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Acceptance, nutritional content, and shelf life of cookies based on millet flour as a functional food

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Abstract. The purpose of this study was to determine the acceptability, nutritional content, and shelf life of cookies based on millet flour as a functional food. This type of research is a laboratory-based descriptive. Formulation cookies flour of millet is distinguished by the addition of flavorings nature of which includes millet flour cookies without additional flavorings (F1), banana flavor millet flour cookies (F2), spice flavor millet flour cookies (F3) and chocolate flavor millet flour cookies (F4). Data collection procedure was carried out by hedonic test on untrained panelists consisting of men and women aged 18-40 years as many as 25 panelists, then the selected formulations were analyzed for nutritional content and shelf life. Data were analyzed using the Kruskal-Wallis analysis method and continued with the Mann-Whitney test if the treatment had a significant effect. The panelists' acceptance showed that the formulation of millet flour cookies had no significant effect ($p>0.05$) on the color, taste, aroma, texture and overall cookies. The F1 cookies formula without the addition of flavoring has the highest average value of the other formulas, which is 4.16 with the preferred category. The results of the proximate test on the selected cookies include water content 6.1%, ash 2.14%, protein 8.38%, fat 30.38%, carbohydrates 53.0%, fiber 2.22%, and total energy 518.98 kcal. The shelf life of cookies using the Arrhenius approach is 14 days at a temperature of 250C, 370C, and a temperature of 440C with the results respectively 134.81 days (4.5 months), 79.18 days (2.6 months) and 59.14 days (1.9 months). While the results of the total microbial test showed that there was a decrease in total microbes in millet flour cookies stored in an incubator at 250C, 370C, and 440C for 4 weeks of storage, respectively 2.05 x 102, 1.05 x 102, and < 4 0.0 x 101, still meets the standard of SNI 01-2973:2011 with a maximum of 1 x 104 colonies/gram. Based on the results of the study, millet flour cookies can be enriched with food sources of protein and fiber so that it can increase the nutritional value of cookies as an additional food.

Keywords: Millet, Functional Food, Acceptability, Nutritional Content of Shelf Life

Introduction

Millet is a cereal plant that can grow on marginal land, namely dry climatic conditions, infertile soils and limited irrigation while other cereal crops are less successful (Nurmala, 2003). Millet plants can grow optimally with potential yields that can reach 3-4 tons/ha (Faesal, 2013) both tropical and sub-tropical areas such as Indonesia, India, China, Asia, North Africa, and America (Ramlah et al., 2020). In Indonesia this plant can be found in the Buru area in Jember, Papua, East Nusa Tenggara, South Sulawesi such as Enrekang, Sidrap, Maros, West Sulawesi

namely Polewali Mandar, Majene and other areas (Fitriani et al., 2013). In Indonesia, the use of millet as a food source is still not widely known to the public. Whereas millet is one of the alternative food crops to replace rice and wheat flour that has the potential to be developed in order to strengthen food security (Rauf & Lestari, 2009; Indriasari et al., 2020).

Millet has excellent nutritional quality as a functional food source of energy and protein which is comparable to other major cereals such as wheat, rice, and corn (Saleh, *et al.*, 2013). This plant is rich in carbohydrates, protein, fat, and fiber (Bandyopadhyay, *el al*., 2017), and has a low glycemic index so that it can be used in therapeutic diets (Thathola, *et al*., 2011).

Millet as a natural source of fiber, calcium, and magnesium, is an alternative food for diabetics. Slow absorption of glucose can regulate the insulin produced in the body's system. Hence, it not only lowers sugar levels but also improves insulin response. Rich in fiber also serves to help prevent constipation (constipation), so the body has a healthy digestive system for diabetics (Parvathi, *et al.*, 2015)

In several previous studies, millet flour has been widely used as an additional ingredient combined with wheat flour in various products such as noodles, bread, nuggets, brownies, and cookies. There were other studies that used other basic ingredients of flour as a substitute or substitute for wheat flour, namely in the research of Sukandar et al. (2014) showed that cookies made from breadfruit flour had low acceptance compared to other flour-based cookies, but the formulation of cookies made from breadfruit flour with soy milk added was the preferred cookie. Therefore, it is necessary to have additional ingredients that can improve the taste, color, aroma, and texture of cookies.

