5)[b]	3,00 (2;5)[b]	3,00 (2;5)[b]	0,001 *	Depend on the ingredients and processing method	-
Chemical Properties							
Total Calories (kcal/50 gram)	237,39± 3,25[a]	241,51± 0,48 [a]	240,25± 0,86[a]	240,03± 2,77[a]	0,213 **	233 - 250	-
Protein (%)	6,27±0,11[a]	10,97±0,14[b]	13,42±0,15[c]	16,28±0,21[d]	0,001 **	10 – 15	Min. 4,5
Fat (%)	42,24±0,52[a]	41,16±1,17[a]	41,17±0,97[a]	42,23±0,73[a]	0,292 **	35 – 45	-
Carbohydrate (%)	51,48±0,49[a]	47,86±1,05[b]	45,42±1,03[c]	41,50±0,58[d]	0,001 **	40 - 50	-
Ash (%)	1,71±0,05[a]	1,93±0,09[ab]	1,96±0,08[b]	2,15±0,11[b]	0,002 **	-	Max. 0,1
Water Content (%)	7,45±1,54[a]	4,93±0,68[a]	5,38±0,94[a]	5,99±0,80[a]	0,079 **	≤ 9,5	Max. 5
Water Activity	0,71±0,06[a]	0,55±0,05[a]	0,59±0,08[a]	0,64±0,05[a]	0,088 **	≤ 0,6	-
Physical Properties							
Breaking Strenght (N)	12,53±2,41[a]	17,16±6,45[a]	14,73±7,25[a]	16,46±3,58[a]	0,722 **	-	-

Notes
- 1 = very don't like, 2 = don't like, 3 = neutral, 4 = like, 5 = very like.
- P0 = 100% wheat flour, P1 = 8% wheat flour : 76% foxtail millet flour : 16% snakehead fish meal, P2 = 8% wheat flour : 66% foxtail millet flour : 26% snakehead fish meal, P3 = 8% wheat flour : 56% foxtail millet flour : 36% snakehead fish meal
- *Kruskal wallis test, ** One way anova test
- Different letter notations for each parameter indicate significantly different results between treatments ($p<0.05$)

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Sensory Properties

Color Sensory Evaluation Test of EFP: The control cookies showed a brownish-yellow color, different from the treatment cookies, which displayed a brown color due to the addition of foxtail millet flour and snakehead fish flour. The foxtail millet used in this research has a yellowish-brown color, attributed to beta-carotene pigments and flavonoid components, such as glycosylvitesin, glycosyloritin, alkali labile, and ferulic acid (18). The resultant foxtail millet flour has a light brown appearance. The process of soaking barley that was carried out before flouring produces a color that was closer to white compared to flouring without soaking. This is due to the degradation of compounds during the soaking process (15). Meanwhile, the snakehead fish flour used in this research had a light-yellow color. The color of cookies was also influenced by baking in the oven due to high temperatures and the Maillard reaction when protein and sugar meet, resulting in a characteristic brownish color (19).

Based on the median value, the liking level for colors for P1 and P2 is classified as liked, while P3 is classified as neutral. This shows that increasing the composition of snakehead fish flour reduces the level of preference for the color of cookies as it darkens. Similar results from other research showed that increasing the composition of foxtail millet and mackerel causes a darker color of the cookies, thereby reducing the favorability (19). This darker brown color is attributed to the high lysine content in snakehead fish. Lysine, with its two amine groups, has higher reactivity to reducing sugars (20).

Aroma Sensory Evaluation Test of EFP: The results showed that P1, which had the highest millet flour composition, had a liking level for aroma that was not significantly different from control cookies. The median value was classified as liked. This contrasts with other studies where an increase in foxtail millet flour composition led to a decrease in aroma preference in purple sweet potato foxtail millet macaroni (21) and foxtail millet bread (18). The off-odor in foxtail millet is attributed to goitrogen components, generally in the form of flavonoid compounds. However, steaming for 10 and 15 minutes is believed to damage the enzymes in these goitrogens, improving the aroma of the macaroni (21). This is related to the nature of flavonoid compounds which are not heat resistant and are easily oxidized at high temperatures (22). The process of soaking foxtail millet for 4 hours before flouring also contributed to producing a mild aroma of foxtail millet flour (15). Also, adding vanilla to cookies could remove unwanted odors (23). Considering these factors, the reduction in the typical foxtail millet aroma in P1 may be attributed to the pre-flouring soaking process, the inclusion of vanilla, and the degradation of flavonoid compounds during the roasting process.

In contrast to the P1 aroma, which was liked by the panelists, the median value of the liking level for aromas for P2 and P3 was classified as neutral. This suggests that increasing the composition of snakehead fish flour reduced the panelists' preference as the fishy aroma intensified. Other research also showed a decrease in liking for cookies with an increasingly fishy aroma (19). The typical fishy aroma of fish comes from nitrogen components, specifically guanidine, trimethylamine oxide, and imidazole derivatives (24). In addition, the Maillard reaction produces volatile compounds with the potential to form aromas (25). The higher protein content of the material results in a stronger aroma from the Maillard reaction (26).

