

Mocaf flour, moringa flour, and mackerel flour food bars as an emergency food source for neurodivergent/autistic children during a natural disaster

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Abstract Indonesia is highly prone to natural disasters, when it strikes it often limits access to safe food for autistic children who require a gluten- and casein-free diet. This study aims to determine the optimal emergency *food bar* formulation suitable for autistic children, using mocaf flour, mackerel flour, and moringa leaf flour. This research used mocaf flour (25g (F1), 27g (F2), 29g (F3)), mackerel flour (5g (F1), 3g (F2), 1g (F3)), and moringa leaf flour (9g for all formulations). Proximate content was analyzed using AOAC 2012 and 2005 methods. The study employed a complete randomized design with two repetitions. Statistical analysis used for the proximate test was ANOVA and Duncan tests, while for sensory evaluation used Kruskal-Wallis and Mann-Whitney test. The best formulation was identified using the exponential method. The results showed that the *food bars* generally met emergency food standards, except for moisture content. ANOVA indicated no significant effect of formulation variation on moisture content ($p=0.07$). However, significant effects were observed on ash content ($p=0.029$), protein ($p=0.001$), and carbohydrate ($p=0.003$), but not on fat content ($p=0.087$). Sensory analysis revealed significant differences in all preference parameters. The best formulation, F3, provided 54% carbohydrates, 32.7% fat, and 8.31% protein, totaling 389.59 kcal per 100 grams.

1 Introduction

Indonesia is a nation highly prone to natural disasters, as a side-effect of its geological and geographical location. According to data obtained from the official BNPB (National Agency for Disaster Countermeasure) website, the total number of natural disasters that have occurred in Indonesia since 2023 has reached 664 incidents, with a total of 62 fatalities, a reported 31,481 experiencing damages and 3,797 displaced. It cannot be understated the amount of loss caused by said incidents, including the loss of access to approachable, safe foods for neurodivergent/autistic children. Because of which, assistance in the form of food

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can be crucial.

Emergency food assistance has to comply with standards of efficiency, mainly the logistical issue of distributing the food in a ready-to-eat state, for instance in the form of a food bar. Food bars are classified as dry food with a low water activity (aW) index, giving them the benefit of a longer shelf life [1]. The definition is in-line with research done by Sumarto & Tajrifani [2], who developed food bars as a source of emergency food during a disaster. Research done by Fatmah et al [3] began development of food bars using ingredients such as broccoli, soy beans and mangrove in case of an emergency. Arguably, food bars can be made using local ingredients such as mocaf flour, produced from processed cassava. During disasters, people's nutritional needs must still be met: energy averaging 2,100 kcal/day for adults, with adjustments for children and the elderly; protein 50-70 g/day to support immunity; fat 15-30% and carbohydrates 55-75% of total energy as the main sources; and micronutrients such as iron, zinc, vitamins A, C maintain body functions.

Mocaf flour, as a product made from cassava that can be easily found in Indonesia, has massive potential as a core ingredient in food bars, due to its abundance, and it being safe to consume for autistic/neurodivergent children who are sensitive to gluten. Not to mention, mocaf flour also has similar characteristics to wheat flour, making it easier to work with [4]. Although, the downside of mocaf flour is its lower protein content compared to its wheat counterpart. Because of this, the production of food bars using mocaf flour needs to be complemented with a high source of protein such as mackerels.

Mackerels as a source of animal protein has a high bioavailability, with a protein content of 21,4 grams per 100 grams, higher than even salmon. It's also more affordable, and has a total amino acid content of 20,877 mg per 100 grams, which plays an important role in synthesizing antibodies and regulating our metabolism as a response from the immune system [4]. The processing of mackerels into flour can extend its shelf life and help fulfill the daily protein intake of autistic/neurodivergent children, when used in food bars based on mocaf flour. However, due to the lack of vitamins and minerals to be found, moringa leaves can be added to the mix in order to help with the shortage of vitamins and minerals.

Moringa leaves are considered as a functional food source, rich in bioactive components used to help the immune system. Phytochemical tests show that moringa leaves contain strong antioxidants such as phenolic, flavonoid (quercetin, kaempferol) and phenolic acid, which function as an immunostimulant, activating CD4⁺ T Cells to fight microbes [5]. Moringa leaves have been shown to have intense antioxidant activity, proven by IC₅₀ tests which reveal concentration of 29,91 µg/mL [6], showing a strong potential to slow down free radicals and prevent oxidative stress. Oxidative stress is an important factor in pathology on the autistic spectrum, with antioxidants found within moringa leaves helping protect cells in the immune system from damage [7]. During disasters, access to balanced, nutrient-dense, and easy-to-consume foods is critical, it opens an opportunity to explore the feasibility of "*Mocaf Flour, Moringa Flour, and Mackerel Flour Food Bars as an Emergency Food Source for Neurodivergent/Autistic Children during a Natural Disaster/during National Disaster Relief Efforts.*"?

