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Title: Combination of Fish Protein, S-Allyl-L-cysteine, and Myristicin as Emergency Food to Support Nutritional Status and Potential Immune Function in Refugees

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ABSTRACT

Background: Prolonged food insecurity due to disaster emergencies induces an increased risk of nutritional problems for toddlers and older people. Emergency food products, such as biscuits are easy to consume and suitable for emergency situations. Functional local foods have the potential to be substitute ingredients in the production of emergency foods that are nutritious, rich in antioxidants, and sustainable. This study aimed to determine the effect of adding local ingredients as an emergency food.

Materials and Methods: This study used a completely randomized experimental research design to at first created product formulation by substituted 3.5% of 45% wheat flour with 2% catfish flour, 1% nutmeg powder, and 0.5% black garlic paste and aimed to analyze the nutritional content, safety, characteristics, acceptability, and efficacy of emergency biscuits.

Results: Biscuits are classified as safe and free of contamination. The nutritional content of one serving of biscuits (72 grams) provides 15.9% energy, 13.3% protein, and 30.6% fat in disaster emergency situations. Organoleptic tests on refugees showed an average acceptability of biscuits including color (3.87 ± 0.755), smell (3.79 ± 0.809), taste (4.11 ± 0.667), and texture (3.93 ± 0.726). The results of the biscuit efficacy test in the toddler group showed a significant increase in body weight ($p= 0.000$) and height ($p= 0.000$). Meanwhile, the biscuit efficacy test in the elderly did not show any significant difference in body mass index ($p>0.05$).

Conclusions: Emergency biscuits made from local food ingredients have met standards for safety, nutrition, good acceptability, and are effective in increasing the anthropometric values of toddlers.

Keywords: anthropometry, emergencies, food, immunity, zero hunger.

INTRODUCTION

In Indonesia, disasters occurred in 3,472 cases in 2024 and increased to 4,727 cases in 2025. Of all the disasters that occurred, the majority were caused by forest fires, landslides, and floods (1). Earthquakes also occur quite frequently, a situation compounded by findings indicating that earthquake victims are vulnerable to malnutrition (2). Disasters are a form of emergency that can result in decreased access to food, resulting in food insecurity. Insufficient food availability is the beginning of a process of health decline which will ultimately affect the level of fulfillment of post-disaster nutritional needs (3). Limited nutritional needs during disaster emergencies have a major impact on public health conditions, especially regarding food and nutrition. This is certainly the government's duty to maintain food security and community nutrition (4).

A prolonged increase in food insecurity among disaster-affected communities can increase the risk of a decline in nutritional status. In fact, 26.5% had a low level of awareness about nutrition and food storage methods during times of crisis (5). In toddlers, food insecurity can cause malnutrition and increase the risk of growth retardation and susceptibility to disease because nutrition plays an important role in the immune system (6). Apart from the toddler group, the elderly also have a higher risk of malnutrition and weight loss than younger age groups (7).

Efforts to fulfill the nutritional needs of victims of disasters are a challenge that needs to continue to be developed in disaster emergency management, both to meet macronutrient and micronutrient needs (8). Emergency food is a type of food that contains high levels of energy and nutrients, specifically designed for victims of disasters (9), as required by WHO and Sphere, emergency food should contain 2100 kcal of calories, 50-53 g of protein, and 40 g of fat (10, 11). Various efforts to increase food security in disaster conditions through emergency food distribution have been carried out, but there is a need to study the optimization of local food-based food ingredients as an innovation for making emergency food.

Emergency food products must be ready-to-eat because they are needed in urgent situations with limited access. Choosing ingredients for making emergency food that are in accordance with local food availability can facilitate access, reduce production costs, and meet nutritional needs in accordance with standards for Emergency Food Products requirements (10). Catfish (*Clarias gariepinus*), nutmeg (*Myristica fragrans*), and garlic (*Allium sativum* L.) are a local food ingredient that have high protein content, antioxidants, and stress-reducing compounds. Catfish is a local commodity fish with high protein content

and abundant availability. Protein is needed by the body in the process of forming body cells and immunity which can be found in food such as fish (13).

Besides catfish as a protein source, humans also need antioxidants to boost the immune system, especially in emergency conditions. Nutmeg is a group of local spices containing *β-caryophyllene* and *eugenol* which are natural antioxidants, and contains *Myristicin* which shows anti-inflammatory effects in its role in inhibiting the production of Nitric oxide (NO), Interleukin-6, and various cytokines/chemokines in macrophages (14, 15). Garlic contains S-Allyl-L-cysteine (SAC), an antioxidant compounds which after the fermentation process have been proven to reduce Reactive Oxygen Species (ROS) production, increase the activity of antioxidant enzymes such as *superoxide dismutase* (SOD), *catalase*, and *glutathione peroxidase* (GPx), and increase macrophage activity which can protect immune cells from oxidative stress, and and increase defense against infection (16, 17).

These local food ingredients will be combined to produce emergency food products, so that not only do they aim to provide a feeling of fullness, but they are also able to meet energy needs, macronutrients, and provide bioactive components. The innovation in developing emergency food that is healthy, practical, and has good acceptability is manifested in the form of functional biscuits (13). Biscuits have a high shelf life and are not easily damaged (12), as well as have high acceptability. Based on the theory obtained, this study aims to determine the effect of adding local ingredients to emergency food on nutritional content, food safety, acceptability, as well as anthropometric variables and nutritional status in affected residents.

