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Development of High Dietary Fiber Cereal Bar as Emergency Food Product and The Chemical-Microbiological Properties and Nutritional Content

Pengembangan Sereal Bar Makanan Tinggi Serat sebagai Produk Makanan Darurat dan Sifat Kimia-Mikrobiologi serta Kandungan Gizi

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ABSTRACT

Background: Dietary fiber is essential for maintaining digestive health, especially during emergencies with limited food availability.
Objectives: To analyze the chemical, microbiological, and nutritional properties of high-fiber cereal bars designed as emergency food.
Methods: This study used an experimental design. The cereal bars were made from rice crisps and oats and tested based on chemical and microbiological parameters. Chemical analysis included dietary fiber, carbohydrates, protein, fat, minerals, and vitamins while the microbiological analysis covered total plate count (TPC) and detection of pathogenic bacteria such as Escherichia coli, Salmonella, and Staphylococcus aureus in accordance with food safety standards from the Indonesian Food and Drug Authority (BPOM). The testing was conducted from November 3–15, 2023, at PT Saraswanti Indo Genetech laboratory, Indonesia.
Results: The test showed that the mixed berry cereal bar contained 9.43% dietary fiber, exceeding BPOM standards. The product was free from heavy metal contamination (arsenic, cadmium, mercury, lead, and tin) and showed no trans fats. Microbiological tests confirmed that the product was safe from pathogenic microbes, with total plate count (TPC) and *Enterobacteriaceae* within safe limits. The product also did not contain *Salmonella* or *Staphylococcus aureus*.
Conclusions: This high-fiber cereal bar meets strict food safety and nutritional standards, making it suitable for development as emergency food. Its high fiber content and lack of harmful contaminants make it safe and nutritious for disaster victims. Continued testing and development with diverse flavors and formulations are recommended to improve acceptance across age groups in emergency situations.

INTRODUCTION

Dietary fiber is essential for maintaining digestive health[1,2], especially in emergencies where food variety is limited, as it helps prevent gastrointestinal issues. High-fiber foods provide a steady energy release, crucial for managing physical and emotional stress of disasters[3]. They also promote satiety and help control hunger during food scarcity. Additionally, fiber stabilizes blood sugar levels[4], reducing the risk of spikes and crashes. Adequate fiber intake lowers the risk of chronic diseases[5–7], supporting overall health and resilience during recovery. The urgency of this study stems from the increasing frequency of natural disasters, particularly in disaster-prone regions such as Indonesia, which disrupt food supply systems and lead to nutritional instability. Dietary fiber is crucial for maintaining digestive health and preventing gastrointestinal issues during emergencies. High-fiber foods provide steady energy, promote satiety, and help manage physical and emotional stress of affected populations. Developing Emergency Food Products (EFP) that meet these nutritional needs is vital for supporting disaster victims during recovery.

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The seriousness of the situation is highlighted by the heightened risk of malnutrition and chronic diseases among those affected by disasters. Insufficient dietary fiber can exacerbate health complications, making the development of high-fiber cereal bars essential. This study aims to innovate EFPs that are nutritionally adequate and culturally acceptable for diverse age groups. Using local Indonesian ingredients, the research supports local economies while promoting food security. The findings will enhance the effectiveness of food aid distribution and ensure that the nutritional needs of disaster victims are met, contributing to immediate relief and long-term recovery. Disasters cause disruption of food supply systems and put people at risk of food scarcity and nutrition instability[8]. The development of emergency food products (EFP) is important in disaster mitigation[9–11], especially in Indonesia which is vulnerable to various types of natural disasters[12–14]. The developed emergency food must not only meet the nutritional needs of disaster victims but also be well received by consumers of various age groups[15–17]. One of the products that has the potential to be developed as an emergency food is high-fiber cereal bars[18], which in addition to being practical and easy to store, also has good nutritional content. This product is expected to help meet the nutritional needs of disaster victims who experience limited access to fresh food during the recovery period.

However, to ensure that this emergency food product is feasible and widely acceptable, it is necessary to conduct an in-depth evaluation of the two variants of high-fiber cereal bars to be developed. This evaluation includes an analysis of the chemical, microbiological, and nutritional content of the product compared to the standards and regulations applicable in Indonesia[19,20]. Therefore, it is crucial to ensure that these products meet safety and nutritional standards and have a high acceptance rate among disaster victims.

By developing more preferred and diverse emergency food products, the government can increase the effectiveness of food aid distribution and ensure that the nutritional needs of disaster victims are properly met. The cereal bars analyzed are products that use local Indonesian ingredients. In order for this product to be accepted abroad, oats from abroad were added. High-fiber cereal bars can be one of the right solutions in meeting the needs of emergency food that is nutritious, safe, and accepted by all age groups in the midst of emergency situations. The purpose of this study is to analyze the chemical, microbiological, and nutritional properties of two variants of emergency food products (EFP) of high-fiber bar cereals.