Taste Sensory Evaluation Test of EFP: The research results show that, although significantly different from the control cookies, the panelists expressed a liking for the taste of P1. P1, with the highest foxtail millet flour composition compared to P2 and P3, suggesting that the distinctive taste of foxtail millet was well-received by the panelists. However, other studies suggested a decline in the acceptability of bread with added foxtail millet flour (18). Macaroni with a high foxtail millet content is reported to have a slightly bitter taste. This is thought to be due to the presence of tannins in foxtail millet (21). The variation in results in this study might be attributed to the process of soaking foxtail millet carried out before sieving. Some of the tannin content dissolved due to the soaking process (15), so that the typical foxtail

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millet taste could still be accepted by the panelists.

In contrast to the taste of P1, which the panelists liked, the median value of the liking level for the taste of P2 was classified as neutral, and P3 was classified as dislike. This means that increasing the composition of snakehead fish flour reduces the panelists' preference due to a stronger fish taste. Similar findings in other research indicate that the preference level decreases with increased mackerel substitution, resulting in a more pronounced fish taste in the cookies (19).

Texture Sensory Evaluation Test of EFP: There are no special requirements regarding the texture of cookies (17), but in general cookies are expected to have a crunchy texture without being overly hard (27). While EFP is expected to have a texture that depends on the ingredients and processing methods used and is strong enough for delivery via various transportation methods as well as for short periods of extreme temperatures (5). Therefore, the desired texture for the treatment cookies is firm yet not excessively hard, maintaining a satisfying crunch that appeals to consumers.

The preference level for the texture of treatment cookies was significantly different from that of the control cookies. The median value of the control cookies was classified as liked, in contrast to the treatment cookies which were classified as neutral. This decrease in the preference level was due to the texture of the treatment cookies not being as crispy as the control cookies and having a slightly harder and rougher texture. Products with a high hardness level, which do not break easily, are generally less favored by panelists due to the impression of being difficult to bite (28).

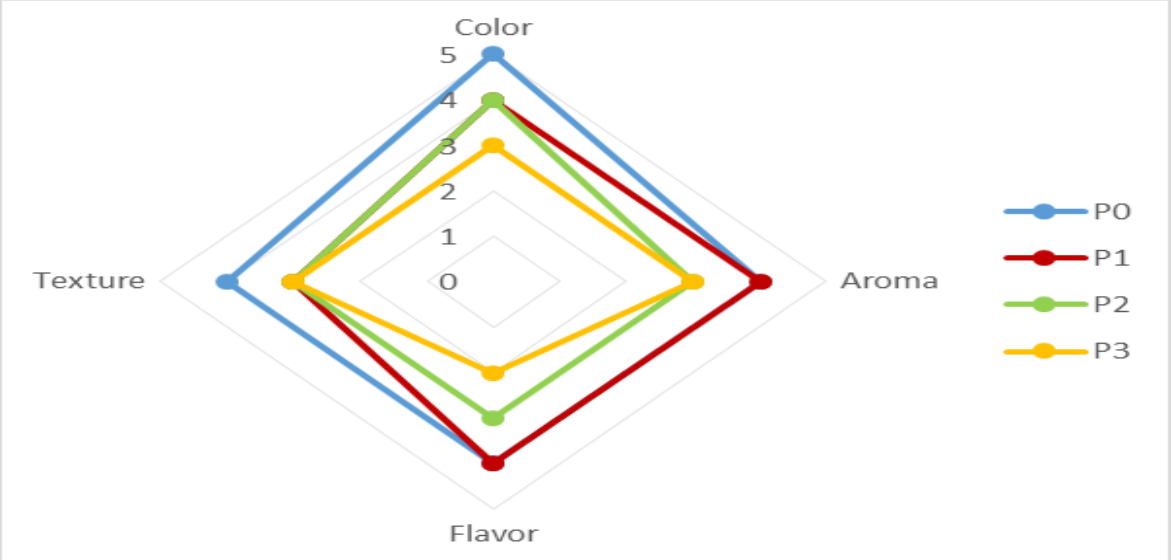

Figure 1. Organoleptic Analysis Results

Notes

- 1 = very don't like, 2 = don't like, 3 = neutral, 4 = like, 5 = very like.

P0 = 100% wheat flour, P1 = 8% wheat flour : 76% foxtail millet flour : 16% snakehead fish meal, P2 = 8% wheat flour : 66% foxtail millet flour : 26% snakehead fish meal, P3 = 8% wheat flour : 56% foxtail millet flour : 36% snakehead fish meal

Chemical Properties

Energy Content of EFP: The research results indicated no difference in energy in the treatment groups. This is attributed to the similar energy content in the raw materials for the treatment cookies, namely 395.74 kcal/100 grams of foxtail millet flour and 390.93 kcal/100 grams of snakehead fish flour. Although not significantly different, the

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energy value in all treatments aligns with the EFP standard, ranging from 233 to 250 kcal.

Protein Content of EFP: Protein plays a crucial role in meeting the physiological needs of refugees, particularly in supporting the growth of children and pregnant women in refugee camps. However, it is advisable to keep protein below 15% of total energy intake to prevent kidney-related issues and increased thirst (5). The research results showed that a higher level of snakehead fish flour results in increased protein content of the cookies. This is because snakehead fish flour has a high protein content of 83.83%, while foxtail millet flour only contains 13.82% protein. Similar research also showed these findings that higher koya flour (snakehead fish and tempeh) resulted greater amount of protein compared to those with high proso millet flour (10).

Fat Content of EFP: The high-fat content in EFP serves various purposes, including increasing the absorption of fat-soluble vitamins, meeting energy needs, imparting a delightful taste, ensuring lightness in cookies, and providing essential fats (5). The fat content in each treatment cookie did not exhibit significant differences, as the fat content in the raw materials for treatment cookies was consistent, with 3.74% fat in foxtail millet flour and 3.77% fat in snakehead fish flour.