As for this study, researchers are interested in looking at the organoleptic quality, nutritional content, and shelf life of cookies made from millet flour with the formulation of flavoring additives as functional food.

Methods

This research is a descriptive study using laboratory analysis with two repetitions. The implementation of the research includes data, analysis, and interpretation of the data obtained from the results of the acceptance test on the panelists and the results of laboratory analysis. The population in this study was foxtail millet, a local variety from Majene Regency, West Sulawesi Province and millet cookies products.

In the preliminary research in the form of making millet flour. Millet seeds are obtained from traditional markets in Majene Regency. First, the millet seeds are washed and then soaked for 4 hours and then dried for about 7-8 hours in the sun. The dried millet seeds were ground using a flour grinder and then sieved using an 80 mesh sieve, then the flour was stored in a jar (Sulistyaningrum et al., 2018). As for making millet flour cookies, several experiments were carried out with modifications to previous research S. Rauf & Mustamin, (2020) which aims to get cookies products with good quality and according to standards. Millet flour is the main ingredient for replacing wheat flour in making cookies.

The results obtained from this preliminary study were continued to the main research, namely the initial stage in the form of making a formula for millet flour cookies with the addition of flavor variants. The second stage, hedonic test of cookie formula to 25 untrained panelists to find out the most preferred cookies formula by panelists. The third stage, the selected cookies formula was analyzed for nutritional content and shelf life with 2 repetitions.

The formula for the use of ingredients for making cookies consists of the main ingredient of 100 grams of millet flour and supporting ingredients in the form of margarine, butter, salt, chicken egg yolk, refined sugar, vanilla, baking powder, milk powder, and additional food

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flavors including F1 for cookies without added flavoring, F2 cookies with banana flavor, F3 cookies with spice flavor, and F4 cookies with chocolate flavor.

Table 1. Formulation of *cookies* based on millet flour

Material	F1	F2	F3	F4
	Measure size	Measure size	Measure size	Measure size
Millet flour	100 gram	100 gram	100 gram	100 gram
Refined sugar	40 gram	40 gram	40 gram	40 gram
Salt	1/4 teaspoon.	1/4 teaspoon.	1/4 teaspoon.	1/4 teaspoon.
Chicken yolk	1 item	1 item	1 item	1 item
Margarine	15 gram	15 gram	15 gram	15 gram
Butter	45 gram	45 gram	45 gram	45 gram
Milk powder	20 gram	20 gram	20 gram	20 gram
Baking powder	1/4 teaspoon	1/4 teaspoon	1/4 teaspoon	1/4 teaspoon
Vanilla	1/2 teaspoon.	1/2 teaspoon.	1/2 teaspoon.	1/2 teaspoon.
Spekoek spice Powder	-	-	1/2 teaspoon.	-
Chocolate bars	-	-	-	15 gram
Ambon banana	-	20 gram	-	-

The stages of making cookies are first add margarine, butter, salt and sugar and then mix briefly on low speed until well blended. Second, add egg yolks, baking powder, vanilla, skim milk, and food flavors (spices, chocolate, and bananas) and mix again. Third, add the millet flour and mix gently with a spatula. Fourth, after the dough is well mixed, if the dough is a bit wet then let the dough rest for ± 10 minutes at refrigerator temperature so that the dough is easy to shape. Fifth, the dough is printed with a thickness of ± 0.8 cm. Finally, bake cookies at 160^0C for ± 10 minutes.