2 Materials and methods

2.1 Materials

Research was conducted from the month of March until June of 2024. Research was done using ingredients bought online, as well as in the Pondok Labu Market, South Jakarta. The ingredients include Mocaf Flour (produced by PT. Rumah Mocaf), moringa leaf flour (produced by PT. Safiya), and mackerels, processed into flour. Researchers also used

supporting ingredients during the food bar manufacturing process, such as limes, lemongrass, tea powder, ginger, margarine, chicken eggs, stevia sugar, salt, cornstarch, coconut oil and vanilla. Tools used to manufacture the food bars during research include a steamer, an 80-mesh sieve, a manual pressing machine, a cabinet dryer, an oven, a mixer, a blender, trays, spatulas, spoons and bowls.

2.1 Processing mackerels into flour

The process of producing mackerel flour starts with cleaning and fileting the fish, and then marinating the meat using lime juice in order to reduce the smell. Afterwards, the fish is steamed for 10 minutes alongside aromatics, and then the water and fat content were reduced manually using a machine press. The fish was then dried at 90°C for 5 hours using a cabinet dryer. This process produces mackerel flour with a high protein content (83,37%) with a low water content (3,81%) which increases the shelf life of the product. Research shows that steaming and rinsing manually improves the quality of protein, and that drying the fish at 90°C is more effective than doing so at 80°C. After being dried, the fish is then grounded and sifted using an 80-mesh sieve.

2.2 Formulating the food bar

In order to meet standards for emergency food sources, the food bar needs to be formulated to contain at least 35-45% fat, 10-15% protein and 40-50% carbohydrates [8]. Mocaf flour contains 350 kcal per 100 grams with 1,2 grams of protein, 0,6 grams of fat and 85 grams of carbs. On the other hand, moringa flour contains 205 kcal per 100 grams, with 27,1 grams of protein, 2,3 grams of fat, and 38,2 grams of carbohydrates [9]. Mackerel flour contains 378,9 kcal per 100 grams, with 83,37 grams of protein and 5,05 grams of fat [10]. The food bar also needs to contain around 230-250 kcal of energy. Formulating the amount of mackerel flour used is done according to the difference in composition between mocaf flour and mackerel flour (Table 1).

Food bars were made in accordance with methods shown by Laeli [11] and Novidahlia [12]. The process starts by making the wet batter, which was made by mixing margarine, salt, stevia/stevia sugar, eggs and coconut oil using a mixer. To create the dry batter, mocaf flour, mackerel flour and moringa leaf flour wre mixed together. Afterwards, the wet and dry batter were combined and then poured onto an 11,5cm x 4cm x 2cm tray, and baked at 100°C for 40 minutes. After letting the pastry rest, it was then baked once more at 150°C for 20 minutes.

Table 1. Food bar ingredients/formulations

Ingredients	F1	F2	F3
Mocal flour (g)	25	27	29
Mackerel flour (g)	5	3	1
Moringa leaf flour (g)	9	9	9
Stevia/stevia sugar	15	15	15
Coconut oil	1	1	1
Margarine	10	10	10
Chicken eggs	20	20	20
Cornstarch	2	2	2
Total weight (g)	87	87	87

2.3 Statistical analysis

A proximate test was done throughout the formulation process/on all ingredients used. The proximate test included testing the nutritional contents of the food bar for carbohydrates, fat, protein, as well as water content and ash content. Results from the test are then analyzed using the ANOVA method. If any data points show any significant differences ($\alpha < 5$), then an additional Duncan test will be performed. Organoleptic tests include hedonic testing involving 30 semi-professional panelists. Three formulas of food bars. Three different batches of bars (made using different amounts of the same core ingredients) were tested and rated based on color, taste, aroma and texture. Organoleptic analysis was done using the Kruskal-Wallis method to find any organoleptic differences between formulas. If any significant differences were to be found ($< 0,05$), then an additional Mann-Whitney test will be performed to determine the differences

3 Results and discussion

3.1 Nutritional content of food bars

The food bars were tested for various nutrients, such as protein, fat, carbohydrates, energy/calories, water and ash (Table 2). It could be said that based on the definition provided by Zhoumas [13] food bars made using these series of ingredients have fulfilled the standards in place for them to be considered as an Emergency Food Source, which are based on the contents of energy, protein, fat and ash. The water content that was found in the food bars fall under the category of Intermediate Moisture Food (IMF), as it has a water content of 10%-40%. Food bars with 10%-40% water content, categorized as Intermediate Moisture Foods (IMF), are ideal for emergencies due to their extended shelf life, microbial safety, palatable texture, and readiness to eat. They provide moderate hydration, reduce dehydration risk, retain nutrient density, and are lightweight for easy transport and storage, making them practical and effective in emergency situations.

