Food Research 10 (3) : 58 - 64 (June 2026)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Acceptability and shelf life of millet cookies (*Setaria italica*) and mackerel (*Rastrelliger kanagurta*) as alternative local food-based supplements for pregnant women at risk of chronic energy deficiency

Hasmawati, H., *Salam, A., Khuzaimah, A., Jafar, N. and Hasan, N.

Department of Nutritional Science, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia

Article history:
Received: 13 January 2026
Revised: 17 February 2026
Accepted: 21 February 2026
Published: 10 May 2026

Keywords:
Acceptance,
Shelf life,
Millet flour,
Mackerel fish flour,
Food additives,
Pregnant women

DOI:
https://doi.org/10.26656/fr.2017.10(3).112

Abstract

Chronic energy deficiency (CED) in pregnant women is a nutritional problem that contributes to an increased risk of pregnancy complications and low birth weight. The development of local food based supplementary foods with acceptable and stable storage is a potential strategy to support efforts to address chronic energy deficiency. This study aimed to evaluate sensory acceptability and predict the shelf life of cookies with the substitution of millet flour and mackerel fish flour as an alternative local food-based supplementary food product for pregnant women at risk of CED. This study used an experimental design. Three formulations were developed with the ratio of millet flour and mackerel fish flour, respectively, F1 (15:5), F2 (35:10), and F3 (50:15). Acceptability testing was conducted on 30 semi-trained pregnant panelists using a 5-point hedonic scale to assess color, aroma, taste, and texture. Sensory data were analyzed using the Kruskal-Wallis test followed by the Mann-Whitney test ($p<0.05$). Shelf life analysis was conducted using the accelerated shelf life testing (ASLT) method with an Arrhenius model approach based on changes in water content at temperatures of 25°C, 37°C, and 44°C. The results showed that F1 was the most acceptable formulation by the panelists, with an average score of 4.15 and was significantly different compared to other formulations ($p<0.05$). Shelf life analysis shows that the product has an estimated shelf life of 132.99 days at 25°C. All microbiological test results are below the maximum limit set in the Indonesian National Standard (SNI). These findings indicate that millet and mackerel cake have acceptable sensory characteristics and adequate storage stability, which indicates its potential as a locally based supplementary food to support maternal nutrition programs.

1. Introduction

Globally, maternal malnutrition remains a public health challenge, especially in low and middle-income countries. World Health Organization (WHO) reported that chronic energy deficiency (CED) and anemia in pregnant women contribute significantly to the incidence of low birth weight (LBW) and pregnancy complications (WHO, 2022). The Global Nutrition Report also shows that maternal undernutrition remains a major determinant of maternal and infant morbidity and mortality in various developing countries (Development Initiatives, 2023). Furthermore, a global analysis by Black *et al*. (2013) confirmed that maternal malnutrition has long-term impacts on child growth and development. This condition is caused by inadequate energy and protein intake over the long term, resulting in insufficient maternal energy reserves. In Indonesia, the status of maternal undernutrition in pregnant women is generally determined based on the size of the upper arm circumference (MUAC) <23.5 cm (Ministry of Health of the Republic of Indonesia, 2023). The high prevalence of CED indicates that existing nutrition interventions still need to be strengthened through more effective, contextual, sustainable approaches that are in line with local food potential.

Supplementary feeding program (SFP) is one of the recommended strategies for preventing and managing CED in pregnant women. However, the success of SFP is determined not only by nutritional adequacy but also by the level of sensory acceptability, practicality of consumption, and product stability during storage and distribution (De Pee and Bloem, 2009). SFP products with low acceptability or limited shelf life have the potential to reduce consumption compliance and reduce

*Corresponding author.
Email: *salamgiziuh@gmail.com*

eISSN: 2550-2166 / © 2026 The Authors.
Published by Rynnye Lyan Resources

the effectiveness of interventions, especially in pregnant women who often experience changes in sensitivity to taste and aroma. Cookies are one type of food that has the potential to be developed as SFP because they have high energy density, are easy to consume, flexible for fortification, and have a relatively long shelf life compared to semi-moist foods (Winarno, 2004; Manley, 2011).