Results

1. Flour and *cookies* of jewawut

The nutritional content of millet flour and millet cookies based on laboratory results is as follows:

Table 2. Nutritional content of millet flour and millet *cookies*

Nutritional content	Millet flour	SNI 3751:2009 flour	Millet *Cookies*	SNI 01-2973-2011 *Cookies*
	Sum	sum	sum	sum
Water (%)	8,96	Max.14.5	6,1	Max. 5
Ash (% bk)	4,88	Max. 0,70	2,14	Max. 3
Protein (% bk)	14,49	Min. 7,0	8,38	Min. 5
Fat (% bk)	16,89	Not available	30,38	Min. 9,5

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Carbohydrates (% bk)	54,78	Not available	53,0	Min 70
Fiber (% bk)	3,53	Not available	2,22	Max. 0,5
Energy (kcal)	429,09	Not available	518,94	Min. 400

Source: Primary Data, 2020

Based on table 2, the nutritional content of millet flour seen from the water content of 8.96%, has met the quality requirements of SNI. Judging from the ash content of 4.88%, it does not meet the quality requirements of SNI. The protein content of 14.49%, above the minimum requirement of SNI means that the protein content has met the quality requirements of SNI. The organoleptic test process used 25 untrained panelists consisting of 15 women and 10 men. The results of the analysis of the acceptability of millet flour cookies can be seen in table 3

Table 3. Results of acceptability test *cookies* millet flour

Parameter	Millet flour cookies score				*Kruskal Wallis test (p=0,05)*
	F1	F2	F3	F4	
color	4,12	3,92	4,08	4,08	0,642
taste	4,08	3,96	3,92	3,92	0,826
Aroma	4,16	4,04	3,96	4,16	0,656
texture	4,16	3,96	4,04	4,08	0,559
sum	4,16	4,12	4,04	4,12	0,832

Source: Primary Data, 2020

a. Color aspects

Based on table 3, it shows that the preference score for the color of millet flour cookies ranges from 3.92-4.12 with a rather like-like category. In the F1 formula, millet flour cookies without the addition of flavorings had the highest average value of the other formulas, namely 4.12. Meanwhile, based on the results of the Kruskal-Wallis analysis, p>0.05 (0.642) showed that there was no significant difference in the color of all millet flour cookie formulas.

b. Aspects of taste

Based on table 3, it shows that the preference score for the taste of millet flour cookies ranges from 3.92-4.08 with a rather like-like category. In the F1 formula, millet flour cookies without the addition of flavorings had the highest average value of the other formulas, namely 4.08. Meanwhile, based on the results of the Kruskal-Wallis analysis, p>0.05 (0.826) showed that there was no significant difference in the taste of all millet flour cookie formulas.

c. Aroma aspect

Based on table 3, it shows that the preference score for the aroma of millet flour cookies ranges from 3.96-4.16 with a rather like-like category. The F1 formula for cookies with millet flour without the addition of flavoring and the F4 formula for cookies with chocolate flavored millet flour had the highest average value of the other formulas, namely 4.16. Meanwhile, based on the results of the Kruskal-Wallis analysis, p>0.05 (0.656) showed that there was no significant difference in taste in all formulas of millet flour cookies.

d. Texture aspects

Based on table 3, it shows that the preference score for the texture of millet flour cookies ranges from 3.96-4.16 with a rather like-like category. In the F1 formula, millet flour cookies without the addition of flavorings had the highest average value of the other formulas, namely 4.16.

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Meanwhile, based on the results of the Kruskal-Wallis analysis, p>0.05 (0.559) showed that there was no significant difference in the texture of all millet flour cookie formulas.

e. Overall

Based on table 3, it shows that the preference score for the whole millet flour cookies ranges from 4.04-4.16 with the like category. In the F1 formula, millet flour cookies without the addition of flavorings had the highest average value of the other formulas, namely 4.16. Meanwhile, based on the results of the Kruskal-Wallis analysis, p>0.05 (0.832) showed that there was no significant difference in the overall level of preference for all millet flour cookie formulas.