Carbohydrate Content of EFP: The research results indicated that higher levels of foxtail millet flour led to increased carbohydrate content in the cookies. This is attributed to foxtail millet flour having a high carbohydrate content of 76.7%, whereas snakehead fish flour contains only 5.42% carbohydrates. Another study reported that foxtail millet flour contained 76.49% carbohydrates, generating a significant carbohydrate source (21).

Ash Content of EFP: EFP is not recommended to receive additional minerals that might alter the taste to be unpleasant or necessitate the inclusion of potentially hazardous flavorings for certain populations (5). To meet emergency food micronutrient needs, one recommended strategy involves supplementing emergency food rations with mineral-rich food ingredients, such as dried fish. This approach is advantageous in that it can reach a large recipient population, and the intervention can be implemented quickly. However, food choices must be familiar to the population and contain the required micronutrients (29). The study results showed increased ash content with the addition of snakehead fish flour, attributed to its ash content of 2.92%, while foxtail millet flour only contains 1.21% ash. In line with other research, the addition of snakehead fish flour increased the ash content in dried snakehead fish noodles (30).

Water Content of EFP: The results showed that in the treatment cookies, the highest water content was in P3, and the lowest was in P1. This shows that the water content increases with increasing levels of snakehead fish flour. This is attributed to the hygroscopic properties of P3, where snakehead fish flour with a water content ≤ 6% exhibits hygroscopicity (31). The hygroscopic properties of the materials maximize water molecule binding, resulting in higher water content (32). Other research also showed similar results that increased snakehead fish flour correlates with higher water content of snakehead fish biscuits (33).

Water Activity of EFP: The water activity of treatment cookies was measured at 0.55 (P1), 0.59 (P2), and 0.64 (P3). This shows that water activity increased with the addition of snakehead fish flour, reflecting the hygroscopic nature of snakehead fish flour. Hygroscopicity, the ability of a substance to absorb water molecules from the environment (32), establishes a proportional relationship between water activity and water content; as the water content value increases, the water activity value will also increase (34). Water activity influences the determination of the shelf life of food products by involving other factors in the form of packaging characteristics and the environment during storage (35). Foxtail millet and snakehead fish cookies that met the EFP requirements were P1 and P2, with a water activity value of ≤0.6, suggesting that these cookies will have a relatively long shelf life.

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Table 4. Best Treatment Calculation Results

	P0	P1	P2	P3
L1	0,988	0,992	0,990	0,988
L2	0,005	0,001	0,002	0,003
L maks.	0,696	0,454	0,616	0,697
Result	1,689	1,448	1,607	1,688
Rank	**4**	**1**	**2**	**3**

Notes
- P0 = 100% wheat flour, P1 = 8% wheat flour : 76% foxtail millet flour : 16% snakehead fish meal, P2 = 8% wheat flour : 66% foxtail millet flour : 26% snakehead fish meal, P3 = 8% wheat flour : 56% foxtail millet flour : 36% snakehead fish meal

Physical Properties

Breaking Strength Value of EFP: The ease of consuming food products can be influenced by the breaking strength of the product. If the breaking strength value is within the range of 3x102 - 2x104 N, it can potentially pose difficulties during consumption (36). Based on testing, the breaking strength value of all cookies suggests they can be consumed without causing difficulty chewing or swallowing, as the cookies produced have optimal breaking strength values.

The research results also showed that the breaking strength of the treatment cookies was highest in P1, followed by P3 and P2. Fluctuations in breaking strength assessment results were caused by the fiber and protein content in the cookies. Fiber and protein can influence texture formation as these compounds bind water to each other (37). Fiber can absorb water in starch granules, resulting in an imperfect gelatinization process and a hard texture (38). Proteins with hydrophilic molecular groups and ionic charges (39) form complex bonds with starch, resulting in a decrease in viscosity and low gel strength and causing higher fracture strength (40). P1 has the highest fiber content, while P3 has the highest protein content. Despite variation in the fiber and protein content in each treatment, high levels of these two nutrients can result in an increase in breaking strength values.

Best Formulation

The research results showed that P1 is the best treatment cookies, presenting organoleptic, chemical, and physical qualities that meet EFP and SNI 2973:2018 standards. P1 has a favorable color, aroma, and taste, and has a neutral value in texture. So, the organoleptic quality of P1 is acceptable. In terms of composition, P1 contains 241.51 kcal/50 grams of energy, 10.97% protein, 41.16% fat, 47.86% carbohydrates, 1.93% ash content, 4.93% water content, and 0.55 water activity, so P1 has fulfilled the energy and macronutrient content in disaster conditions. The water content and water activity of P1 cookies are in accordance with standards, suggesting a long shelf life. With a breaking strength of 17.16 N, P1 can be consumed without causing difficulties in chewing or swallowing, as it exhibits an optimal breaking strength value. EFP can be consumed directly or crushed and combined with water to create weaning food (5).

The recommended daily intake of P1 is 18 pieces (25 grams each) to meet the need for 2100 kcal. Meanwhile, estimates of EFP needs, based on recommended dietary allowances for Indonesians (41), are presented in Table 5.