Millet (*Setaria italica*) is a minor cereal rich in protein, dietary fiber, B-complex vitamins, and complex carbohydrates that contribute to a sustainable energy supply. Besides its potential as a gluten-free food ingredient, mill*et al*so offers agronomic advantages due to its tolerance to dry and marginal land conditions. Its substitution in bakery products has been reported to improve nutritional quality, although use in high proportions can affect sensory characteristics, particularly the appearance of a bitter taste (Saleh *et al*., 2013; Karakannavar *et al*., 2022). Meanwhile, mackerel (*Rastrellinger kanagurta*) is a source of high-quality animal protein containing omega-3 fatty acids, particularly EPA and DHA, which play an important role in supporting maternal health and fetal nervous system and brain development during pregnancy (Kris-etherton *et al*., 2002). Several previous studies have reported the use of millet flour and fish flour separately in bakery products to increase nutritional value (Sharma *et al*., 2016).

Although both ingredients have been extensively researched separately, studies combining them in a single cookie product specifically designed as a supplementary food for pregnant women with CED are still very limited. Furthermore, most previous studies have focused solely on formulation and acceptability, without evaluating long-term storage stability using a predictive kinetics approach. Therefore, this study offers a novel approach in integrating sensory evaluation and shelf life prediction based on the Arrhenius model to support the development of products that are not only nutritious but also stable and safe. This limitation limits the application of locally sourced food-based SFP products in large-scale nutrition intervention programs.

The aspect of storage stability becomes increasingly important in products containing fish flour. Mackerel fish flour has a relatively high fat content, including unsaturated fatty acids that are susceptible to oxidation. Lipid oxidation can cause rancidity, changes in aroma, and sensory degradation during storage (Choe and Min, 2006; Shahidi and Zhong, 2015). If left unchecked, these changes can decrease consumer acceptance and reduce the nutritional quality of the product. Therefore, shelf life testing using the accelerated shelf life testing (ASLT) approach with the Arrhenius model is necessary to predict product stability and ensure that cookies remain safe and acceptable during the distribution period.

Based on this background, this study aims to evaluate the sensory acceptability and predict the shelf life of cookies with millet flour and mackerel fish flour substitution as an alternative supplementary food based on local food for pregnant women with CED. By integrating sensory evaluation and shelf life kinetics prediction, this study is expected to provide scientific contributions in the development of products that not only have good nutritional value but are also stable and suitable to support nutritional intervention programs for pregnant women.

2. Materials and methods

This study uses an experimental design and focuses on product development, acceptability testing, and shelf life prediction using accelerated shelf life testing (ASLT). Proximate analysis was not included in this study. The study was conducted from March to May 2025 at the Food Technology Laboratory of the Nutrition Department of the Health Polytechnic of the Ministry of Health, Makassar, the Bread Production House, the Sudiang Community Health Center, and the Makassar Public Health Laboratory, with the aim of assessing the sensory quality and storage stability of cookies made from local food as supplementary food for pregnant women with chronic energy deficiency (CED).

2.1 Formulation, manufacturing process, and packaging of cookies

Millet seeds were obtained from traditional markets in Makassar City and processed into flour in the laboratory through sorting, washing, soaking, drying at 60°C for 12 h, grinding, and sieving through 80 mesh. Mackerel fish were obtained from local markets, then processed into flour through cleaning, steaming, oven drying at 55°C for 20 h, grinding, and sieving through 60 mesh before being used in the formulation. The main ingredients used in this study include wheat flour, millet flour (*Setaria italica*), mackerel fish flour (*Rastrelliger kanagurta*), cornstarch, sugar, butter, eggs, salt, and baking soda. Substitution of millet flour and mackerel fish flour was carried out for the total wheat flour as the base ingredient. Three formulas were developed in Table 1.

Table 1. Formulation of cookies with different levels of millet flour and mackerel fish flour substitution.

Formula	Flour (%)	Millet flour (%)	Mackerel fish flour (%)	Total (%)
F1	80	15	5	100
F2	55	35	10	100
F3	35	50	15	100

https://doi.org/10.26656/fr.2017.10(3).112

The process of making cookies is carried out using the creaming method, namely by beating butter, eggs, baking soda, and salt until homogeneous, then adding dry ingredients gradually until a uniform dough is obtained. The dough is molded with a weight of 5 g per piece to ensure uniformity of size and weight. Cookies are baked at a temperature of 150-180°C for 25-30 min until cooked and crispy, then cooled at room temperature. After cooling, cookies are packaged using tightly closed LDPE standing pouch plastic packaging to minimize exposure to moisture and environmental contamination, before sensory testing and shelf life analysis are carried out.