METHODS

The test was carried out at Saraswanti Indo Genetech. Testing was conducted from November 3–15, 2023. The samples used in this study were cereal bars developed as emergency food products, with the main ingredients being rice crispy, oats, vegetable oil, sugar, and maltodextrin. Chemical analysis was carried out to determine the composition of chemical substances contained in cereal bar products, such as the content of dietary fiber, carbohydrates, proteins, fats, as well as the content of minerals and vitamins. Techniques that can be used in this test include a proximate test to analyze macronutrient composition (fat, protein, carbohydrates), as well as fiber measurement with special methods such as the gravimetric method for dietary fiber content[21–23].

The high-fiber cereal bars were made from the following ingredients: rice crispy, oats, plant-based fats, sugar, and maltodextrin. The production process consisted of several phases, namely mixing the ingredients in a specific proportion to form a consistent dough, shaping the dough into bars, drying the bars to reduce its moisture and enhance its shelf stability, and packaging the cereal bars under specific conditions to maintain their quality.

The exact proportions of each ingredient are proprietary, but they are designed to maximize dietary fiber content while ensuring taste and texture. A number of samples were analyzed, and two variants of high-fiber cereal bars were analyzed. Variable/parameters measured included chemical compositions, consisting of: dietary fiber, carbohydrates, proteins, fats, vitamins, and minerals, and microbiological contamination consisted of total plate count, *Enterobacteriaceae*, pathogenic bacteria (salmonella, staphylococcus aureus). Moisture content analysis was conducted to assess shelf-life stability. Chemical analysis was conducted through a proximate analysis to determine macronutrient composition (fat, protein, carbohydrates). Fiber measurement was conducted using the gravimetric method. Heavy metal testing was conducted using Inductively Coupled Plasma Mass Spectrometry (ICP MS) for arsenic, cadmium, mercury, lead, and tin.

Microbiological testing; total plate count was measured using Standar Nasional Indonesia - International Organization for Standardization (SNI ISO) 4833-1:2015, *Enterobacteriaceae* testing used SNI ISO 21528-2:2017, pathogen detection: Salmonella: ISO 6579-1:2017/Amd 1:2020, Staphylococcus aureus: ISO 6888-1:1999/Amd 2:2018, Standards used chemical analysis: SNI 01-2894-1992 for sulfite content. Methods for cholesterol and trans fatty acids were conducted through Gas Chromatography - Flame Ionization Detector (GC-FID). Microbiological Standards: SNI ISO 4833-1:2015 for total plate count, SNI ISO 21528-2:2017 for *Enterobacteriaceae* , ISO 6579-1:2017 for Salmonella. ISO 6888-1:1999 for Staphylococcus aureus.

The analysis of high-fiber cereal bars was conducted using methods established by the Association of Official Analytical Chemists (AOAC). The dietary fiber content was determined using AOAC Method 985.29, which involves enzymatic-gravimetric analysis to quantify total dietary fiber after hydrolyzing starches. Proximate analysis for macronutrients—protein, fat, and carbohydrates—was performed using AOAC Methods 979.09, 920.39, and 930.09, respectively. Microbiological safety was assessed through total plate count using AOAC Method 966.23, along with specific methods for detecting pathogens such as Escherichia coli, Salmonella, and Staphylococcus aureus.

To ensure the validity and reliability of the results, the study strictly followed these standardized AOAC methods, minimizing variations and enhancing comparability. All analytical instruments were regularly

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calibrated, and control samples were analyzed alongside test samples to verify results. Each analysis was performed in replicates to ensure reproducibility, and research personnels were trained in the specific methods to ensure proper execution. Additionally, a quality assurance program was established to monitor compliance with standards, ensuring that the results obtained were valid and reliable, thus providing a strong basis for the conclusions drawn about the high-fiber cereal bars. This process has been approved by the Health Research Ethics Commission of the Ministry of Health of Palu (Number: 0015.1/KEPK-KPK/1/2023), with an ethical exception granted by the commission for this study.

RESULTS AND DISCUSSIONS

Refugees often face significant challenges in obtaining nutritious food that meets their dietary needs. In emergency situations, where access to food sources is limited, and living conditions are unstable, it is crucial for them to receive a balanced nutritional intake. The need for food rich in fiber, proteins, and vitamins becomes essential for maintaining health and resilience, as well as helping them adapt to high-stress levels. This is where high-fiber cereal bars can serve as an effective solution. These products are specifically designed to meet the nutritional needs of refugees, with a balanced composition and significant health benefits.