MATERIALS AND METHODS

Product development employed a completely randomized experimental research design. The research stages began with product development, characteristic testing, nutritional content testing, acceptability testing, and efficacy testing on refugees. This research was approved by Airlangga University, Faculty of Dental Medicine Health Research Ethical Clearance Commission (number: 859/HRECC.FODM/VII/2023).

All cooking processes, and organoleptic tests were performed in the Nutrition Laboratory, Nutrition Department, Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia. Analysis of nutritional content and characteristic tests were conducted at the Saraswanti Laboratory, Bogor, Indonesia. Organoleptic and efficacy tests involved refugees affected by Mount Semeru lava floods in Lumajang, East Java, Indonesia.

Development of biscuit

The raw materials used in the formulation of biscuits as emergency food utilize local Indonesian food products, namely catfish (*Clarias gariepinus*), nutmeg (*Myristica fragrans*), and garlic (*Allium sativum* L.). Raw local materials were processed before being used in the biscuit making process. Catfish was processed from cooking, grinding, then drying to become ready-to-use catfish powder. Nutmeg was ground into a ready-to-use powder. The garlic used is fermented single garlic, or usually called black garlic, which was then softened into a paste. Usually, the standard ingredients of making biscuits carried out by mixing these ingredients: wheat flour, sugar, water, margarine, oil, corn starch, soy protein isolate, salt, milk powder, chocolate powder, eggs, milk flavour, vitamin mineral premix. Meanwhile, this emergency biscuits adopting substitution method to increase its nutritional and bioactive values. As much as 3.5% of 45% wheat flour was substituted with 2% catfish flour, 1% nutmeg powder, and 0.5% black garlic paste. After all the ingredients were mixed evenly, the dough was molded then baked.

Characteristic test

Product characteristics were tested in accordance with Indonesian National Standard (INS) number 2973 of 2022 concerning biscuits (18), which consists of testing the physical characteristics of biscuits. In addition, testing for metal content and food contamination (insects, foreign objects, bacteria) was conducted to meet product food safety standards.

Nutritional value test

Nutritional content analysis was carried out by a nationally accredited laboratory. Crude fat was determined gravimetrically using the Weibull acid hydrolysis method (AOAC 922.06). Crude protein was measured by the titrimetric Kjeldahl method (AOAC 981.10). Carbohydrate content was calculated by difference (USDA). Fat-soluble vitamins (A and E) were quantified using HPLC-PDA (High-Performance Liquid Chromatography with Photodiode Array Detector) (AOAC 2001.13). Water-soluble B-complex vitamins (B1, B2, B3, B6, B9) were analyzed using UPLC-PDA (Ultra-Performance Liquid Chromatography with Photodiode Array Detector) (AOAC 2015.06). Trace vitamins (B12, D3, K) were quantified using LC-MS/MS or LC-MS (Liquid Chromatography with Mass Spectrometry) (AOAC 2011.10, AOAC 2016.05). Essential minerals (Na, P, Se, Zn, Fe, Ca) were quantified by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) (AOAC 2011.14).

Acceptability test

Acceptability assessment was carried out through hedonic tests on color, smell, taste and texture parameters. Hedonic tests or organoleptic tests are kinds of test that are based on sensing. Sensing is a physio-psychological process for consciously assessing the properties of an object due to the stimulation received by the body's sensory receptors (19). Sensory evaluation of the product aims to ensure product acceptability among untrained panelists according to the target group to provide an overview of the product's acceptability (20).

The data were collected using a questionnaire with the 5-point hedonic scale, 5 = really like; 4 = like; 3 = fair; 2 = dislike, and 1 = worst. The biscuit acceptability test was carried out by 80 untrained panelists consisting of 40 toddlers' caregivers representing toddlers and 40 elderly people. The number of panelists was taken from the total population of refugees of Mount Semeru lava flood who actively live in permanent housing in the Lumajang area, who are willing to participate in the research, and meet the age criteria of 6-59 months (for the toddler/caregiver group), >60 years (for the elderly group), do not have egg and fish allergies, and do not have a history of chronic disease (except stunting and wasting are allowed).

Before the study began, each subject was asked for informed consent, beginning with an explanation of the intervention, the data collected, and how to handle adverse effects. If adverse effects were discovered during the study, the subject could withdraw from the study and receive treatment covered entirely by the researcher.

Efficacy test

The subjects (refugees of Mount Semeru lava flood) who took part in the efficacy test were panelists involved in the acceptability test. They were separated into two groups, the toddlers and the elderly. A quasi-experimental pre-post intervention study to determine grouping by name shuffling using an online spinning wheels application. The intervention was carried out by providing emergency biscuits as additional food to be consumed for 1 month. Toddler subjects were given 1 pack of emergency biscuits or 36 grams/day, while elderly subjects were given 2 packs or 72 grams/day. All data related to consumption evaluation are recorded on monitoring cards for each subject; these cards include a daily consumption checklist, the amount actually consumed, and reasons of why not consuming. Data collection included anthropometry (body weight and height) which was carried out 2 times (pre and post intervention). For the elderly, the anthropometric data obtained was converted into body mass index (BMI).