2.2 Acceptance test

Acceptability testing was conducted using a hedonic test on 30 panelists of pregnant women who met the inclusion criteria: healthy, no taste or smell disorders, no allergies to the food ingredients used, and no hyperemesis gravidarum. Sensory parameters assessed included color, aroma, taste, and texture.

The assessment was carried out using a hedonic scale of 1-5 with the interpretation: 1 = really dislike, 2 = dislike, 3 = neutral, 4 = like, 5 = really like. Samples were randomly assigned with numerical codes to avoid bias. This study received ethical approval from the Health Research Ethics Committee of the Faculty of Public Health, Hasanuddin University, and all panelists signed informed consent after receiving an explanation of the study.

2.3 Shelf life analysis

Shelf-life testing was conducted on the best formulation based on the results of the acceptance test using the accelerated shelf life testing (ASLT) method with an Arrhenius model approach. Changes in water content were used as an indicator of quality decline because they directly affect the texture and stability of cookies as a dry food product.

Cookie samples packaged in LDPE standing pouches were stored at three accelerated temperatures, namely 25°C, 37°C, and 44°C, and observed for 14 days. Data on changes in water content were analyzed using a zero-order reaction kinetics model, and then the model with the highest coefficient of determination (R2) value was selected. The R2 value at 25°C was 0.970; at 37°C it was 0.773; and at 44°C it was 0.656. The critical water content limit was set at 5%, referring to SNI 2971:2022 as the basis for determining the end of shelf life. The reaction rate constant (k) is used to calculate the activation energy (Ea) through the Arrhenius equation, which is then used to predict the shelf life of the product at room storage temperature.

2.4 Microbiological testing

The total plate count (TPC) test was performed using the pour plate method with reference to Awaru (2021). A 5-gram sample of food was first crushed and weighed, then placed in 45 mL of sterile peptone water as an initial dilution of 10^{-1}. The solution was homogenized using a vortex. Next, a multilevel dilution was carried out up to 10^{-5} by transferring 1 ml of the solution into 9 ml of sterile peptone water sequentially. From each dilution level, 1 ml of the suspension was pipetted into a sterile petri dish, then 15-20 ml of liquid Vogel Johnson Agar (VJA) medium was added. The dish was rotated in a figure 8 shape to mix the sample and medium homogeneously, then allowed to solidify. The petri dish was incubated in an inverted position at 37°C for 24-48 h. After incubation, the colonies that grew were counted as the total plate count (TPC). The results were expressed as colony-forming units (CFU/g).

2.5 Data analysis

Acceptability test data were analyzed using the Kruskal-Wallis test, followed by the Mann-Whitney test to determine the differences between formulations. Shelf life data were analyzed mathematically based on the reaction kinetics approach and the Arrhenius equation.

3. Results

The visual appearance of cookies from the three formulations (F1, F2, and F3) is presented in Figure 1. Differences in color intensity were observed, with higher substitution levels of millet flour and mackerel fish flour producing darker cookies. Based on Table 2, the results of the sensory assessment indicate that the substitution of millet flour and mackerel flour has a significant effect on all parameters of cookie preferences. F1 obtained the highest average value in the parameters of color (4.23), texture (4.20), aroma (3.83), and taste (4.33), while F3 consistently showed the lowest value in all four parameters. The results of the statistical test showed a significant difference between the formulations in all sensory parameters ($p < 0.05$), with p values of 0.017 for color, 0.004 for texture, 0.026 for aroma, and 0.000 for taste, respectively. The results of the Kruskal-Wallis test confirmed that the differences in formulations had a significant effect on panelists' sensory acceptance. The effect size analysis showed that the effect of formulation on taste and texture parameters was large ($\eta^2 > 0.14$),

Formula 1 Formula 2 Formula 3

Figure 1. Appearance of formulations.

https://doi.org/10.26656/fr.2017.10(3).112

Table 2. Average hedonic score of cookies with various levels of substitution of millet flour and mackerel fish flour.