High-fiber cereal bars contain a substantial amount of fiber, reaching about 9.43%, which can help prevent common digestive issues among refugees, such as constipation. Fiber also plays a role in providing longer-lasting satiety, thus reducing feelings of hunger amid food scarcity. Additionally, these products contain proteins and carbohydrates that are necessary for energy, which is vital for refugees who need to engage in daily activities under challenging conditions. Another advantage of cereal bars is their long shelf-life, allowing them to be stored without refrigeration. This makes them an ideal choice for emergency situations where food stability is essential.

Compared to other food products, such as instant meals and canned foods, high-fiber cereal bars offer a healthier alternative. Instant meals often contain high levels of salt and preservatives that can negatively impact long-term health. Meanwhile, canned foods are typically low in fiber and nutrients, which may not sufficiently meet the dietary needs of refugees. Thus, these cereal bars not only provide longer-lasting satiety but also offer better nutritional values.

The benefits of high-fiber cereal bars for the refugee population are significant. These products support digestive health, increase the energy needed for daily activities, and provide greater comfort and satisfaction over time. In crisis situations, where stress and uncertainty are high, receiving nutritious and satisfying food can have a positive impact on the mental and physical health of refugees. With practical and lightweight packaging, these cereal bars can be easily distributed to refugee camps, reaching more people in need.

From a production cost perspective, raw materials such as rice and oats are relatively affordable, and large-scale production can lower the cost per unit. By enhancing efficiency in the production and distribution processes, total costs can be minimized, making these products accessible to a larger number of refugees. Effective distribution programs, including collaborations with humanitarian aid organizations, can ensure that these cereal bars reach those who need them most.

Overall, high-fiber cereal bars represent a highly relevant and practical solution for refugees. By providing the necessary nutritional intake, while considering practical and cost aspects, these products not only help meet food needs during emergencies but also contribute to the long-term recovery of health and well-being for this vulnerable population.

Table 1. Chemical test results and nutritional content of cereal bars

No.	Parameter	Unit	Result	Limit Of Detection	Method
1	Sulfite	mg/kg	Not detected	1.6	SNI 01-2894-1992. Point 2.6.3
2	Dietary Fiber	%	9.43	-	18-8-6-2/MU/SMM-SIG
3	Cholesterol	mg/100 g	23.65	-	18-6-5/MU/SMM-SIG (GC-FID)
4	Trans Fatty Acids	%	Not detected	0.0015	18-6-1/MU/SMM-SIG (GC-FID)
5	Arsenic (As)	mg/kg	Not detected	0.0003	18-13-14/MU/SMM-SIG (ICP MS)
6	Kadmium (Cd)	mg/kg	Not detected	0.0005	18-13-14/MU/SMM-SIG (ICP MS)
7	Mercury (Hg)	mg/kg	Not detected	0.001	18-13-14/MU/SMM-SIG (ICP MS)
8	Lead (Pb)	mg/kg	Not detected	0.0004	18-13-14/MU/SMM-SIG (ICP MS)
9	Tin (Sn)	mg/kg	Not detected	0.0025	18-13-14/MU/SMM-SIG (ICP MS)
10	Carbohydrates (By Difference)	%	73.89	-	18-8-9/MU/SMM-SIG (Count)
11	Total Fat	%	12.53	-	18-8-5/MU/SMM-SIG point 3.2.2 (Weibull)
12	Protein	%	4.92	-	18-8-31/MU/SMM-SIG (Titrimetric)
13	Saturated Fat	%	9.71	-	18-6-1/MU/SMM-SIG (GC-FID)
14	Natrium (Na)	mg/100 g	61.28	-	18-13-1/MU/SMM-SIG (ICP OES)
15	Total Energy	Kcal/100g	428.01	-	Calculation

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No.	Parameter	Unit	Result	Limit Of Detection	Method
16	Energy from Fat	Kcal/100g	112.77	-	Calculation
17	Total Sugar	%	25.1	-	18-8-8/MU/SMM-SIG (Luff Schoorl)
18	Total Ash	%	0.67	-	SNI 01-2891-1992 point 6.1
19	Moisture Content	%	7.99	-	SNI 01-2891 - 1992, point 5.1

SNI = Standar Nasional Indonesia (Indonesian National Standard)
SIG = Saraswanti Indo Genetech
GC-FID = Gas Chromatography-Flame Ionization Detector
ICP MS = MS: Inductively Coupled Plasma Mass Spectrometry
ICP OES = Inductively Coupled Plasma Optical Emission Spectroscopy