Proper packaging is essential for EFP, considering its utilization in environments with varying temperature and humidity conditions, including extreme environments lacking delivery infrastructure. Therefore, all packaging components must withstand diverse temperatures and physical challenges. The recommended packaging for EFP involves a trilaminated structure comprising aluminum foil, polyethylene terephthalate (polyester), and polyamide (nylon). Polyester and nylon provide extra protection against pressure, punctures, and tears during transportation or distribution. Internally, bags made of trilamination maintain oxygen levels below 2% during storage for up to 3 years at 23°C. The main packaging is advised to be made of pulp-based material with a barrier

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layer (5). Additionally, vacuum packaging, oxygen absorbers, and dark packaging can minimize fat and oil contact with light (37). The packaging should also feature a clear food label with the production date, nutritional value, composition, and expiration date. If possible, include food preparation instructions in an easily understandable language. In Indonesia, it is mandatory to provide halal information (42). Notches in the package seal should be incorporated to facilitate opening by EFP recipients, who may not have access to scissors or other tools (5).

Table 5. Estimated Number of EFP Pieces (25 grams) per Day Based on Age Group

Age	Estimated Number of EFP Pieces (25 grams) per Day	
	Male	Female
7 - 11 month	7	
1 - 3 year	12	
4 - 6 year	12	
7 - 9 year	14	
10 - 12 year	17	16
13 - 15 year	20	17
16 - 18 year	22	18
19 - 29 year	22	19
30 - 49 year	21	18
50 - 64 year	18	15
65 - 80 year	15	13
>80 year	14	12
1st trimester of pregnancy	-	+2
2nd trimester of pregnancy	-	+3
3rd trimester of pregnancy	-	+3
Breastfeeding for the first 6 months	-	+3
Breastfeeding for the second 6 months	-	+4

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CONCLUSION

Foxtail millet and snakehead fish cookie with the best treatment is P1. P1 has organoleptic, chemical, and physical qualities that comply with the EFP and SNI 2973:2018 standards, so it can be used as an alternative to EFP. The recommended daily consumption is 18 pieces, each weighing 25 grams, if consumed as a standalone meal, or 4-5 pieces if enjoyed as a snack. Further research needs to be done regarding packaging, total microbes, shelf life, micronutrient content, and fiber content.

Author contributions:

Idea of research: ALW, RDA, MA; Study design: RMW, HIN; Data analysis: ALW, RDA, MA; Manuscript writing and revisions for important content: ALW, RDA, MA, RMW, HIN.

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We have no conflicts of interest to disclose.

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Data are available for access via metadata.

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Original Research

Qualities of Diabetic Food Developed from Brown Rice and Oyster Mushroom

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ABSTRACT

The prevalence of diabetes mellitus has been increasing. This study aimed to develop Food for Special Dietary Use (FSDU) for individuals with diabetes. Different combinations of food ingredients were added to the basic formula, consisting of brown rice and mushroom flour in a ratio of 70% and 11%. The combinations used in the formulation were F1 = 9% moringa and fish flour, F2 = 10% carrot and fish flour, F3 = 11% moringa and tempeh flour, and F4 = 12% tempeh flour. The results showed that the FSDU contained energy, fat, and fiber ranging from 391.33–404.33 Kcal, 5.53–7.75 g, and 4.22–7.60 g per 100 g product, respectively. These values were slightly higher than the respective value of a commercial product. The panelists expressed positive acceptance of the developed FSDU products, with F2 chosen as the most preferred. The developed FSDU exhibited lower scores for feeling of hunger, desire to eat, and prospective food consumption compared to the commercial product. The product provided a feeling of fullness similar to the commercial counterpart. In conclusion, the FSDU based on brown rice and oyster mushroom with an additional 10% carrot fish flour would be the most preferred option for further use as FSDU for diabetics.

Keywords: Diabetes Mellitus, Brown Rice, Mushroom, Food for Special Dietary Use

INTRODUCTION

Diabetes mellitus (DM) is a chronic disease characterized by inadequate insulin production from the pancreas and insulin resistance, which causes an increase in blood glucose levels (1). The prevalence of diabetes mellitus continues to increase every year, and the International Diabetes Federation (IDF) predicts an increase in the number of people with DM in Indonesia to reach 14.1 million by 2035 (2). According to the Perkeni Consensus, DM management should include a comprehensive approach encompassing education, physical activity, pharmacology, and nutritional therapy with the 3J principle, namely the right amount of meal, the right type of meal, and the right mealtime (3)(4). The dietary aspect of DM management also involves making the right selection of food to consume. Proper food selection will have a positive influence on health in addition to personal preference based on sensory attributes mainly related to taste (5). This fundamental principle should guide the development of any food products with a particular consumer target.

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For DM management, brown rice is preferred as it offers a good taste and a less complex texture compared to other cereals, such as black rice. Choosing brown rice has been shown to aid diabetics in weight management, helping them achieve normal body mass index (BMI), body fat percentage, blood glucose levels, and HbA1C (6). Brown rice also contributes to obesity prevention due to its high beta-glucan content (7). Another promising food for DM management is the oyster mushroom. Widely enjoyed and rich in nutritional value, oyster mushrooms are notable for their high beta-glucan content, which contributes to a lower glycemic index (8). Within the gastrointestinal tract, beta-glucan is well fermented, resulting in high fatty acid production. This process could aid in reducing cholesterol elevation and lowering blood glucose levels.