2. Shelf life of *cookies*

a. Up to air

The initial moisture content of millet flour cookies was 3.32%. The standard value for accepting cookies is based on SNI 01-2973:2011 with a maximum moisture content of 5%. The results of the analysis of the water content of the F1 formula are as follows:

Table 3. The results of the analysis of the water content of the selected formula cookies

Sample	Day 1	Water Rate (%)		
		Temperature 25^0C	Temperature 37^0C	Temperature 44^0C
Cookies Formula F1	0	3,32	3,32	3,32
	4	2,03	2,97	3,37
	7	2,9	2,84	2,27
	11	2,79	3,19	2,48
	14	3,4	3,14	2,3

Source: Primary Data, 2020

Based on table 3, it can be seen that there was an increase in water content during 14 days of storage in cookies stored at 25^0C, from 3.32% to 3.4%. Meanwhile, there was a decrease in the moisture content of cookies at 37^0C, from 3.32% to 3.14% and at 44^0C, 3.32% to 2.3% during 14 days of storage.

Table 4. Constant values of quality changes and shelf life of millet flour cookies

Temperature (^{0}C)	Value k	Shelf life (days)	Shelf life (months)
25	0,0124	134,81	4,5
37	0,0212	79,18	2,6
44	0,0284	59,14	1,9

Source: Primary Data, 2020

Based on Table 4, it can be seen that the increase in the value of the reaction rate (k) of cookies varies at each storage temperature. The highest k value is at a storage temperature of 44^0C, which is 0.0284 and the lowest k value is at a temperature of 25^0C, which is 0.0124. The results obtained from the calculation of the shelf life of cookies at storage temperatures of 25^0C, 37^0C, and 44^0C respectively were 134.81 days (4.5 months), 79.18 days (2.6 months) and 59.15 days (1.9 months). The equation obtained for determining shelf life is y = -4096,5x + 9,3615 with an activation energy of 8.135 kcal/mol.

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b. Total Microbes

Table 5. results of total microbial analysis of millet flour cookies

Storage length	ALT result at storage temperature (colony/g)		
	Temperature 25^0C	Temperature 37^0C	Temperature 44^0C
Day 0	$2,6x10^2$	$2,6x10^2$	$2,6x10^2$
Week 1	$2,45x10^2$	$1,1x10^2$	$<4x10^1$
Week 2	$2,15x10^2$	$1,15x10^2$	$<4x10^1$
Week 4	$2,05x10^2$	$1,05x10^2$	$<4x10^1$

Source : Primary Data, 2020

The results of the total microbial analysis of millet flour cookies listed in table 5 show that there was a decrease in total microbes in millet flour cookies that were stored in an incubator with temperatures of 25^0C, 37^0C, and 44^0C from 0 day storage to week 1 to week 4 storage. The highest decrease in total microbes was found at room temperature storage, which was a decrease of 0.55 x 10^2. Then followed by storage at 37^0C where there was a decrease of 0.05 x 10^2. The total microbes at 44^0C storage temperature remained stable, namely under $4.0x10^1$. All cookies that were stored in the three temperatures for 30 days were still within the safe limits of SNI 01-2973:2011 which is 1 x 10^4 colonies/gram.

Discussion

1. Nutritional content of *cookies* based on jewawut flour

a. Ash Content

Based on table 1, the ash content in millet flour cookies is 2.14%, indicating the results according to the SNI (Indonesian National Standard) quality standard are maximum 3%. The ash content in millet flour cookies is influenced by the flour or mineral content in the flour material and the processing during baking. The ash content in the product is closely related to the quality of food products, the higher the ash content, the lower the product quality. In Febrianto, Basito and Anam, (2014) states that the determination of total flour is used to determine the parameters of the nutritional value in food ingredients, to determine whether a processing process is good or not, and to determine the type of ingredients used.

b. Water Content

Moisture content in millet flour cookies is 6.1%, it does not meet the SNI maximum quality standard of 5%. The high water content in millet flour cookies is possible due to the storage process at laboratory room temperature with 42% humidity in PP (Polypropylene) plastic containers during the 14 day research waiting period so it is estimated that it can affect the moisture content in cookies.