Tabel 2. Microbiology test results of cereal bars

No.	Parameter	n	c	Result	m	M	Unit	Method
1	Total plate count	1	2	$1.0x10^1$	10^3	10^4	colony/g	SNI ISO 4833-1: 2015
2	Total plate count	2	2	<10	10^3	10^4	colony/g	SNI ISO 4833-1: 2015
3	Total plate count	3	2	<10	10^3	10^4	colony/g	SNI ISO 4833-1: 2015
4	Total plate count	4	2	$1.0x10^1$	10^3	10^4	colony/g	SNI ISO 4833-1: 2015
5	Total plate count	5	2	$4.0x10^1$	10^3	10^4	colony/g	SNI ISO 4833-1: 2015
6	*Enterobacteriaceae*	1	2	<10	10	10^2	colony/g	SNI ISO 21528-2:2017
7	*Enterobacteriaceae*	2	2	<10	10	10^2	colony/g	SNI ISO 21528-2:2017
8	*Enterobacteriaceae*	3	2	<10	10	10^2	colony/g	SNI ISO 21528-2:2017
9	*Enterobacteriaceae*	4	2	<10	10	10^2	colony/g	SNI ISO 21528-2:2017
10	*Enterobacteriaceae*	5	2	<10	10	10^2	colony/g	SNI ISO 21528-2:2017
11	Salmonella sp.	1	0	Negative	Negative	NA	/ 25 g	ISO 6579-1:2017/Amd 1:2020
12	Salmonella sp.	2	0	Negative	Negative	NA	/ 25 g	ISO 6579-1:2017/Amd 1:2020
13	Salmonella sp.	3	0	Negative	Negative	NA	/ 25 g	ISO 6579-1:2017/Amd 1:2020
14	Salmonella sp.	4	0	Negative	Negative	NA	/ 25 g	ISO 6579-1:2017/Amd 1:2020
15	Salmonella sp.	5	0	Negative	Negative	NA	/25 g	ISO 6579-1:2017/Amd 1:2020
16	Staphylococcus aureus	1	1	<10	10^2	$2x10^2$	colony/g	ISO 6888-1:1999/Amd 2: 2018
17	Staphylococcus aureus	2	1	<10	10^2	$2x10^2$	colony/g	ISO 6888-1:1999/Amd 2: 2018
18	Staphylococcus aureus	3	1	<10	10^2	$2x10^2$	colony/g	ISO 6888-1:1999/Amd 2: 2018
19	Staphylococcus aureus	4	1	<10	10^2	$2x10^2$	colony/g	ISO 6888-1:1999/Amd 2: 2018
20	Staphylococcus aureus	5	1	<10	10^2	$2x10^2$	colony/g	ISO 6888-1:1999/Amd 2: 2018

n = Number of Samples
c = Number of Positive Samples
m = Lower Limit of Acceptable Value
M = Upper Limit of Acceptable Value
SNI ISO = Standar Nasional Indonesia - International Organization for Standardization
NA = Not Applicable

Emergency Food Products (EFP) have an important role in disaster management, especially in Indonesia, which is prone to natural disasters. One form of innovation in the development of emergency food is high-fiber cereal bars with mixed berry flavor. This product is designed to meet the nutritional needs of

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disaster victims, while maintaining strict taste quality and food safety. In this study, cereal bars made mainly from rice and oat crisps were developed, with measurements of chemical and microbiological properties that showed promising results. Content Dietary fiber is an important component in food products, especially for emergency food, because it is able to support digestive health during the recovery period[24,25]. In this study, mixed berry flavored cereal bars had a dietary fiber content of 9.43 grams per 100 grams of product. This content is much higher than the standard set by the Indonesian Food and Drug Supervisory Agency (BPOM), which is 6 grams per 100 grams in solid form. This advantage shows that this product is not only qualified as an emergency food, but can also provide significant health benefits, especially in maintaining the intestinal health of disaster victims who may experience stress or limited access to healthy food.

The safety of emergency food products is a top priority during development, particularly in relation to the presence of harmful contaminants such as heavy metals and other chemical substances. According to laboratory test results, this mixed berry-flavored cereal bar shows no detection of sulfites, which are commonly used as preservatives but can cause side effects in sensitive individuals. Additionally, the cholesterol content in this product is 23.65 mg per 100 grams, which remains within the safe limit for daily consumption and complies with the standards for emergency food products. The product is also free from trans fatty acids, which were not detected in measurements. Since trans fatty acids are known to increase the risk of heart disease, their absence further enhances the health value of the product.

One of the important aspects in the safety evaluation of food products is the presence of heavy metal contamination, such as arsenic, cadmium, mercury, and lead[26–29]. The test results showed that the five types of heavy metals were not detected in mixed berry-flavored cereal bars. The absence of heavy metals in this product confirms that this cereal bar is safe to consume in emergency situations, where food safety is very crucial. The absence of heavy metals such as arsenic and mercury is very important because these substances are known to be harmful even in small amounts. This finding ensures that the product can be widely distributed to disaster victims without the risk of significant health hazards. This is in accordance with the food safety regulations set by BPOM Indonesia, which sets strict thresholds for these contaminants in food.