Parameter	Average cookies with the substitution of millet flour and mackerel fish flour			p-value
	F1	F2	F3	
Color	4.23±0.568[a]	3.70±0.988[bc]	3.60±0.968[c]	0.017
Texture	4.20±0.664[a]	3.90±0.712[ac]	3.43±0.97[bc]	0.004
Aroma	3.83±0.791[a]	3.50±1.042[ac]	3.13±1.008[bc]	0.026
Flavor	4.33±0.661[a]	3.20±0.64[b]	2.33±0.922[c]	0.000

Values are presented as mean±SD. Values with different superscripts in the same row are statistically significantly different ($p<0.05$) using the Kruskal-Wallis test followed by the Mann-Whitney test as a post-hoc test.

while the effect on color and aroma parameters was in the moderate category. These findings indicate that differences in substitution levels are not only statistically significant but also have real practical implications for the level of cookie acceptance by panelists.

Based on the research results in Table 3, the moisture content of cookies packaged in standing pouch plastic bags increased during storage. At a temperature of 25°C, the moisture content increased from 0.26% on day 0 to 0.83% on day 14. Meanwhile, storage at 37°C and 44°C showed a higher increase in moisture content, reaching 0.63% and 0.94%, respectively, after 14 days of storage. However, the moisture content of cookies under all storage conditions remained below 5%, thus meeting the moisture content quality requirements for cookies according to SNI 01-2973:2022. In general, an increase in storage temperature was followed by an increase in the moisture content of cookies.

Table 3. Water content (%) of selected formula cookies during storage at various temperatures.

Day	Water content (%)		
	25°C	37°C	44°C
0	0.26	0.26	0.26
7	0.47	0.58	0.92
14	0.83	0.63	0.94

Based on the research results in Table 4, it shows that during 14 days of storage at three temperatures (25°C, 37°C, and 44°C), the number of microbes in cookies made from millet flour and mackerel fish flour fluctuated, but all TPC values remained well below the maximum SNI limit (4.00 log CFU/g). This indicates that the cookies are still microbiologically safe and have good stability during storage.

Table 4. Total plate count of cookies during storage at various temperatures.

Day	SNI limit (log CFU/g)	Total plate count (log CFU/g) at different storage temperatures		
		25°C	37°C	44°C
0	4	2.63	2.63	2.63
7		2.11	2.52	2.32
14		2.54	2.52	2.62

Based on the results of the accelerated shelf life testing (ASLT) in Table 5 using the Arrhenius model, it shows that cookies made from millet flour and mackerel fish flour have a shelf life of 132.99 days at 25°C, 126.70 days at 37°C, and 123.40 days at 44°C. There is a decrease in shelf life as the storage temperature increases. This pattern indicates that temperature plays an important role in accelerating the rate of product quality decline.

Table 5. Prediction of cookie shelf life at various storage temperatures based on the Arrhenius model.

Storage temperature	Shelf life (Days)
25	132.99
37	126.7
44	123.4

The shelf life values obtained indicate that cookies are classified as a relatively stable dry food product, even when stored at accelerated temperatures. The decrease in shelf life at higher temperatures indicates an increase in the rate of quality degradation reactions during storage.

4. Discussion

4.1 Acceptability test

The color difference between formulations is related to the intensity of the Maillard reaction that occurs during the baking process. The Maillard reaction is a non-enzymatic reaction between the free amino groups of proteins and the carbonyl groups of reducing sugars, producing brown compounds called melanoidins. Increasing the proportion of mackerel fish flour in F2 and F3 increases the protein content in the dough, thereby increasing the chance of the Maillard reaction occurring and producing a darker color. An overly intense brown color can decrease consumer acceptance because it is perceived as overcooked or visually unappealing (Winarno, 2004; Choe and Min, 2006). Furthermore, the natural pigments in mill*et al*so contribute to product color changes. Millet is known to contain phenolic compounds that can undergo a browning reaction during heating (Saleh *et al*., 2013). Thus, the combination of increased protein from fish flour and phenolic compounds from millet accelerated browning intensity in formulations with higher substitution levels. The darker appearance observed in F2 and F3 (Figure 1) supports the sensory findings, where higher substitution levels resulted in lower color acceptance scores. The addition of fish flour in high concentrations can disrupt the gluten structure of wheat flour, ultimately reducing the fragility and crispiness of cookies, according to findings (Nadimin, 2021).