Brown rice and oyster mushroom have the potential to be incorporated into the development of Food for Special Dietary Uses (FSDU) for individuals with diabetes. Problems related to food availability for diabetics currently include limited availability of food products to choose from, which leads to low dietary compliance and uncontrolled glucose levels. Additionally, there is a need to develop liquid food products for diabetics with difficulty swallowing, particularly for the elderly or hospitalized patients (9). Therefore, the purpose of this study was to develop FSDU for diabetics based on brown rice and oyster mushrooms enriched with local food ingredients.

METHOD

Research Design

The development of FSDU for diabetics was carried out using a complete randomized design. The basic food ingredients in the formulation were a combination of brown rice and mushroom flour with a ratio of 70% and 11%, respectively. Various levels of additional ingredients were then used as treatment factors with the following levels: F1 with 9% moringa and fish flour (MFF), F2 with 10% carrot and fish flour (CFF), F3 with 11% moringa and tempeh flour (MTF), and F4 with 12 % tempeh flour (TF). Each treatment was replicated three times to obtain 12 experimental units. The percentage of food ingredients in the FSDU formulation is presented in Table 1. The quality of the formulas was evaluated using the hedonic method, and the most preferred formula was determined using the Zeleny Multiple Attribute (ZMA) approach. The subjective satiety visual analog scale (VAS) test was employed to assess the satiety effect of the formulas.

Data Collection

The data collected in the study included hedonic and subjective satiety data of the developed foods. The parameters used in the hedonic assessment were color, aroma, taste, and texture, each rated on a six-level preference scale ranging from “dislike extremely” to “like extremely.” The test was carried out using 25 semi-trained panelists. The developed FSDU products were provided to the panelists after dissolving and mixing 4 grams of food samples into 30 ml of warm water. Subsequently, the most preferred formula was compared to commercial FSDU (F0) available in the local market. The organoleptic test was conducted from May to September 2022 at the Food Laboratory of the Department of Nutrition, Faculty of Health Sciences, Universitas Brawijaya, Indonesia.

The subjective satiety data were collected through the Visual Analogue Scale (VAS) method on fasting and at 30, 60, 90, and 120 minutes after consuming the most preferred FSDU formula and the commercial products. The VAS questionnaire was used to express the level of hunger, fullness, desire to eat, and prospective food consumption. The subjects were asked to draw a short vertical line across a 100 mm line provided at a point representing their degree of satiety. Each line was provided with words anchored at each end, describing the satiety extremes. The questions used during the test were Q1 = ‘How hungry do you feel?’, Q2 = ‘How full do you feel?’, Q3 = ‘How strong is your desire to eat?’, and Q4 = ‘How much do you think you can eat?’. VAS scores were then obtained by measuring the distance from the leftmost point to the line mark drawn by the participants (10). The test involved 18 voluntary adult participants who met the following criteria: aged between 18-22 years old, had a normal BMI of 18.5-23 kg/m^2, were in good health and able to

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communicate well, had no allergies to the test foods (oyster mushrooms, cork fish, carrots, soybean oil, coconut oil, and milk), were non-smoker and not on a particular diet, and were not menstruating for females. The satiety test was conducted from May to September 2022 at the same laboratory for the hedonic test.

Data Analysis

The effect of the treatment on the sensory qualities of the final products was analyzed using the Kruskal-Wallis non-parametric test. The Mann-Whitney multiple comparison test was conducted when any significant difference was found. The best formula was determined from the treatment that had the smallest L1, L2, and L∞ values following the Zeleny Multiple Attribute (ZMA) approach. All statistical tests were performed using SPSS version 20 at a 95% level of confidence.

RESULTS

The developed FSDU formulas contained an energy content between 391.33 to 404.33 Kcal per 100 g, which was slightly higher than that of the commercial product (377 Kcal) of equal weight. Similarly, the fiber content of the FSDU for all formulas exceeded that of the commercial product. The nutrient contents of the developed FSDU in more detail are presented in Table 2.

Sensory Qualities

As for sensory qualities, as can be seen from Table 3, the developed FSDU generally exhibited slightly lower sensory qualities as compared to the commercial product. A higher value in the table indicates better panelist acceptance, while a lower value suggests the opposite. The FSDU development resulted in the end products differing in color, most probably influenced by the color of the ingredients used. The color difference among formulas was statistically significant ($p < 0.05$). The FSDU products with moringa and fish flour had a greenish-white color.

The Kruskal-Wallis test results showed a significant difference ($p < 0.05$) in aroma among the treatment groups. Therefore, the post-hoc test was conducted using the Mann-Whitney, and the results showed no difference ($p > 0.05$) between F1 and F2, F1 and F3, F1 and F4, F2 and F3, F2 and F4, and F3 and F4 in the level of aroma preference for the FSDU product development based on brown rice and oyster mushroom. However, significant differences ($p < 0.05$) were observed between F0 and F1, F0 and F2, F0 and F3, and F0 and F4. The Kruskal-Wallis test for the flavor showed a significant difference ($p < 0.05$) among the treatment groups. The subsequent test showed no difference ($p > 0.05$) between F1 and F2, F1 and F3, F1 and F4, F2 and F3, F2 and F4, and F3 and F4 in the level of taste preference for the FSDU product development based on brown rice and oyster mushroom. Meanwhile, the statistical differences ($p < 0.05$) were detected between F0 and F1, F0 and F2, F0 and F3, and F0 and F4. The Kruskal-Wallis test for texture showed a significant difference ($p < 0.05$) among the treatment groups. The Mann-Whitney test then showed that the level of texture did not statistically differ ($p > 0.05$) between F1 and F2, F1 and F4, F2, and F4, as well as F3 and F4. In contrast, there were differences ($p < 0.05$) between F0 and F1, F0 and F2, F0 and F3, F0 and F4, F1 and F3, and F2 and F3.