This cereal bar product uses rice crisps and oats as the main ingredients. These two ingredients were chosen because they have a high fiber content and a texture that is easy to consume in various conditions, including emergency situations. Oats are known to be rich in soluble fiber, which can help lower cholesterol levels[30–32] and control blood sugar levels[33–35]. Rice crisps, on the other hand, provide a crunchy texture that is preferred by a wide range of ages, including children and adults. The use of these healthy and easy-to-obtain ingredients increases the potential of cereal bar products to be an effective emergency food choice. In addition, since this product does not require special preparations, such as heating or further processing, it can be directly consumed in emergency situations, making it practical and efficient.

Carbohydrates are a very important main source of energy, especially in emergency situations when energy needs increase. This mixed berry cereal bars with carbohydrate content of 73.89% is sufficient to support the energy needs of disaster victims. This high carbohydrate content helps maintain the body's stamina and energy in emergency situations where access to food may be limited. In addition, the use of ingredients such as rice crisps and oats also provides complex carbohydrates, which are more slowly digested by the body, thus providing long-lasting energy. Regarding fat and saturated fat levels, the total fat content in this cereal bar was recorded at 12.53%, with saturated fat reaching 9.71%. Although the saturated fat content is quite high, this product is still within safe limits for emergency consumption. Fats are necessary to provide high energy, especially in conditions where calorie requirements are increased. In addition, fat also plays a role in the absorption of fat-soluble vitamins such as vitamins A, D, E, and K, which are important for the health of the body. The imbalance between saturated and unsaturated fats is usually a concern, but in the context of emergency foods, the presence of saturated fats is acceptable as these foods are designed to be used for a limited period of time. The importance of fat in providing longer energy and its role in maintaining body temperature, especially in extreme disaster situations, cannot be ignored.

The protein content in this cereal bar reached 4.92%. Although not as high as other animal or vegetable protein sources, this content is adequate to support protein intake needs in emergency conditions. Protein plays an important role in repairing and building damaged body tissues, especially for disaster victims who may experience physical stress or malnutrition. In addition, protein also helps in maintaining the body's immune function, which is very important in emergency situations.

The sodium in this cereal bar is measured at 61.28 mg per 100 grams. This relatively low sodium content ensures the product is safe for consumption by a wide range of groups, including those who may have salt sensitivities or high blood pressure. In the context of emergency food, moderate sodium levels are also important to prevent dehydration, which is often a problem in disaster situations. In terms of energy total, one of the important components in the development of emergency food is the total energy that can be supplied by the product. This cereal bar provides a total energy of 428.01 kcal per 100 grams, which is quite high and meets the calorie needs of disaster victims. This amount provides enough energy intake to help disaster victims survive in critical conditions. The sugar content in this cereal bar was recorded at 25.1%. This fairly high sugar content provides a sweet taste that can increase product acceptance by consumers, especially children. In addition, sugar also serves as a source of fast energy needed in emergency situations. On the other hand, the low ash content of 0.67% indicates that the product has good purity, with a small amount of non-organic minerals that the body does not need.

The moisture content in this product reaches

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7.99%, which is relatively low. Low moisture content is essential for emergency food products, as it helps to extend the shelf life of the product and prevent the growth of microorganisms that can cause food spoilage. In emergency situations, food with a low moisture content is safer and can be stored for a long period without the need for refrigeration.

Microbiological safety is one of the most important aspects in the development of food products, especially those intended for consumption in emergency situations. In this study, the total number of plates, *Enterobacteriaceae*, *Salmonella spp.,* and *Staphylococcus aureus* was measured. The results showed that the average total plate count was below standard, indicating that the product was safe from microbial contamination. The low measurement of the total plate count indicates that this product is manufactured with high hygiene standards, and a good manufacturing process so that there is no growth of pathogenic microorganisms harmful to health.

The presence of *Enterobacteriaceae* was also measured and the results showed less than 10 colonies per gram. *Enterobacteriaceae* is a group of bacteria that is often used as an indicator of the microbiological quality of a food product. The presence of these bacteria in low quantities indicates that the product is produced in clean and maintained conditions, thereby reducing the risk of infection or disease caused by microorganisms. Maintaining the quality of microbiology is important, considering that emergency food products are often consumed by vulnerable groups such as children, the elderly, and pregnant women.