Statistical analysis

Two data topics were statistically analyzed. The panelists' hedonic test results were analyzed for differences between groups on each variable. The data in the color, aroma, and texture variables were normally distributed, so the test used was one-way ANOVA, while the taste variable data that was not normally distributed was tested using Mann Whitney. The other data, the results of the efficacy test on refugees, were analyzed for differences before and after the biscuit intervention. For toddler's weight and height, each statistical analysis was carried out using the paired t-test, because the data was normally distributed, which was then followed by a Cohen's d test to measure the effect size. On the other hand, in the analysis of elderly's BMI, the Wilcoxon signed ranks test was used because the data was not normally distributed. Statistical analysis was performed using IBM Statistics SPSS 23 (IBM Corp., New York, NY, USA).

RESULTS

Appearance

Emergency biscuits have normal color characteristics in the form of brownish (Figure 1), sweet taste, and normal smell like biscuits in general.

Food Safety

Table 1 shows the results of laboratory tests regarding the characteristics of emergency biscuits in terms of food safety. The biological contamination parameters shows negative to low findings (less than the maximum limit). Apart from that, chemical contamination, the heavy metal content arsenic, cadmium, mercury, lead and tin, was also not found in emergency biscuit products so that based on the food safety level adjusted by INS 2973 of 2022 concerning biscuits, emergency biscuits are classified as safe and free from contamination.



Figure 1. Physical Appearance of The Product

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Table 1. Food Contamination Test Results According to INS 2973:2022 Concerning Biscuits

Parameter	Unit	Limit of Detection	Standard	Result	Note
Taste	-	-	Normal	Normal, sweet	Fulfilled
Smell	-	-	Normal	Normal	Fulfilled
Color	-	-	Normal	Normal, chocolate	Fulfilled
Ash content	%	-	-	2.64	Fulfilled
Water content	%	-	Max. 5	2.91	Fulfilled
Metal contamination:					
Lead (Pb)	mg / kg	0.0004	Max. 0.5	Not detected	Fulfilled
Cadmium (Cd)	mg / kg	0.0005	Max. 0.2	Not detected	Fulfilled
Tin (Sn)	mg / kg	0.0025	Max. 40	Not detected	Fulfilled
Mercury (Hg)	mg / kg	0.001	Max. 0.05	Not detected	Fulfilled
Arsenic (As)	mg / kg	0.0003	Max. 0.5	Not detected	Fulfilled
Microbes contamination:					
Total Plate Number	colony / g	-	Max. 1×10^4	8.2×10^2	Fulfilled
Coliform	APM/g	-	20	<3	Fulfilled
Escherichia coli	APM / g	-	<3	<3	Fulfilled
Salmonella sp.	/25 g	-	Negative	Negative	Fulfilled
Staphylococcus aureus	colony / g	-	Max. 1×10^2	<10	Fulfilled
Bacillus cereus	colony / g	-	Max. 1×10^2	<10	Fulfilled
Yeast mold	colony / g	-	Max. 2×10^2	<10	Fulfilled

Nutritional value

Emergency biscuits which are formulated as emergency food based on local food in the form of catfish, nutmeg powder, and fermented garlic not only meet macronutrient content standards, but also contain essential micronutrients that the body needs. In this study, the nutritional content of biscuits was formulated to meet the recommended emergency food nutritional value of 10% of the total daily energy provided for snacks or snacks consumed

between main meals. The test results for the macronutrient content of biscuits compared to the standard nutritional needs in emergency conditions according to WHO 2004 (10) and Sphere 2018 (11) can be seen in Table 2 which shows that two serving of biscuits (72 grams) can fulfill 15.9% of energy, 12.5-13.3% of protein, and 30.6% of fat requirements in emergencies. Meanwhile, one serving of biscuits (36 grams) can fulfill 12% of energy in toddlers.

Table 2. Macronutrient Content of Emergency Biscuits Compared to Nutritional Needs during Emergency According to WHO and Sphere

Nutrient	Nutritional Value Per 100 Grams	Nutritional Value Per Serving (2 packages/ 72 grams)*	Nutritional Needs during Emergency	Fulfillment (%)
Energy (kcal)	462.8	333.2	2100	15.9
Protein (g)	9.2	6.6	50-53	12.5 – 13.3
Fat (g)	17	12.2	40	30.6

*Source: Humanitarian Charter and Minimum Standards in Humanitarian Response (8,9)

The product fulfills at least 10% of daily snack requirements, so it can be concluded that the content of emergency biscuits has met the minimum percentage limit for fulfillment as a snack in emergency conditions. The high protein content is obtained from the addition of catfish meal and soy protein isolate. Meanwhile, the addition of solid fat and powdered milk to biscuits supports the high energy and fat content. The biscuit formulation with high fat, energy, and protein content aims to meet macronutrient needs during emergency times with limited food sources so that a decline in nutritional status can be prevented.

Table 3. Nutritional Content of Biscuits Per 100 g Compared to Daily Recommendation Intake (DRI) of Toddlers and the Elderly