Differences in aroma acceptance between formulations are related to the formation of volatile compounds from mackerel fish flour during roasting. Fish flour contains unsaturated fatty acids, especially EPA and DHA, which are susceptible to lipid oxidation at high temperatures. This oxidation process produces aldehydes, ketones, and other volatile compounds that contribute to the characteristic fishy odor (Choe and Min, 2006; Shahidi and Zhong, 2010). The higher the proportion of fish flour, the greater the potential for the formation of these volatile compounds, resulting in a more dominant fish aroma intensity in F2 and F3. Pregnant women's sensitivity to certain aromas may also increase due to physiological changes during pregnancy, making fishy aromas more easily rejected than more neutral aromas. Research conducted by Pratiwi (2013) on the use of mackerel meat flour in making fish sticks showed that the more fish meat flour used, the more pronounced the fish aroma in the fish sticks.

Flavor parameters showed the most significant differences between formulations. Increasing fish flour substitution can produce a stronger savory flavor due to the content of free amino acids and peptides from protein degradation. However, in high concentrations, this flavor can develop into an unpleasant aftertaste (Muchtadi *et al*., 2013). Furthermore, high amounts of millet have been reported to produce a slightly bitter sensation due to the content of phenolic compounds and dietary fiber (Saleh *et al*., 2013). Sharma *et al*. (2016) also reported that millet substitution above 40% in cookie products tends to reduce sensory acceptance, especially in terms of taste and texture. This explains why F1, with a more moderate substitution level, has a more acceptable flavor balance.

4.2 Water content of cookies

Moisture content is an important parameter in determining the texture and quality stability of cookies. Dry food products such as cookies are hygroscopic, so they readily absorb water vapor from the environment during storage. Increasing moisture content can cause a change in texture from crispy to softer due to the plasticization of the starch and protein matrix (Labuza and Altunakar, 2007).

Millet has a relatively high dietary fiber content. Fiber has a water-holding capacity that can affect dough structure and the final texture of the product (Sudha *et al*., 2007). On the other hand, protein from fish flour also contributes to water retention in the dough system. The combination of high fiber and high protein can increase water-binding capacity, which, at high concentrations, can potentially increase the hardness and decrease the crispness of cookies. This finding is consistent with research by Fustier *et al*. (2008), which reported that changes in water content during storage are directly related to changes in texture and decreased sensory acceptance in biscuit products.

Despite an increase in water content during storage at various temperatures, the moisture content of cookies made from millet flour and mackerel flour in this study remained within the required quality limits. The use of tightly sealed packaging, such as standing pouches, also plays a role in slowing the rate of water vapor absorption and maintaining product quality stability during storage (Robertson, 2016).

4.3 Microbiological safety

The total plate count (TPC) indicates the number of microbes in a product. TPC is useful for indicating quality, shelf life/half-life, contamination, and hygienic status during the production process. The SNI 01-2973:2022 standard regarding the maximum limit of microbial contamination in cookies is 4.00 log CFU/gram. Based on Table 4, it can be seen that the level of microbial contamination in cookies made from millet flour and mackerel fish flour decreased after storage for 0 days to 2 weeks at various temperatures and still met the SNI 01-2973:2022 standard (National Standardization Agency, 2022).

The decrease in the number of microbes at the beginning of storage can be caused by the low water content and water activity (aw) in cookies, as well as the presence of antimicrobial bioactive compounds from mackerel, such as omega-3 fatty acids, which have mild antibacterial properties (Muchtadi *et al*., 2013). However, the increase on the 14th day indicates that even though the product is classified as dry, cross-contamination and environmental exposure still have the potential to trigger microbial growth. Products with low water activity generally inhibit the growth of pathogenic microorganisms, although some heat-resistant microbes can still survive (International Commission on Microbiological Specifications for Foods (ICMSF), 2005; Beuchat *et al*., 2013).

Despite fluctuations in microbial counts during storage, the TPC results for all cookie samples at various temperatures and storage times remained well below the maximum microbial contamination limit, which is 4.00 log CFU/g, according to SNI 01-2973:2022. This indicates that cookies made from millet flour and mackerel fish flour are still safe for consumption for up to 14 days, provided they are stored hygienically and tightly closed.

4.4 Shelf life

The decrease in shelf life with increasing storage temperature is in accordance with the Arrhenius kinetic theory, which states that increasing temperature will increase the rate of chemical reactions that cause a decrease in food quality (Herawati, 2018). This condition explains why cookies stored at 44°C have a shorter shelf life than those stored at 25°C.