Food bars made using the series of ingredients have been found to have a higher ash content compared to the standard, however it's still within safe levels for consumption, which is less than 4% [14]. The higher ash content could be attributed to the addition of mackerels, which contain several minerals such as calcium. Mackerels have a calcium content of 83,43mg per 100 grams [6].

The protein content in the formulated food bars have been shown to decrease alongside a reduction of mackerel flour. ANOVA testing proves the significant difference in protein content. Other than the decrease of mackerel flour in the mixture, protein contents could also decrease due to longer cooking times and prolonged exposure to heat, as F3 doesn't meet standards for protein content in order to be considered as an Emergency Food Source. At temperatures above 100°C, especially >150°C, protein quality decreases due to maillard reactions and thermal degradation.

Fat content in the food bar is derived from mackerel flour, margarine, coconut oil and chicken eggs. Although soy was not used to avoid allergens in autistic/neurodivergent children, all formulations meet all the standards required to be considered as an Emergency Food Source (32%-49.8%) based on its fat content. ANOVA testing finds that there are no significant differences between the three formulations when it comes to fat content ($p=0.087$).

Research has shown that all three formulations have met the standards for carbohydrates in Emergency Food Sources (36.8-54%). The high amount of carbohydrates in the formulated food bars could be attributed to the concentration of mocaflour, which has a high carbohydrate content (97%). ANOVA testing has found significant differences in

carbohydrate content between the three formulations, and a Duncan test has confirmed said findings.

3.2 Organoleptic characteristics of the food bar

Ratings/reviews on the food bar show that F3 was the highly preferred choice when it comes to color, texture, aroma and flavor. The color of F3 was preferred as it produced a deep jade color from the moringa flour. F3’s texture was firmer due to the use of mocaf flour, while the flavor and texture of F3 was also preferred, even if there was a slight bitter taste due to the moringa leaves, that was neutralized by the mocaf flour. Statistical tests show significant differences between formulations, especially between F1 and F3. F3 was most liked by the panelists despite its lower protein content, possibly due to the use of less mackerel flour compared to the other formulations. This may result in a more favorable taste, aroma or texture, but with reduced protein content as mackerel meal is the main source of protein in the product.

Table 2. Proximate testing results

Nutritional Content	Average Approximate Testing Result			Sig.	Standard for Emergency Food Sources (%)
	F1	F2	F3		
Carbohydrates	50.62±0.12'	53.28±0.20*	54.93±0.6°	0.003	36.8-54 ^a
Fat	33.63±-0.3'	32.7±1.1'	35.05±0.21*	0.087	32-48.9 ^a
Protein	12.30±0.21'	10.17±0.25*	8.3±0.21°	0.001	9.2-16.3 ^a
Ash	2.30±0.021'	2.18±0.035*	2.16±0.028*	0.029	1.4 ^b
Water	20.58±0.32'	20.35±0.35*	19.43 ±0.32*	0.07	9.5 ^b

Annotation: '* and °': values with the same symbol show no significant differences during 5% rates of testing (Duncan Test);
Sources: a. [11]
b. [12]

4 Conclusion

Tests performed on the food bar found that an increase in mackerel flour results in a higher water, ash and protein content, and causes no significant increase towards fat content. Analysis shows that the formulations factors play a significant role in variations on ash, protein, and carbohydrate content. Other than that, different formulas factors also affect color, aroma, and texture, with panelists preferring the third food bar formula (F3) although it has the lowest protein content.

5 Recommendation

Further research needs to be done, involving adding additional protein source, physical tests and antioxidant activity, especially due to the use of moringa flour, to see its role in safeguarding the immune systems of autistic/neurodivergent children during disaster situations. Reducing water content in emergency food sources could be done by increasing the surface area of the product during the cooking process. Otherwise, tests on shelf life should be done in order to confirm the safety of the food bars as an emergency food

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