Nutrient	Nutritional Value Per 100 Grams	Nutritional Value Per Serving (1 package/ 36 grams)	DRI 6-59 months	Fulfillment (%)	Nutritional Value Per Serving (2 package/ 72 grams)	DRI >60 years	Fulfillment (%)
Carbohydrate (g)	69.0	24.8	130.0	19.1	49.7	130.0	38.2
Vitamin A (mcg)	160.0	57.6	400.0	14.4	115.2	900.0	12.8
Vitamin D (mcg)	3.9	1.4	15.0	9.4	2.8	15.0	18.7
Vitamin E (mg)	8.8	3.2	7.0	45.3	6.3	15.0	42.2
Vitamin K (mcg)	7.1	2.6	55.0	4.6	5.1	120.0	4.3
Vitamin B1 (mg)	0.0	0.0	0.6	1.2	0.0	1.2	1.2
Vitamin B2 (mg)	0.5	0.2	0.6	30.0	0.4	1.3	27.7
Vitamin B3 (mg)	9.4	3.4	8.0	42.3	6.8	16.0	42.3
Vitamin B6 (mg)	0.1	0.0	0.6	3.0	0.0	1.7	2.1
Vitamin B12 (mcg)	0.2	0.1	1.2	6.0	0.1	2.4	6.0
Folic acid (mcg)	147.1	53.0	200.0	26.5	105.9	400.0	26.5
Iron (mg)	8.5	3.1	10.0	30.6	6.1	8.0	76.5
Iodine (mcg)	112.4	40.5	90.0	45.0	80.9	150.0	54.0
Zinc (mg)	3.7	1.3	5.0	26.6	2.7	11.0	24.2
Calcium (mg)	511.7	184.2	1000.0	18.4	368.4	1000.0	36.8
Selenium (mcg)	28.6	10.3	30.0	34.3	20.6	55.0	37.4
Phosphor (mg)	3.4	1.2	500.0	0.2	242.6	700.0	34.6
Fluoride (mg)	0.0	0.0	1.0	1.1	0.0	4.0	0.5
Sodium (mg)	259.2	93.3	1000.0	9.3	186.6	1500.0	12.4

Table 3 shows the results of the analysis of the micronutrient and carbohydrate content of biscuits and their comparison with the standard nutritional requirements for the

toddler and elderly age groups. There is no limit of detection in nutritional analysis, so the results displayed have shown up to the smallest nominal value. Toddlers and the elderly are the main targets in developing emergency biscuit products, so the nutritional content analysis is focused on meeting the nutritional needs of these two groups. One serving of biscuits in the toddler group is 36 grams or the equivalent of one pack of biscuits, while in the elderly group is 72 grams or as equal as two packs of biscuits. The carbohydrate content meets 19% of the needs of toddlers and 38% of the needs of the elderly so that both are in accordance with the minimum standard for fulfilling food products as snacks at 10%. In the toddler age group, the micronutrients presented in Table 3 have met the minimum daily requirement which is more than 10% of daily requirements. In the elderly age group, some vitamins and minerals have also met the minimum daily requirement for snacks.

Acceptability test result

The average hedonic test results in each age group are shown in Figure 2. Emergency biscuit products were tested organoleptically involving untrained panelists which included mothers of toddlers as caregivers of toddlers and the elderly. The average acceptability of biscuits in the toddler group in all assessment aspects including color, smell, taste, and texture was 3.80 or lower than the elderly group which got an average of biscuit acceptability of 4.04 from test scale 1-5. Even though differences in assessments between the two age groups were found, the emergency biscuits received liked ratings from the panelists with a rating of more than 3 (liked) from both groups of panelists.

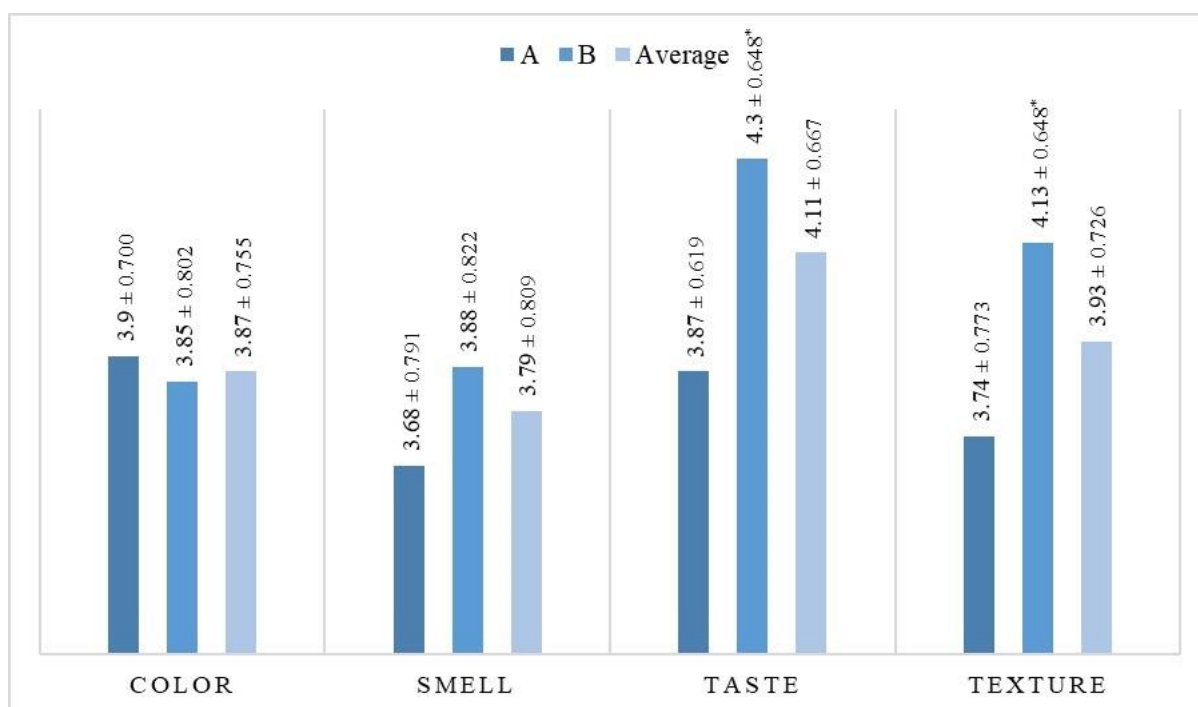


Figure 2. Average Acceptability of Emergency Biscuits by Toddlers and Elderly Refugees