In Jamaluddin dkk (2014) that the interaction between the product and water molecules in the environment will result in water vapor being able to move from the environment into the product. The transfer of moisture from the environment to cookies or vice versa occurs during storage. As for the research Herawati (2008) explained that the permeability of polyethylene (PE) plastic is smaller than polypropylene (PP) so that it can cause the amount of water vapor to more easily enter the packaging material per unit of time.

c. Protein content

The protein content of millet flour cookies is 8.38%, it has met the SNI quality standard, which is at least 5%. The protein content of cookies is strongly influenced by the basic ingredients used, namely millet flour as a protein source based on the BPOM reference with a protein content of 14.49%. In addition, the protein content of cookies is also supported by the use of additional ingredients such as powdered milk.

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In research Yustini dkk. (2019) explained that millet flour as one of the ingredients for developing food products with high protein content can improve the function of flour so that it can be used as a single raw material or does not require substitution anymore.

However, in the processing, the protein content of millet flour cookies is reduced due to heating during baking at 160^0C and 10 minutes. Based on BPOM on nutritional claims for food products, the protein content of millet flour cookies does not meet the requirements as a protein source, which is 20% of the nutritional label reference or 12 grams/100 grams. In research Kasim et al. (2018) explained that the higher the temperature and the roasting time, the lower the protein content.

d. Fat content

The fat content of millet flour cookies is 30.38%, indicating that the results have met the SNI quality standard, which is at least 9.5%. The high fat content in cookies is strongly influenced by the supporting materials used. The addition of margarine, butter, and egg yolks can increase the fat content of the product.

From research results Hasibuan and Hardika (2015), commercial margarine contains a fat fraction of 83.7% and a water fraction of 16.3% and a carotene content of 10 ppm in fat. The butter has a fairly high fat content of 82% and a water content of 15.9% (Ensminger et al., 1993). The egg yolk contains 32% fat (Widyastuti et al., 2015).

In Research conducted by Kasim et al., (2018) explained that the higher the temperature and the roasting time, the lower the protein content. During roasting, the amount of free water is lost and the protein will be denatured to form a simpler structure.

Fat can interact with starch granules and prevent hydration so that the increase in viscosity of the material becomes low. The mechanism of inhibition is that fat will form a layer on the outside of the starch granules and at the same time will inhibit the penetration of water into the granules. Less water penetration will result in high gelatinization and will form less fluffy cookies with a denser/compact texture (Oktavia, 2007)

e. Fiber content

The fiber content in millet flour cookies is 2.22%, it has met the SNI quality standard, which is at least 0.5%. The fiber content in cookies comes from the basic ingredient of cookies, namely millet flour as a source of fiber by 3.45%. Food is called a source of dietary fiber if it contains at least 3 percent of food fiber according to BPOM standards, while food is called high in fiber if it contains at least 6 percent of dietary fiber (Widowati, Sasmitaloka & Banurea, 2020).

From the results of this study, even though millet flour is a source of fiber, in the process of making cookies there is a decrease in fiber content so that efforts are needed to enrich cookies with other fiber sources as functional foods. Fiber content decreased due to roasting at a high temperature of 160^0C.

As in Shahzad (2011), that the fiber that gets heat treatment above 150^0C causes the fiber to break easily and become brittle due to the reduced fiber density. Hemicellulose is the first component in the fiber that is damaged when exposed to heat due to the low heat stability of hemicellulose so that hemicellulose is degraded.

Consumption of fiber that is not optimal is increasingly becoming a global concern, because the average consumption in many countries is still far below the WHO recommendation, which is 25-40 grams / day. Chandra *et al.*, (2016) mentioned that there is dietary fiber -glucan as an important component in millet which can have a positive effect on health such as antihypercholesterolemia, antiradiation, anti-inflammatory and antidiabetic. As for in Richter *et al.*, (2015) that -glucan fiber has an impact on children's physical health and increases children's immune system, especially in children who have respiratory system problems.