Most Preferred FSDU Formula

All formulations in the FSDU product development, namely F1, F2, F3, and F4 exhibited noticeable differences from the commercial products (F0). The most preferred formula is shown by the highest rank on the Zeleny value, as presented in Table 4. Among the FSDU products, the formulation containing an additional 10% carrot fishmeal (F2) was perceived as the best product by the consumer with a total value of 0.0426. The characteristics of F2 are a white-brown appearance, a subtle fishy aroma, a lack of sweetness, and a sandy texture with minimal sediment.

Satiety Effect Test

The Visual Analogue Scale (VAS) test is a subjective assessment method that measures hunger, fullness, desire to eat, and prospective food consumption at each measurement time. F2, the best formula of the developed FSDU, resulted in a greater feeling of fullness than the commercial product. This outcome could be attributed to the higher fiber and energy contents observed in F2 (Table 2).

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Table 1. The Formula of FSDU for Diabetics

Ingredients (%)	F1	F2	F3	F4
Brown rice	70	70	70	70
Oyster mushroom flour	11	11	11	11
Moringa and fish mixed flour	9	-	-	-
Carrot and fish mixed flour	-	10	-	-
Moringa and tempeh mixed flour	-	-	11	-
Tempeh flour	-	-	-	12
Other additional ingredients	9	9	7	7

Note: F1 = FSDU of moringa and fish flour (MFF), F2 = FSDU of carrot and fish flour (CFF), F3 = FSDU of moringa and tempeh flour (MTF), F4 = FSDU of tempeh flour (TF)

DISCUSSION

Color

Color plays a crucial role as a sensory attribute that the human eye perceives when evaluating the quality of a food product. An appealing color not only enhances the visual appeal of the product but also attracts the attention of panelists, encouraging them to sample the product (5). The green color observed in some FSDU products is most probably caused by the chlorophyll content of moringa leaves (11). FSDU products with mixed carrot and fishmeal had a brownish-white color, likely influenced by the presence of β-carotene in carrots. The intensity of the orange-brown color in these products increased with higher levels of β-carotene usage (12). FSDU products with additional moringa flour and tempeh flour had a slightly yellowish-white color, primarily influenced by the natural color of tempeh. During the flouring process, the amino acid lysine in tempeh undergoes a Maillard reaction, contributing to the overall coloration (13).

Aroma

The aroma of the FSDU product is significantly impacted by the chemical composition of the added ingredients. Compounds with distinct smells are termed aromatic compounds. These compounds release recognizable scents when two conditions are fulfilled: the compound must be volatile, allowing it to easily reach the olfactory system at the top of the nose, and the compound must be present in sufficient concentration to interact with one or more olfactory receptors. (14). The FSDU product development with added moringa fishmeal 9% (F1) and carrot fishmeal 10% (F2) had a slightly fishy aroma. This aroma can result from reactions involving free amino acids in fish meat or various oxidation processes of free fatty acids within the fish meat content (15). A previous study by Nadimin (2019) on cookie products with the substitution of rice bran flour and mackerel stated that adding fish flour produced a fishy aroma in the product (16). On the other hand, the FSDU product developed with brown rice and oyster mushrooms added with 11% moringa tempeh flour (F3) had a more subtle and delicate aroma. This characteristic aroma is attributed to secondary metabolites, such as saponins, found in moringa leaves. The languorous aroma, accompanied by a bitter taste from the saponins, can influence consumer acceptance of the product (17). The least preferred FSDU product development based on brown rice and oyster mushrooms was the product with the addition of 12% tempeh flour (F4).

Taste

Taste is the sensory response to food's neural stimuli or sensations when placed in the mouth, involving attributes like pleasant, delicious, and savory. Further sensations are produced by the sense of taste, also known as the tongue (18). Overall, the four formulations of FSDU product development based on brown rice and oyster mushroom with added 9% moringa fishmeal (F1), 10% carrot fishmeal (F2), 11% moringa tempeh flour (F3), and 12% tempeh flour (F4) had a non-sweet taste, in contrast to the sweet taste of commercial FSDU products (F0). These can be attributed to variations in sugar levels in

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each treatment. In previous research, the percentage of sugar for F1, F2, F3, and F4 were 14.22%, 13.69%, 13.75%, and 10.88%, respectively. These values were much lower than the sugar level for commercial products, 22.07%. The FSDU product based on brown rice and oyster mushrooms with the second most preferred position was the FSDU product with the addition of 10% carrot fish flour (F2), which was not sweet but slightly fishy. Cork fish has a less sharp flavor when compared to anchovies or tuna (19). On the other hand, FSDU product development based on brown rice and oyster mushroom with the addition of moringa flour in the formula of 11% moringa tempeh (F3) and 9% moringa fish (F1) produced a non-sweet taste but slightly bitter. The result was in accordance with previous research on adding moringa flour to modified cassava flour biscuits, which states that higher moringa flour content intensifies the moringa flavor and may be less preferred by consumers (20). FSDU product development based on brown rice and oyster mushroom with 12% additional tempeh flour (F4) had a non-sweet but savory taste, derived from the high protein and fat content in tempeh flour.