Note: A = toddlers' caregiver; B = elderly

*) there is a significant difference in the Mann-Whitney test with p value <0.05

In general, the hedonic test results for biscuits in both age groups fall into the "somewhat preferred" to "liked" category so that the product can be accepted by both age groups (Figure 2). The best assessment of the four aspects is generally found in the taste component with an average acceptability score reaching 4.11 ± 0.667 from a maximum score of 5. In the toddler age group, the highest assessment score was the color aspect of 3.90 ± 0.700 , while in the elderly age group was 4.3 ± 0.648 . There were no differences in organoleptic test results between toddlers and the elderly in color and smell parameters, but significant differences ($p < 0.05$) were found between the two groups in the taste and texture assessment.

Color

Color is an important component that gives consumers the first impression of a food product so that it can influence consumer perceptions and preferences (21). The results showed that there were no significant differences in the assessment of color components in the two groups. Both groups of panelists, namely the toddlers (3.90 ± 0.700) and the elderly (3.85 ± 0.802), showed quite good assessment results regarding the color aspect of the biscuits.

Smell

Aroma is one of the important parameter in assessing food products which is observed by the human sense of smell because it can provide a quick perception and assessment of product acceptability among panelists (22). The organoleptic test results showed that the elderly group (3.88 ± 0.822) gave a higher score on the biscuit aroma than toddlers (3.68 ± 0.791). However, there were no significant differences in the assessment of the biscuit aroma components in the two groups of respondents. Thus, both target groups indicated that the aroma of the biscuits fell into the liked category.

Taste

Taste is the result of sensing or stimulation caused by the material formed in a food product and received by the sense of taste (23). The results of the organoleptic test for biscuits in the two age groups showed a significant difference ($p\text{-value} < 0.05$). The average assessment of taste components in toddlers was 3.87 ± 0.619 , while the elderly had a higher average of 4.3 ± 0.648 . Elderly prefer the taste of biscuits than toddlers because of the differences in eating preferences in the two age groups.

Texture

Table 3 shows that there are significant differences regarding the level of panelists' preference for biscuit texture. On average, toddlers gave a texture assessment of 3.74 ± 0.773 , while elderly gave 4.13 ± 0.648 . The differences in assessments between the two target groups were caused by differences in preferences for food texture when consuming biscuits.