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f. Carbohydrate content

Carbohydrate content in millet flour cookies is 53.0%, indicating that the results do not meet the SNI quality standard, which is at least 70%. However, the results obtained indicate that carbohydrates are the main nutritional component contained in millet cookies. Low carbohydrate content is influenced by the high fat content in cookies based on calculations by difference.

Fatkurahman et al. (2012) stated that the carbohydrate content calculated by difference is influenced by other nutritional components, namely protein, fat, water, and Flour. The higher the components of other nutrients, the lower the carbohydrate content and vice versa if the components of other nutrients are lower, the carbohydrate content is higher.

g. Energy content

The energy content of millet flour cookies is 518.94 kcal. This shows that it has met the SNI quality standard, which is at least 400 kcal. Cookies are consumed as an additional meal or snack (snack) and the energy requirement that must be met for the interlude is 20% of the energy requirement for one day. Interlude time is divided twice a day, namely morning interlude and afternoon interlude with the distribution of 10% of energy needs per one meal time (Almatsier, 2002). The average energy requirement for the general age group (4-80 years) in Indonesia is 2150 kcal (BPOM RI, 2016b). So the calorie intake for snacks is 430 kcal per day or as much as 215 kcal for 1 snack.

Based on BPOM RI (2019), The serving dose of cookies is included in category 15.0 in the form of ready-to-eat snacks with the basic ingredients of potatoes, cereals, tubers, flour or starch (from tubers and nuts) non-extruded having a serving size range of 20-40 grams. So the serving size for cookies based on millet flour is 40 grams (4 pieces).

Each serving of millet flour cookies is able to meet the protein needs of 3.4 grams or 6% of the RDA, 12.2 grams of fat or 18% of the RDA, 21.2 grams of carbohydrates or 7% of the RDA, 0.9 grams of fiber or 3 % RDA, and energy is 207.6 kcal or 10% RDA. Processed foods that include claims on the label must meet an intake per serving of no more than 18 grams of total fat and at least 3 grams of fiber per serving (BPOM RI, 2016a). As for protein, at least 10% per serving based on the requirements of the codex stan (Codex Alimentarius Commission, 2007). Thus the results of the nutritional content per serving on millet flour-based cookies have met the daily energy and fat needs but have not met the requirements as a source of protein and fiber. This is thought to be the result of the cookies baking process resulting in reduced protein and fiber content in cookies. Therefore, it is necessary for cookies to be enriched with sources of protein and fiber from other food ingredients.

2. Acceptability of *cookies* based on jewawut flour

a. Preference for colour

Based on the results in table 3, there is no significant difference (ρ=0.642) to the level of color preference in the cookies formula. The F1 formula for millet flour cookies without the addition of flavoring has the highest average value of the other formulas, which is 4.12 with the like category.

The color in cookies is strongly influenced by the basic ingredients used, namely millet flour which has a slightly brownish color characteristic. As research results Sulistyaningrum et al. (2018) that millet flour by soaking 4-5 hours will produce a brownish white color. This is a result of the longer immersion process that causes the phenolic components to degrade. The color of millet is caused by phenolic components such as glycosylvitesin, glycosiloritin, alkali-labile, and ferulic acid. In addition, the brown color of cookies is also due to the Mailard reaction or non-enzymatic browning during the baking process.

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b. Taste

Based on the results in table 3, there is no significant difference (ρ = 0.826) to the level of taste preference in the cookie formula. The F1 formula for millet flour cookies without the addition of flavoring has the highest average value of the other formulas, which is 4.08 in the like category. The resulting millet flour-based cookies have a mix of sweet and savory flavors that are sufficient.