Table 2. The Nutrient Contents of FSDU for Diabetics (per 100g)

Nutrients	F1 	F2 	F3 	F4 
Energy (Kcal)	395.28 ± 0.15	391.33 ± 0.58	397.08 ± 0.18	404.33 ± 0.58
Protein (g)	13.76 ± 0.12	14.53 ± 0.02	13.51 ± 0.09	13.83 ± 0.10
Fat (g)	6.16 ± 0.11	5.53 ± 0.16	6.16 ± 0.04	7.75 ± 0.04
Carbohydrate (g)	71.20 ± 0.35	70.93 ± 0.17	71.90 ± 0.17	69.77 ± 0.15
Fibre (g)	7.60 ± 0.08	4.22 ± 0.03	6.99 ± 0.07	4.27 ± 0.04

Note: F1 = FSDU of moringa and fish flour (MFF), F2 = FSDU of carrot and fish flour (CFF), F3 = FSDU of moringa and tempeh flour (MTF), F4 = FSDU of tempeh flour (TF). The contents of energy, protein, fat, carbohydrate, and fibre of F0 are 377.00 ± 0.23 Kcal, 13.86 ± 0.05 g, 0.43 ± 0.03 g, 79.45 ± 0.04 g, and 4.11 ± 0.03 g respectively.

Texture

Texture is one of the properties of materials that can be experienced through skin touch or tasting by biting, chewing, and swallowing. The important parameters for textures include finger-sensation and tongue-sensation (21). Overall, from all formulas, the texture of FSDU product based on brown rice and oyster mushrooms was liquid and not thick. It aligns with the notion that an optimal formula texture should not be overly thick (22). However, variations in the smoothness of the liquid texture were evident. FSDU commercial products (F0) exhibited a tendency toward a smooth liquid consistency without sediment settling, while all FSDU product formulations had a sandy texture with minimal sediment. The presence of sediment may be indicative of the low solubility of the FSDU product development, making the flour challenging to dissolve in water.

The sandy texture and sediment might be caused by the fiber content in the product (23). Based on previous research, the FSDU commercial product (F0) contains a total dietary fiber of 4.11%. This value was the smallest compared to the total dietary fiber of products F1, F2, F3, and F4, which were 7.60%, 4.22%, 6.99%, and 4.26%, respectively. In addition, the particle size of the flour could contribute to the sandy texture. To reduce the sediment, thorough homogenization before serving and prompt consumption are recommended, as extended waiting times between production and consumption may result in increased sedimentation. Although, based on the

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assessment, the panelists liked the texture of the FSDU product development based on brown rice and oyster mushrooms, further improvement is needed to produce a smoother, less gritty texture. Rahadiyanti et al. (2022) who examined enteral formulas based on tempeh flour and jicama flour emphasized the need for improvements in texture based on panelist preferences (24).

Most Preferred FSDU Formula

One of the distinct characteristics of the most preferred FSDU formula is the product with a non-sweet taste. Although sweetness is typically a fundamental taste that appeals to most individuals, it is acceptable that individuals with diabetes have become accustomed to a less sweet or plain taste profile, meeting the dietary recommendations to reduce sugar intake. The general dietary recommendation for diabetics, among others, is to reduce sugar which could slowly develop a habit of consuming less-sweet foods. Another F2 characteristic is the presence of light sediment in the FSDU. This is likely attributed to the carbohydrate composition of brown rice. However, this poses no issue for the FSDU, as it aligns with the specific requirements associated with the use of brown rice as an ingredient.

Table 4. The Zeleny Value of the Developed FSDU

Formula	F1	F2	F3	F4
L1	0.1113	0.0254	0.1439	0.0749
L2	0.0063	0.0004	0.0069	0.0024
L∞	0.0636	0.0169	0.0590	0.0424
Total	0.1812	0.0426	0.2098	0.1196
Rank	3	1	4	2

Note: F1 = FSDU of moringa and fish flour (MFF), F2 = FSDU of carrot and fish flour (CFF), F3 = FSDU of moringa and tempeh flour (MTF), F4 = FSDU of tempeh flour (TF)

Satiety Effect Test

Resistant starch and water-soluble fiber play a role in maintaining fullness with their ability to bind water and other organic compounds. Fiber, known for inhibiting gastric emptying time and slowing food absorption in the intestine, contributes to prolonged feelings of fullness (8). Previous research on satiety effects has indicated that resistant starch, present in foods that are challenging to digest in the intestine, enhances satiety by increasing chyme viscosity and triggering the release of hormones such as CCK and GLP-1. These hormones are associated with delayed gastric emptying, increased satiety, and reduced food intake. GLP-1 hormone levels are proportional to calorie intake, with higher caloric intake leading to increased GLP-1 hormone release (25).

Protein has the potential to provide a higher satiety effect than carbohydrates and fats by increasing fullness in the stomach, thereby suppressing the desire to consume excess food (26). Protein promotes the release of the hormone CCK in the gut, which acts as an appetite suppressant by delaying gastric emptying and influence biomarkers associated with satiety (appetite initiation and cessation). Higher concentrations of CCK are associated with lower levels of subjective hunger. Conversely, fat intake exerts a satiety effect that occurs rapidly but lacks longevity (27). Excessive fat consumption could affect triglyceride accumulation, inflammation in the hypothalamus, and reduced orexigenic signaling, which results in insulin resistance and weight gain (28).