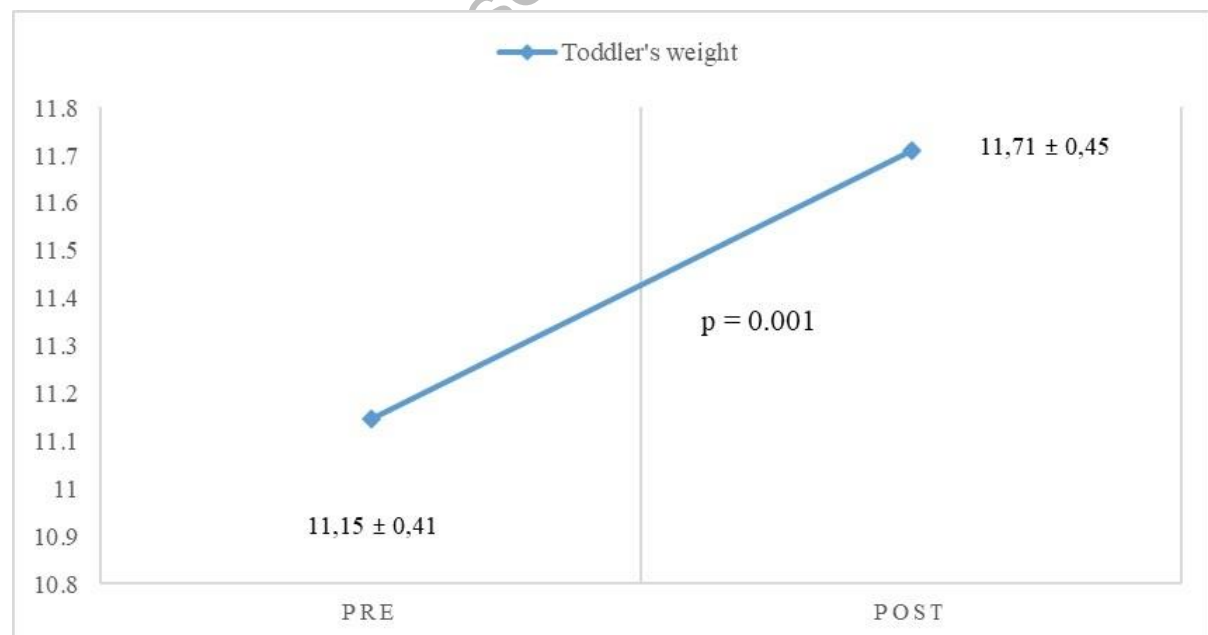


Figure 3. Consort flow diagram from participant recruitment to analysis

Efficacy testing on toddlers

Emergency biscuit products that have passed laboratory tests related to contamination and organoleptic tests, were then tested on toddlers as the main target group. As shown in Figure 3, during the 1-month intervention period, 4 toddlers dropped out, so that the total number of toddlers who participated in the efficacy test until the end was 36 childrens. The reasons for dropping out were that one toddler moved away, while the other three refused to consume the biscuits during the intervention period. The results of the effectiveness of giving biscuits on toddlers' weight are illustrated in Figure 4. It is known that before intervention, the average weight of toddlers was 10.89 ± 0.41 kg. After giving emergency biscuits (1 pack) for a period of one month of regular administration, the average weight of toddlers was 11.68 ± 0.42 kg. This study shows that providing emergency biscuits as additional food can significantly increase toddlers' weight ($p < 0.05$), although the results of the effect size analysis (Cohen's d) show a small impact (value range 0.20). The results of this study are in line with another scientific study which shows that there is a significant effect of providing additional food on increasing the weight of toddlers during disaster emergencies (24). A toddler's body weight is an indicator of acute malnutrition. The significant increase in the weight of toddlers after providing the intervention indicates that additional food plays an important role in meeting the daily nutritional needs of toddlers, especially during disaster emergencies. Therefore, giving biscuits containing complex nutrients that have been adapted to the needs during a disaster can increase the weight of toddlers so that they remain in line with the growth rate of their age group.

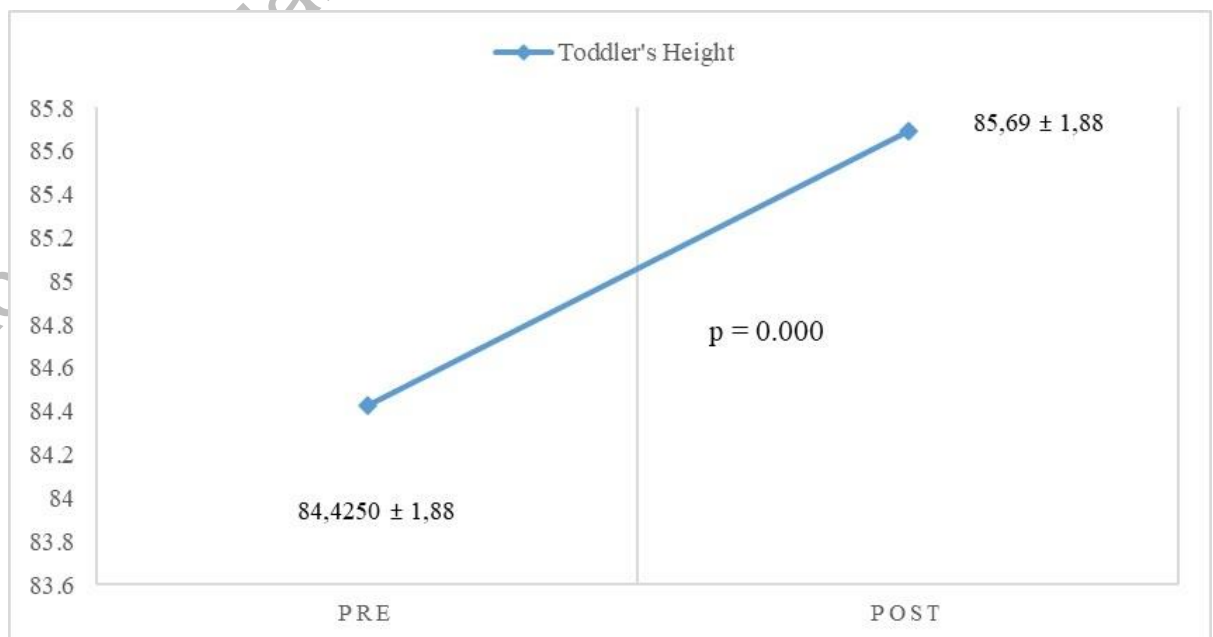


Figure 4. Average Change in Toddlers' Weight during Intervention (kg)

The assessment of the efficacy of biscuits on toddlers was carried out on two anthropometric indicators, weight and height. The results of the analysis of changes in the average height/body length of toddlers before and after the biscuit intervention can be seen in Figure 5. The average height or body length of toddlers before intervention was 84.38 ± 1.85 cm. After being treated with biscuits for a full month, the toddler's height or body length was measured again with an average result of 85.77 ± 1.86 cm. Similar to the results of the weight analysis, the height analysis shows that there is a significant increase in the average height or body length of toddlers ($p < 0.05$) due to the provision of emergency biscuits, although the effect size results were small. Another similar research also shows a significant effect of providing additional food on increasing the height of toddlers during disaster emergencies (25). The height or length of a toddler's body is an indicator of chronic malnutrition which decreases if the toddler does not receive optimal nutritional intake for a long period of time. The provision of emergency supplementary food can meet the nutritional needs of toddlers and is expected to prevent nutritional issues during and after disasters.