In products containing fish flour, lipid oxidation is a major factor in quality degradation during storage. The unsaturated fatty acids in mackerel are susceptible to oxidation, producing peroxides and aldehydes that can affect the product's aroma and flavor (Shahidi and Zhong, 2010). Therefore, increasing storage temperature accelerates the oxidation rate and shortens the product's shelf life.

The results of this study align with the global trend of developing fortified cookies based on minor cereals and alternative proteins. Sharma *et al*. (2016) showed that the use of high proportions of millet increases nutritional value but has the potential to reduce sensory acceptability. Dias *et al*. (2023) also emphasized that the balance between protein, fiber, and moisture content is crucial for consumer acceptance of gluten-free bakery products. Therefore, F1 demonstrates an optimal balance between increased nutritional value and sensory acceptability, making it more potential to be developed as a supplementary food product based on local foods.

The estimation of the shelf life of cookies in this study was conducted using the accelerated shelf life testing (ASLT) method with an Arrhenius model approach, which is effective in describing the effect of temperature on the rate of quality decline in dry food products. Increasing storage temperature is known to accelerate the rate of quality degradation reactions, especially those related to fat oxidation, thereby shortening the shelf life of cookies (Ardyanti *et al*., 2024).

From a public health perspective, these shelf-life prediction results have important implications for the development of Supplementary Feeding Program (SFP) products for pregnant women at risk of chronic energy deficiency. The relatively stable shelf-life suggests that these cookies have the potential to be distributed and stored in primary health care facilities without requiring special storage systems, thus supporting the efficiency and sustainability of maternal nutrition intervention programs.

However, this study has several limitations. Shelf-life predictions were conducted using accelerated conditions that do not fully represent temperature and humidity variations during actual distribution in the field. Furthermore, the quality kinetics modeling focused on moisture content parameters, thus not reflecting the full dynamics of product quality degradation, including sensory changes and long-term microbiological stability. Therefore, these shelf-life results should be viewed as preliminary estimates that require further validation.

5. Conclusion

Cookies with millet flour and mackerel fish flour substitutes showed a good level of sensory acceptance, especially in F1, and had adequate storage stability based on the predicted results of accelerated shelf life testing (ASLT) using the Arrhenius model. The estimated shelf life of 132.99 days at 25°C and the microbiological quality that met the SNI standard of this product indicated the stability of quality and microbiological safety during the testing period. These findings indicate the potential for developing locally based food products as an alternative supplementary feeding program (SFP) for pregnant women at risk of experiencing chronic energy deficiency (CED). However, a proximate composition analysis was not performed in this study. Therefore, further research is needed to comprehensively examine the nutrient profile, assess its contribution to meeting the Recommended Dietary Intake (RDA) for pregnant women, and test its effectiveness through intervention studies.

References

Ardyanti, D.K., Yuwono, S.S. and Septifani, R. (2024). Estimation shelf life elicited soybean sprout cookies with accelerated shelf life testing method arrhenius model. *Journal of Food and Agroindustry,* 12(3), 165–174. https://doi.org/10.21776/ub.jpa.2024.012.03.5

Awaru, A.F. (2021). Food microbiology practical module. Makassar, Indonesia: PT. Isam Light of Indonesia.

Beuchat, L.R., Komitopoulou, E., Beckers, H. and Betts, R.P. (2013). Low – water activity foods: Increased concern as vehicles of foodborne pathogens. *Journal of Food Protection*, 76(1), 150–172. https://doi.org/10.4315/0362-028X.JFP-12-211

Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R. and Uauy, R.

(2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet*, 382(9890), 427–451. https://doi.org/10.1016/S0140-6736(13)60937-X

Choe, E. and Min, D.B. (2006). Mechanisms and factors for edible oil oxidation. *Comprehensive Reviews in Food Science and Food Safety,* 5(4), 169–186. https://doi.org/10.1111/j.1541-4337.2006.00009.x

De Pee, S. and Bloem, M.W. (2009). Current and potential role of specially formulated foods and food supplements for preventing malnutrition among 6- to 23-month-old children and for treating moderate malnutrition among 6- to 59-month-old children. *Food Nutrition Bulletin*, 30(3 Suppl.), S434-S463. https://doi.org/10.1177/15648265090303S305