Salmonella spp. and *Staphylococcus aureus* are two major pathogens that are often of concern in food safety analysis. In this test, the results showed that *Salmonella spp.* was not detected in this cereal bar product, which indicates that this product is safe from salmonellosis infection. In addition, *Staphylococcus aureus* measurement indicates fewer than 10 colonies per gram, which indicates that this product does not have a significant risk of contamination. The presence of these bacteria can cause food poisoning, so the result indicating the absence or very low number of these bacteria are encouraging.

All products of cereal bars with mixed berry-flavors are not detected to contain heavy metals. The number of microbes in cereal bar products meets the standards and regulations in Indonesia. The nutritional content of this product is in accordance with the regulations of the Indonesian Minister of Health regarding supplementary foods for toddlers and pregnant women by Minister of Health of the Republic of Indonesia 2021.

Future research should adopt a longitudinal approach to evaluate the long-term effects of high-fiber cereal bars on disaster victims' health, while also exploring consumer preferences for various flavors and formulations to enhance acceptance across different age groups. Expanding the nutritional analysis to include other essential nutrients and conducting field studies in disaster-prone areas would provide practical insights into usability and effectiveness. The study's strengths lie in its rigorous methodology and focus on dietary fiber, addressing critical nutritional needs during emergencies. However, limitations such as a small sample size and the short-term nature of the analysis highlight the need for broader investigations that include multiple product variants and long-term outcomes, ultimately improving the development of emergency food products.

CONCLUSIONS

Cereal bars show chemical and microbiological test results that meet food safety standards. This product contains 9.43% dietary fiber, 23.65 mg/100g cholesterol, is free from trans fatty acids and does not contain heavy metals such as arsenic, cadmium, mercury, lead, and tin. Microbiological tests showed that the total plate count (ALT) and *Enterobacteriaceae* were within safe limits, as well as free of pathogenic bacteria such as *Salmonella* and *Staphylococcus aureus*. In terms of nutritional content, this cereal bar is rich in carbohydrates (73.89%) with a total energy of 428.01 Kcal/100g, making it an ideal source of energy in emergency conditions. This mixberry bar cereal is safe and has the appropriate nutritional content to be developed as a safe, nutritious, and suitable emergency food for various age groups.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

AR: conceptualization, methodology, writing–review and editing; SS: methodology, supervision; EK: methodology; formal analysis, writing–original draft, LN: investigation, DN: formal analysis, resources; SB: writing–original draft, writing–review and editing, FH: methodology; formal analysis, writing, TM: methodology, supervision.

REFERENCES

1. Gill, S. K., Rossi, M., Bajka, B. & Whelan, K. Dietary fibre in gastrointestinal health and disease. *Nat. Rev. Gastroenterol. Hepatol.* **18**, 101–116 (2021) https://doi.org/10.1038/s41575-020-00375-4.
2. Müller, M., Canfora, E. & Blaak, E. Gastrointestinal Transit Time, Glucose Homeostasis and Metabolic Health: Modulation

How to cite: *Radiati, A., Sumarto, S., Hafid, F., Kamelia, E., Nurcahyani, L., Mariani, D., Badriah, S., & Muhandri, T. (2024). Development of High Dietary Fiber Cereal Bar as Emergency Food Product and The Chemical-Microbiological Properties and Nutritional Content: Pengembangan Sereal Bar Makanan Tinggi Serat sebagai Produk Makanan Darurat dan Sifat Kimia-Mikrobiologi serta Kandungan Gizi. Amerta Nutrition, 8(2SP), 67–74.*