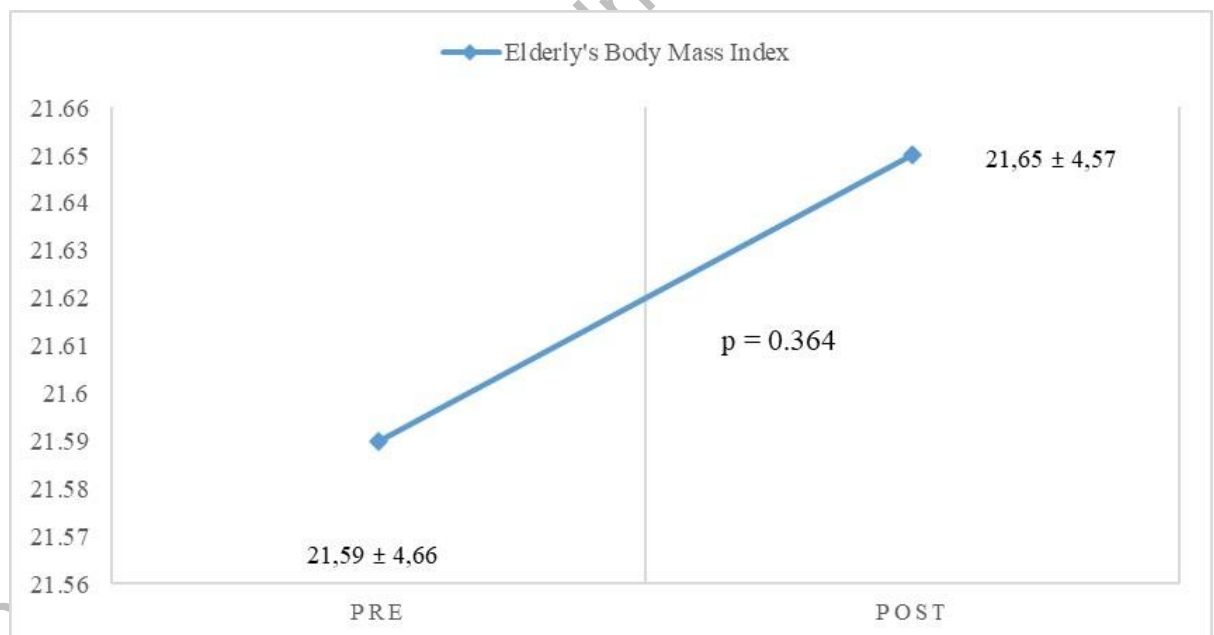


Figure 5. Average Change in Toddlers' Height during Intervention (cm)

Efficacy testing on elderly

In the elderly subjects, 10 people dropped out, mostly due to returned to their original homes, so that the total number of elderly people who completed the efficacy test was 30 people. Among the elderly group, a significant number of dropouts were attributed to subjects living alone, a lack of appetite, and difficulty accepting education regarding product

consumption; consequently, they refused to continue using the product. Figure 6 shows the results of changes in the Body Mass Index (BMI) of the elderly during the intervention period. It is known that before the intervention, the average body mass index for elderly was $20.79 \pm 0.64 \text{ kg/m}^2$. After giving emergency biscuits for a period of one month (2 packs/day), the average body mass index for the elderly was $21.62 \pm 0.94 \text{ kg/m}^2$. This shows a trend toward improvement in the body mass index of the elderly, although the changes was not significant ($p>0.05$). These results are in line with a research by Chanwikrai et al., (26) which showed that the intervention of providing snacks to the elderly did not have a significant effect on body mass index within a period of 4 weeks. In the elderly age group, changes in body mass index rarely occur because they are no longer in their growth period.

Figure 6. Average Change in BMI for the Elderly (kg/m^2)

DISCUSSION

Sensory Acceptance and Characteristics

Emergency biscuits have a brown color which is generally similar to biscuit products found on the market indicating that they are easily accepted by the panelists. The brown color of the biscuits is influenced by the caramelization of the sugar during the biscuit baking process (27). Apart from that, the ingredients used in the manufacturing process, catfish meal and nutmeg powder, cause a darker brownish color on the biscuits (28). Garlic that has gone through a fermentation process with high enough temperature and humidity exposure has the effect of changing its color to blackish brown or is called black garlic (29). The addition of black garlic paste to the biscuits affects the darker brown color with some of the black garlic paste fibers are visible in the biscuit pieces. However, the color change due to the addition of black garlic did not reduce the panelists' acceptability to the color components.

The aroma of biscuits is generally dominated by the main components in the form of fat, milk, and eggs which become stronger after the high temperature baking process (30). Meanwhile, emergency biscuits have a strong spice aroma that come from nutmeg powder. The distinctive aroma of nutmeg is the result of the chemical bond between *phenol monoterpene* alcohol and volatile *hydrocarbon monoterpene* which easily evaporates (22, 31). Specifically, nutmeg contains *myristicin*, a derivative of the *phenylpropanoid* compound which has a sharp herbal aroma and is very volatile (32). The *phenylpropanoid* and *trans-cinnamaldehyde* compounds contained in nutmeg are aroma compounds that have the effect of increasing appetite improving the acceptability of biscuits to the target audience (33).

Biscuits generally have a sweet and savory taste which come from the combination of margarine, milk, and sugar contained in the biscuits (27). Meanwhile, emergency biscuits have a strong spice taste from the nutmeg powder added to the biscuit formulation. The spice taste of biscuits tends to be more favored by the elderly, compared to by toddlers. This is caused by the taste preference of the toddler age group which prefers sweet flavors that come from sugar and fruit (34).

Texture is a description of sensations that can be observed (with the eyes), bitten, chewed, and swallowed (with the mouth), as well as through touch (35). The texture of food is influenced by various ingredients in the formulation. Elderly people tend to prefer soft-textured biscuits because of their reduced motor ability to chew food properly (36). Toddlers usually don't like hard textures and are difficult to chew so they prefer soft forms of food (37). However, significant differences in assessments between the two groups could occur due to differences in preferences regarding the texture of the preferred biscuits. Acceptance of food texture in toddlers is influenced by age, skills in oral processing of food, and rejection of foods containing grains (38). This causes the hedonic test assessment of the texture component of toddlers to be lower than that of the elderly.