Figure 1, illustrating the fullness response, shows no significant increase in FSDU commercial products at the 60th minute. FSDU commercial products had a low glycemic index content. A correlation exists between satiety level and glycemic index content, where a low glycemic index provides a higher satiety effect due to slower and prolonged glucose disposal (29). Indicators of desire to eat and prospective food consumption correlate with hunger and fullness. However, individuals might still consume food even

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when feeling full, and conversely, they might refrain from consuming food when they are hungry. Hunger and fullness fluctuate within an hour, influenced by the release of hormones regulating satiety, which is tied to the macronutrient content of food.

The measurement of satiety level using the VAS method is subjectively related to several internal and external factors, including food sensory characteristics, geographical conditions, physical activity, sleep duration, physiological and psychological conditions of respondents, and social situations experienced by respondents. However, this study was conducted without any control of several factors, including the respondents' physical activity, sleep duration, and physiological and psychological conditions, so it is important to acknowledge that these factors could potentially impact the observed satiety effects. FSDU product based on brown rice and oyster mushrooms tended to cause a more significant satiety effect correlated with the nutrients it contains, which influenced the sensation of hunger and fullness. Therefore, based on consideration of the satiety level testing results, FSDU product development based on brown rice and oyster mushroom can be chosen as a substitute for additional specialized dietary management for individuals with diabetes, contributing to improved blood glucose control.

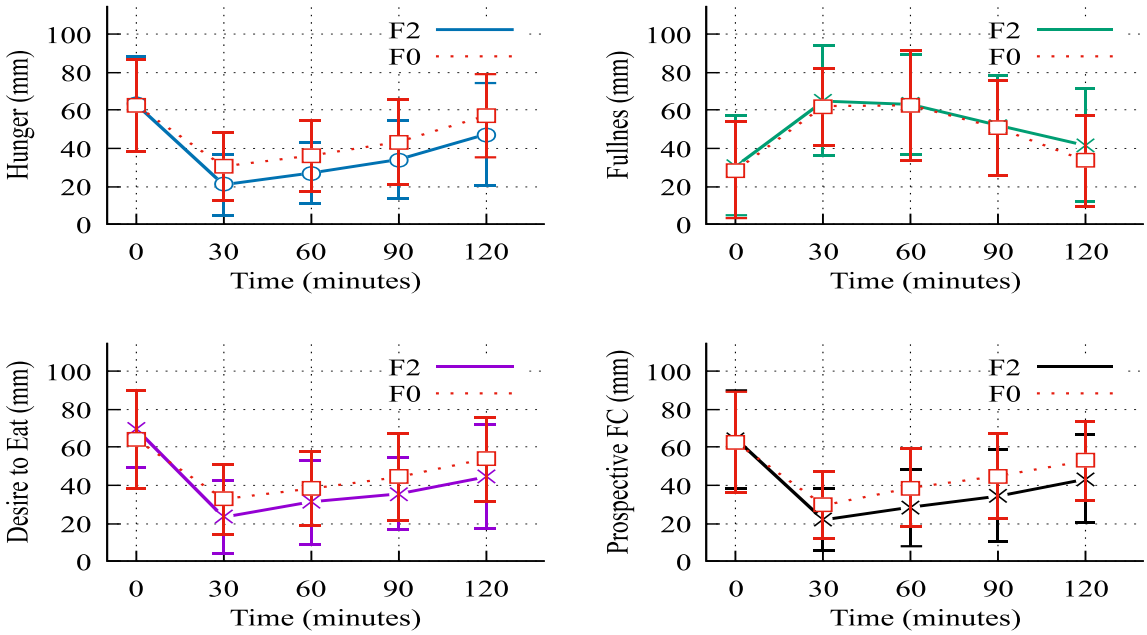

Figure 1. The VAS Score of the Developed FSDU

CONCLUSION

The FSDU for individuals with diabetes, developed based on brown rice and oyster mushroom, contains energy, fat, and fiber ranging from 391.33–404.33 Kcal, 5.53–7.75 g, and 4.22–7.60 g per 100 g product, respectively. These values are all slightly higher than the respective value of the commercial product. The sensory qualities of the developed FSDU based on color, aroma, taste, and texture were significantly lower ($p < 0.05$) as compared to the commercial product. However, all formulas could be sensorially accepted by the panelist, except for the taste of F4. The most favored FSDU product for diabetics was achieved by the addition of 10% carrot and fish flour (F2) into the base formula. This product has characteristics of a brownish-white color, a slightly fishy aroma, a non-sweet taste, and a sandy liquid texture with little sediment.

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Compared to the commercial product, the most preferred FSDU formula provides a lower feeling of hunger, desire to eat, and prospective food consumption after 30 minutes of consuming, maintaining this effect throughout the 120-minute observation period. The developed formula has been perceived to serve a feeling of fullness similar to the commercial product starting from the time of administration. Moreover, after 90 minutes, the formula results in a higher score of fullness, potentially attributed to its higher fiber content. The cumulative satiety test on the VAS test indicates no significant difference between the FSDU product developed and the commercial products.

Author contributions

ES: conceptualization, funding acquisition, original draft writing. YK: funding acquisition, data processing and visualization, final draft writing of English version, review, and editing. DH: supervision, methodology. IK: supervision, methodology. V: investigation, data processing, original draft writing. SZAK: investigation, data processing, original draft writing.

Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

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Data availability

The data related to the above findings cannot be shared as the data also form part of an ongoing study.

Ethical clearance

The ethical clearance to conduct this study was obtained from the Ethics Commission Board of the Polytechnic of Health Ministry of Health Malang, with decree number 441/KEPK-POLKESMA/2022.

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