The taste of these cookies is influenced by the use of basic ingredients of millet flour and supporting ingredients such as refined sugar, fat in the form of margarine and butter. As for the main ingredient, millet flour can leave a bitter aftertaste because of the polyphenol content in the form of tannins. However, the bitter taste is not felt in these cookies because the process of making millet flour uses the wet method, namely the presence of soaking which can reduce the tannin content in millet. This is stated in the research results Sulistyaningrum et al. (2018) that the phenolic compounds in millet are dominated by tannins. The tannin content will dissolve in the first 3 hours in the immersion water which functions as a polar organic solvent

c. Aroma

Based on the results of the Kruskal Wallis test in table 3, there is no significant difference (ρ = 0.656) to the level of preference for aroma in the cookie formula. The formula for F1 cookies is millet flour without the addition of flavoring and the formula for F4 cookies with the addition of chocolate flavoring has the highest average value of the other formulas, which is 4.16 with the like category.

The aroma of cookies for all formulas was liked by the panelists, although each formula was distinguished from the addition of flavoring, it did not provide a significant difference to the level of preference for aroma. This is because the strong aroma produced comes from the basic ingredients of millet flour then other supporting ingredients in the form of butter and chocolate. For the use of butter (butter) produces an aroma during the roasting process. Matz and Matz (1978) Butter in the aqueous phase contains milk protein, natural minerals, lactose, skim milk and water. In the aqueous phase, butter has components which are the source of compounds that give rise to aroma. The heating process during baking will make the volatile compounds evaporate and cause a certain aroma which is a distinctive aroma that stands out from cookie products.

In addition, the chocolate aroma contained in the F4 formula is one of the processed cocoa products that has a distinctive taste and aroma and is in great demand by the public. The compound that is considered to have a major contribution to the aroma and taste in cocoa is pyrazine, which is non-volatile. In addition, carbonyl compounds and esters also form the distinctive aroma of chocolate during the cocoa bean roasting process (heating) (Selamat, Harun & Ghazali, 1994)

d. Texture

Based on the results in table 3, there is no significant difference (ρ=0.559) on the level of texture preference in the cookies formula. The F1 formula for millet flour cookies without the addition of flavoring has the highest average value of the other formulas, which is 4.16 in the like category.

The crunchy texture is influenced by the use of the main ingredients and supporting ingredients for cookies in the form of millet flour and fat in the form of butter and margarine. The texture of cookies made from millet flour has a crunchy texture and can be liked by panelists even though it feels grainy in the throat when swallowed, presumably because millet flour contains fiber and is gluten-free.

As in research Aggarwal, Sharma and Shivani (2018) explained that millet and oat flour are gluten-free and high in fiber and protein. Most of the millet flour consists of coarser particles

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which may affect the spreadability of cookies, besides that it produces a gritty mouthfeel and a crunchier texture compared to control cookies.

The benefits of gluten-free cookies can be provided for individuals who have allergies to gluten such as people with celiac disease and people with autism spectrum disorder (ASD) who are required to avoid gluten so that it does not have a negative impact on the body (Mulloy et al., 2010).

Foxtail millet millet flour has a starch content ranging from 65.9% to 73.1% (Yin et al., 2019) consists of amylose and amylopectin. The amylose content of millet flour is classified as very low, namely <10% which is 8.31% and the rest consists of a high amylopectin content of 91.69% (Sulistyaningrum et al., 2018). The lower the amylose content of an ingredient, the lower the ability to bind water, so the water content is higher, resulting in hard cookies (Nurani and Yuwono, 2014).

The crunchiness of the cookies texture is influenced by the low water content lost during baking. In Fellows (2000) explained that the crispness in a food product can be related to the water content. This is because the more water that is evaporated during roasting, air cavities will form so that the resulting product is more crispy. The texture of cookies is also influenced by the use of fat in the form of butter or margarine. Fat substitution has a greater influence in determining the texture of cookies than sugar or flour substitution (Campbell, Ketelsen and Antenucci, 1994).

g. Overall

The results of the Kruskal Wallis test in table 3 show that there is no significant difference (ρ=0.832) to the overall assessment aspect of the cookies formula. The F1 formula for millet flour cookies without the addition of flavoring has the highest average value of the other formulas, namely 4.16 in the like category. This shows that even millet flour-based cookies without the addition of flavor have been accepted by the panelists for consumption even though all panelists have never known or tried processed foods made from millet flour such as cookies.