by Dietary Fibers. *Nutrients* **10**, 275 (2018) https://doi.org/10.3390/nu10030275.
3. Goodlad, R. A. & Englyst, H. N. Redefining dietary fibre: potentially a recipe for disaster. *Lancet* **358**, 1833–1834 (2001) https://doi.org/10.1016/S0140-6736(01)06882-9.
4. Zhang, G. *et al.* Effect and mechanism of insoluble dietary fiber on postprandial blood sugar regulation. *Trends Food Sci. Technol.* **146**, 104354 (2024) https://doi.org/10.1016/j.tifs.2024.104354.
5. Li, M. & Ma, S. A review of healthy role of dietary fiber in modulating chronic diseases. *Food Res. Int.* **191**, 114682 (2024) https://doi.org/10.1016/j.foodres.2024.114682.
6. Ye, Z. Association between dietary fiber intake and cardiovascular mortality in patients with and without chronic kidney disease. *Precis. Nutr.* **3**, (2024) https://doi.org/10.1097/PN9.0000000000000064..
7. Gai, W., Lin, L., Wang, Y., Bian, J. & Tao, Y. Relationship between dietary fiber and all-cause mortality, cardiovascular mortality, and cardiovascular disease in patients with chronic kidney disease: a systematic review and meta-analysis. *J. Nephrol.* **37**, 77–93 (2024) https://doi.org/10.1007/s40620-023-01808-4.
8. Saggu, A. K., Tomer, V., Kumar, A. & Pandey, P. Consideration of Phytonutrients, Probiotics and Prebiotics for enhanced immunity during disaster relief situation – A review. *Clin. Nutr. Open Sci.* **47**, 131–146 (2023) https://doi.org/10.1016/j.nutos.2022.12.011.
9. Ghorbani, E., Dabbagh Moghaddam, A., Sharifan, A. & Kiani, H. Emergency Food Product Packaging by Pectin-Based Antimicrobial Coatings Functionalized by Pomegranate Peel Extracts. *J. Food Qual.* **2021**, 1–10 (2021) https://doi.org/10.1155/2021/6631021.
10. Hasan, N. W., Putri, T. P. & Zainal. Preparation of cookies from banana flour, soy flour, and Moringa leaf flour as an emergency food product. *IOP Conf. Ser. Earth Environ. Sci.* **486**, 012059 (2020) https://doi.org/10.1088/1755-1315/486/1/012059.
11. Fatmah, F. Mangrove Sword Bean Food Bar as the Emergency Food Product for Children Under the Age of Five Due to Landslides. *IDRiM J.* **14**, 197–211 (2024) https://doi.org/10.5595/001c.116627.
12. Putra, B. J., Saputra, R. & Situmorang, D. D. B. Non-Pharmacological Cooking Therapy: An Idea for Recovering the Mental Health of Adolescents as Disaster Victims of Mount Merapi Natural Eruption in Yogyakarta (Indonesia). *Prehosp. Disaster Med.* **38**, 544–545 (2023) https://doi.org/10.1017/S1049023X23005988.
13. Gasior, K., Wright, G., Barnes, H. & Noble, M. Adaptive social protection in Indonesia: Stress-testing the effect of a natural disaster on poverty and vulnerability. *Soc. Policy Adm.* **58**, 505–520 (2024) https://doi.org/10.1111/spol.12983.
14. Oktora, S. I. *et al.* Identifying the potential participation in natural disaster insurance: first attempt based on a national socio-economic survey in Indonesia. *Int. J. Disaster Resil. Built Environ.* **15**, 177–192 (2024) https://doi.org/10.1108/IJDRBE-04-2022-0034.
15. Sumarto, S., Radiati, A., Aprianty, D., Nuraeni, I. & Karimah, I. Development of Emergency Food Products From Various Flour of Cereals, Tubers, Pulses, and Local Freshwater Fish From Indonesia. *Asian J. Eng. Soc. Heal.* **2**, 171–187 (2023) https://doi.org/10.46799/ajesh.v2i3.48.
16. Pandin, M. G. R., Waloejo, C. S., Sunyowati, D. & Rizkyah, I. The Potential of Mocaf (Modified Cassava Flour) as Disaster Emergency Food. *IOP Conf. Ser. Earth Environ. Sci.* **995**, 012006 (2022) https://doi.org/10.1088/1755-1315/995/1/012006.
17. Balachanthar, S., Zakaria, N. A. & Lee, L. K. Development of emergency food assistance design: a nutritionally balanced, culturally tailored and cost-effective strategy for flood mitigation. *Ecol. Food Nutr.* **57**, 314–329 (2018) https://doi.org/10.1080/03670244.2018.1492380.
18. Tombini, C. *et al.* High-dietary fibers cereal bars containing malt bagasse by-product from the brewing industry. *J. Food Sci. Technol.* **61**, 1326–1333 (2024) https://doi.org/10.1007/s13197-023-05902-0.
19. Badan Pengawas Obat dan Makanan. *Peraturan Badan Pengawas Obat dan Makanan Nomor 13 Tahun 2023 Tentang Kategori Pangan*. 1–6 (BPOM, 2023).
20. Badan Pengawas Obat dan Makanan. *Peraturan Badan Pengawas Obat dan Makanan Nomor 1 Tahun 2022 tentang Pengawasan Klaim pada Label dan Iklan Pangan Olahan*. (2022).
21. McCleary, B. V *et al.* Total Dietary Fiber (CODEX Definition) in Foods and Food Ingredients by a Rapid Enzymatic-Gravimetric Method and Liquid Chromatography: Collaborative Study, First Action 2017.16. *J. AOAC Int.* **102**, 196–207 (2019) https://doi.org/10.5740/jaoacint.18-0180.
22. Kim, Y. *et al.* Thermo-gravimetric analysis method to determine the fiber volume fraction for PAN-based CFRP considering oxidation of carbon fiber and matrix. *Compos. Part A Appl. Sci. Manuf.* **102**, 40–47 (2017) https://doi.org/10.1016/j.compositesa.2017.07.024.
23. McCleary, B. AACC International Approved Methods Technical Committee Report: Collaborative Study on Determination of Total Dietary Fiber (Digestion-Resistant Carbohydrates per Codex Definition) by a Rapid Enzymatic-Gravimetric Method and Liquid Chromatography. *Cereal Foods World* **63**, 80–84 (2018) https://doi.org/10.1094/CFW-63-2-0080.
24. McGrath, A. P., Motsinger, L. A., Brejda, J. & Hancock, L. Prebiotic fiber blend supports growth and development and favorable digestive health