Development Initiatives. (2023). Global Nutrition Report 2023. Retrieved from website: https://globalnutritionreport.org/reports/2023-global-nutrition-report

Dias, V., Val, E., Scarton, M., Silva, M.T. and Carolina, A. (2023). Current status and future prospects of sensory and consumer research approaches to gluten-free bakery and pasta products. *Food Research Internasional,* 173, 113389. https://doi.org/10.1016/j.foodres.2023.113389

Fustier, P., Castaigne, F., Turgeon, S.L. and Biliaderis, C.G. (2008). Impact of ingredients and storage conditions on the texture and sensory properties of biscuits. *Journal of Food Engineering,* 86(3), 379–389. https://doi.org/10.1016/j.jfoodeng.2007.10.024

Herawati, H. (2018). Determining the shelf life of food products. *Journal of Agricultural Research and Development*, 27(4), 124–130.

International Commission on Microbiological Specifications for Foods (ICMSF). (2005). Microorganisms in foods 6: Microbial ecology of food commodities. https://doi.org/10.1007/0-387-28801-5

Karakannavar, S., Nayak, G., Hegde, S. and Sreeramaiah, H. (2022). Development and evaluation of the proso millet cookies. *International Journal on Advanced Science Engineering and Information Technology,* 10 (2), 12–16.

Ministry of Health of the Republic of Indonesia. (2023). Technical guidelines for providing supplementary food for pregnant women with chronic energy deficiency (CED). Retrieved from Ministry of Health of the Republic of Indonesia website: https://kesmas.kemkes.go.id/assets/uploads/contents/others/20230516_Juknis_Tatalaksana_Gizi_V18.pdf

Kris-Etherton, P.M., Harris, W.S. and Appel, L.J. (2002). Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. *Circulation,* 106(21), 2747–2757. https://doi.org/10.1161/01.CIR.0000038493.65177.94

Labuza, T.P. and Altunakar, B. (2007). Water activity prediction and moisture sorption isotherms. *Food Science and Technology International,* 13(4), 241–247. https://doi.org/10.1002/9780470376454.ch5

Manley, D. (2011). Manley's technology of biscuits, crackers and cookies. 4th ed. Cambridge, UK: Woodhead Publishing. https://doi.org/10.1016/B978-0-12-384947-2.00076-3

Muchtadi, T.R., Sugiyono and Ayustaningwarno, F. (2013). Food Science. 4th ed. Bandung, Indonesia.

Nadimin, N. (2019). Mutu Organoleptik Cookies dengan Penambahan Tepung Bekatul dan Ikan Kembung. *Media Gizi Pangan,* 26(1), 8-15. https://doi.org/10.32382/MGP.V26I1.991

Pratiwi, F.I. (2013). Utilization of mackerel meat flour for making fish sticks. Semarang, Indonesia: Semarang State University, BSc. Thesis.

Robertson, G.L. (2016). Food packaging: Principles and practices. 3rd ed. Boca Raton, USA: CRC Press. https://doi.org/10.1201/b21347

Saleh, A.S.M., Zhang, Q., Chen, J. and Shen, Q. (2013). Millet grains: Nutritional quality, processing, and potential health benefits. *Comprehensive Reviews in Food Science and Food Safety*, 12(3), 281–295. https://doi.org/10.1111/1541-4337.12012

Shahidi, F. and Zhong, Y. (2010). Lipid oxidation and improving the oxidative stability. *Chemical Society Reviews*, 39(11), 4067–4079. https://doi.org/10.1039/b922183m

Sharma, S., Saxena, D.C. and Riar, C.S. (2016). Nutritional, sensory and antioxidant properties of gluten-free cookies from minor millets. *Journal of Cereal Science*, 72, 153–161. https://doi.org/10.1016/j.jcs.2016.10.012

National Standardization Agency. (2022). Biscuits (SNI 2973:2022). Jakarta, Indonesia: National Standardization Agency.

Sudha, M.L., Vetrimani, R. and Leelavathi, K. (2007). Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. *Food Chemistry*, 100(4), 1365–1370. https://doi.org/10.1016/j.foodchem.2005.12.013

Winarno, F.G. (2004). Food chemistry and nutrition. Jakarta, Indonesia: Gramedia Pustaka Utama.

World Health Organization (WHO). (2022). WHO recommendations on maternal nutrition. Retrieved from WHO website: https://www.who.int/publications/i/item/9789240051343