The texture of the biscuit is influenced by the ingredients in the biscuit formula being made. Protein is one of the nutritional components that influences the texture of biscuits. Biscuits with high protein content have a crunchier texture (39). The addition of catfish flour to the biscuits gives the biscuits a crunchy effect. Meanwhile, the milk and egg content in the biscuit formula can help provide a soft texture, resulting in biscuits still easy to chew.

In addition to having a high level of acceptability, these biscuits—formulated for emergency situations with the inclusion of 2% catfish flour, 1% nutmeg powder, and 0.5% black garlic—exhibit characteristics that meet national safety standards (Indonesia), specifically regarding the absence of contamination, while also satisfying nutritional requirements for emergency scenarios as well as the daily nutritional needs of toddlers and the elderly.

Effect of biscuit intervention on anthropometric profile

Emergency biscuits have a high energy and protein content and fulfill more than 10% of total daily energy in emergency conditions. Toddlers have a greater proportion of nutritional needs than the adult age group to support the growth of bones, teeth, muscles, and blood (40). In emergency conditions, toddlers can experience hunger or lack of intake due to limited food availability which results in malnutrition. Emergency biscuits with high energy and protein content, which mainly come from catfish meal as additional food, can provide a

significant increase in intake to prevent malnutrition. Other studies that also utilize animal protein from fish sources as an ingredient in supplementary food also showed similar results, an increase in weight and height in toddlers. For example, research in Zambia that utilizes Chisense fish powder (41), research in Bengkulu, Indonesia that utilizes gaguk fish (*Arius thalassinus*) (42), and research in Ambon, Indonesia that utilizes skipjack tuna (*Katsuwonus pelamis*) (43).

Toddlers are in a golden period of growth, especially when supported by a complete nutritional intake. One nutrient that plays a significant role in growth is protein. The protein components in emergency biscuits come from two sources: catfish meal (animal protein) and soy protein isolate (vegetable protein). Catfish has a relatively high protein content, dominated by essential amino acids (leucine and lysine), which are much richer than other animal products (44), and dominated by glutamate as a type of non-essential amino acid (45, 46). Furthermore, catfish also contains up to 8 types of essential amino acids and 7 types of non-essential amino acids (47). Amino acids such as lysine and arginine are associated with the activation of the growth hormone axis (Growth Hormone/Insulin Growth Factor-1) by stimulating the proliferation and differentiation of chondrocytes in the epithelial growth plate, thereby promoting linear growth (height) and tissue formation (48, 49). The process of protein synthesis in the body (e.g., muscle, organ, bone) for growth requires not only amino acids, but also sufficient energy, other nutrients, and hormones (50). Therefore, the development of emergency biscuit products with the addition of catfish flour in this study also considers the adequacy of energy and the diversity of other nutrients (Tables 2 and 3). However, this study still lacks in terms of hormone analysis, which may be a confounding factor in influencing growth outcomes.

As we age, loss of fat mass and muscle mass is common so the risk of malnutrition increases. Providing snacks to the elderly has been proven to be effective in increasing energy intake and nutritional status (26). Changes in body mass index take longer than changes in body weight, so monitoring the intervention within one month is not enough to review the significance of changes resulting from the intervention. However, these findings at least confirm that providing emergency biscuits containing catfish powder, black garlic and nutmeg powder can prevent a reduction in the nutritional status of the elderly, especially in the post-disaster period. A reduction in nutritional status in the elderly reflects a weakened immune system. The SAC component in black garlic reflects ideal antioxidant activity, scavenging DPPH (1,1-diphenyl- 2-picryl-hydrazyl) free radicals, superoxide radicals, and reducing oxidative stress in the human body (51, 52). In nutmeg, the myristicin content does

not directly strengthen immune cells (for example, increasing T cells), but contributes to inhibiting the production of inflammatory mediators (chemokines and cytokines) by macrophage cells (15). Other components in nutmeg (lignans and neolignans) also contribute to immune response activity (53). The two components present in this emergency biscuit product support immune function, thereby contributing to the maintenance of nutritional status.

Several limitations should be acknowledged. The lack of a control group limits causal inference and makes it difficult to distinguish intervention effects from changes that may have occurred over time. The small sample size and the focus on a single disaster setting also constitute limitations, potentially making it difficult to generalize the findings to other disasters involving larger samples. The short follow-up period of one month also limits the assessment of longer-term effects and sustainability. In addition, the absence of dietary intake monitoring, biochemical immune and nutritional markers prevented objective assessment of physiological changes and potential underlying mechanisms. Finally, a Hawthorne effect cannot be ruled out, as participants may have altered their behavior simply because they were aware of being observed.

CONCLUSIONS

Biscuits substituted with 2% catfish flour, 1% nutmeg powder, and 0.5% black garlic that formulated for emergency conditions demonstrated acceptable nutritional and laboratory characteristics. The results of sensory acceptance was generally favorable (overall ~3.9–4.1). Giving emergency biscuits to toddlers during one-month intervention resulted in a significant increase in body weight ($p=0.000$) and height ($p=0.000$). Meanwhile, in the elderly, although not significant ($p=0.202$), giving emergency biscuits can help maintain stable nutritional status. Overall, emergency biscuits can be used as an emergency food option that meets nutritional and food safety standards for all age groups, especially for toddlers and the elderly, and it is hoped that they can be adopted by other countries by utilizing their respective local potential.

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