3. Shelf life of millet flour based cookies

a. Water Content

The results show that during 14 days of storage, cookies stored at 3 different temperatures have a low water content, which is still below 5% based on the requirements of SNI 01-2973:2011. In addition, it appears that the greater the storage temperature, the lower the moisture content in cookies. The same thing was also found in research Hedi Agam Akbar et al. (2019) revealed that the storage of dry instant sour keueng seasoning at 40^0C and 50^0C tended to decrease in total water content, and the biggest decrease was at 50^0C, from 14% to 12.49%, while at 40^0C there was a decrease from 14% to 13.32. %. This is because storage at higher temperatures can result in drier storage space so that it can cause the water content of the material to decrease (Masithoh & Fauzi, 2014).

The water content of a food material greatly affects its shelf life, because microbes are increasingly inhibited by the lower water content. The higher the water content of the food, the faster the damage caused by microbial activity, this is because the microbes need free water for their growth (Sulistyaningrum et al., 2018).

Based on the calculation of shelf life, the higher the storage temperature the shorter the shelf life because the increase in temperature causes the faster the reaction rate which causes the cookies to spoil faster so that the shelf life is getting shorter. The rate of chemical reactions is faster at higher temperatures so that the product quality declines faster (Palupi *et al.*, 2010).

b. Total microbes

Based on table 5, it can be seen that the level of microbial contamination in cookies based on millet flour at 0 days of storage to 4 weeks of storage at various temperatures has decreased and still meets the standard of SNI 01-2973:2011. The decrease in microbial contamination in the ALT test is thought to be caused by the limited oxygen available in the packaging and the stability of the storage temperature. In the microbial test in ALT it is referred to as aerobic microbial count (AMC) or aerobic plate count (APC), meaning that these microbes require free oxygen to grow and develop. Lack of oxygen in the packaging causes ALT microbes cannot grow and even die (Andayani and Agustini, 2019).

The relationship between storage temperature and the decrease in total microbes is that the higher the storage temperature, the lower the moisture content of cookies. Moisture content in cookies can affect the durability of cookies against microbial attack used by microorganisms for growth. In Winarno (1997) explained that a high water content can cause the product to be more easily damaged, due to the presence of destructive microorganisms that utilize the amount of water contained in the product for its growth.

Conclusion

The acceptability of the selected millet flour cookies, namely the F1 formula of millet cookies without the addition of flavoring, had the highest average value of the other formulas, namely 4.16 with the preferred category. The results of statistical tests showed that there was no significant difference in the level of preference for color, taste, aroma, texture, and overall of the four millet flour cookies formulas by untrained panelists. The proximate levels contained in the selected millet flour cookies formula are F1 which contains 6.1% water, 2.14% Flour, 8.38% protein, 30.38% fat, 53.0% carbohydrates, 2.22% fiber, and total energy 518.94%. For the content of Flour, protein, fat, and fiber, it has met the requirements of SNI. However, the water content exceeds the maximum value of SNI while the carbohydrate content is less than the minimum value of SNI. The shelf life of millet flour cookies at storage temperatures of 25^0C, 37^0C, and 44^0C are 134.81 days (4.5 months), 79.18 days (2.6 months) and 59.14 days (1.9 months). Total microbes in millet flour-based cookies for 4 weeks of storage at temperatures of 25^0C, 37^0C, and 44^0C decreased by 2.05×10^2, 1.05×10^2, and $<4.0 \times 10^1$, still meeting SNI standards. 01-2973:2011 a maximum of 1×10^4 colonies/gram.

Suggestion

Further research is to develop cookies based on millet flour with enriched other food sources of fiber and protein in increasing nutritional value that is beneficial for handling nutritional problems. In addition, further researchers who are interested in similar research should carry out organoleptic tests using trained panelists.

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