How to cite: *Radiati, A., Sumarto, S., Hafid, F., Kamelia, E., Nurcahyani, L., Mariani, D., Badriah, S., & Muhandri, T. (2024). Development of High Dietary Fiber Cereal Bar as Emergency Food Product and The Chemical-Microbiological Properties and Nutritional Content: Pengembangan Sereal Bar Makanan Tinggi Serat sebagai Produk Makanan Darurat dan Sifat Kimia-Mikrobiologi serta Kandungan Gizi. Amerta Nutrition, 8(2SP), 67–74.*

in puppies. *Front. Vet. Sci.* **11**, (2024) https://doi.org/10.3389/fvets.2024.1409394

25. Cheng, J., Sahin, A., Hu, C., Korczak, R. & Zhou, J. Editorial: New advances in dietary fibers and their role in metabolic, digestive, and immune health. *Front. Nutr.* **11**, (2024) https://doi.org/10.3389/fnut.2024.1404346.
26. Mielcarek, K. *et al.* Arsenic, cadmium, lead and mercury content and health risk assessment of consuming freshwater fish with elements of chemometric analysis. *Food Chem.* **379**, 132167 (2022) https://doi.org/10.1016/j.foodchem.2022.132167.
27. Parker, G. H., Gillie, C. E., Miller, J. V., Badger, D. E. & Kreider, M. L. Human health risk assessment of arsenic, cadmium, lead, and mercury ingestion from baby foods. *Toxicol. Reports* **9**, 238–249 (2022) https://doi.org/10.1016/j.toxrep.2022.02.001.
28. Mayne, S. T. The FDA's action plan to reduce dietary exposure to arsenic, lead, cadmium, and mercury for infants and young children. *Am. J. Clin. Nutr.* **117**, 647–648 (2023) https://doi.org/10.1016/j.ajcnut.2023.02.004.
29. Mukhi, S., Rukmini, M. S., Ajay Manjrekar, P., Iyyaswami, R. & H., S. Assessment of Arsenic, Vanadium, Mercury, and Cadmium in Food and Drug Packaging. *F1000Research* **11**, 648 (2024) https://doi.org/10.12688/f1000research.121473.3.
30. MS Wolever, T. *et al.* An Oat β-Glucan Beverage Reduces LDL Cholesterol and Cardiovascular Disease Risk in Men and Women with Borderline High Cholesterol: A Double-Blind, Randomized, Controlled Clinical Trial. *J. Nutr.* **151**, 2655–2666 (2021) https://doi.org/10.1093/jn/nxab154.
31. Xu, D. *et al.* Serum Metabolomics Reveals Underlying Mechanisms of Cholesterol-Lowering Effects of Oat Consumption: A Randomized Controlled Trial in a Mildly Hypercholesterolemic Population. *Mol. Nutr. Food Res.* **65**, (2021) https://doi.org/10.1002/mnfr.202001059.
32. Amerizadeh, A., Ghaheh, H. S., Vaseghi, G., Farajzadegan, Z. & Asgary, S. Effect of Oat (Avena sativa L.) Consumption on Lipid Profile With Focus on Triglycerides and High-density Lipoprotein Cholesterol (HDL-C): An Updated Systematic Review. *Curr. Probl. Cardiol.* **48**, 101153 (2023) https://doi.org/10.1016/j.cpcardiol.2022.101153.
33. Kim, I.-S., Hwang, C.-W., Yang, W.-S. & Kim, C.-H. Multiple Antioxidative and Bioactive Molecules of Oats (Avena sativa L.) in Human Health. *Antioxidants* **10**, 1454 (2021) https://doi.org/10.3390/antiox10091454.
34. Barati, Z., Iravani, M., Karandish, M., Haghighizadeh, M. H. & Masihi, S. The effect of oat bran consumption on gestational diabetes: a randomized controlled clinical trial. *BMC Endocr. Disord.* **21**, 67 (2021) https://doi.org/10.1186/s12902-021-00731-8.
35. Wehrli, F. *et al.* Oat Intake and Risk of Type 2 Diabetes, Cardiovascular Disease and All-Cause Mortality: A Systematic Review and Meta-Analysis. *Nutrients* **13**, 2560 (2021) https://doi.org/10.3390/nu13082560.

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