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Healthy Cookies: Nutritious Food Innovation Through Fortification By-products of Tuna (*Thunnus* sp.) Fish Bone Flour

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Abstract. Healthy cookies is one of the processed pastries by utilizing the nutritional content contained in tuna fish bone by-products so that it is used as an alternative snack for people with osteoporosis. This study aims to analyze the chemical and sensory characteristics of cookies added with tuna fish bone flour. The research method used was an experimental method with two treatments, namely cookies without the addition of tuna fish bone flour and cookies with 6% tuna fish bone flour substitution which were analyzed using one-way Anova on XLStat software. The results showed that the addition of 6% tuna fish bone flour produced higher values of ash, protein and fat content, namely 3.170%, 25.878% and 43.865% while the water content and carbohydrates decreased, namely 5.488% and 21.599% The sensory results of cookies adding tuna fish bone flour received a "good" assessment of color and texture and "neutral" on aroma, taste and overall acceptability.

Keywords: cookies; tuna bone; proximate; sensory

I. INTRODUCTION

Osteoporosis or known as bone loss is a brittle bone disease characterized by loss of bone density after reaching old age. In children, calcium deficiency can cause inhibition of bone growth/rickets, but it can also cause osteomalacia [1]. This requires us to produce calcium in sufficient quantities and calcium production can be obtained through food consumed every day. Current popular sources of calcium are milk and calcium supplements, but both tend to be out of reach of the purchasing power of the Indonesian people in general. Based on this, an alternative source of calcium is needed that is able to fullfill the needs of the community in the form of cheap and abundant calcium-rich foods or drinks. One source of high calcium can be obtained from the by-products of tuna fish bones.

The tuna fish commodity is one of the commodities that has a large share in the country's foreign exchange supply. KKP (2017) revealed that Indonesia has supplied more than 16% of tuna production in the world, but tuna production on an industrial or household scale has not been maximally utilized. Its utilization so far is still limited to meat (fillets) for consumption. The large amount of meat production and consumption will produce a high amount of by-products. By-products are the remains of a production process in the form of bones, skin, offal and swimming bubbles, which can reach 20-60% of the raw material and bone by-products of about 2-5% [2]. Utilization of fisheries industry by-products into a valuable product

will increase income and reduce negative impacts on the environment. One part of tuna by-products that has the potential to be utilized is the bone.

Tuna bone is a by-product of fish processing that is rich in calcium, phosphorus and selenium. The utilization of tuna bones as a source of calcium is one of the efforts to fullfill calcium needs while adding economic value to the by-products of tuna bones. Trilaksani [3] revealed that tuna fish bones have a calcium content of 39.24% and Deswita & Fitriyani [4] revealed that tuna fish bones have a calcium content of 14.01%. Based on these data, it proves that tuna fish bone by-products have the potential to be used as a source of calcium in the human body and utilized in the processing of food products that are easily accepted by the Indonesian people. One form of food that is easily accepted by the Indonesian people based on how to consume it is pastries or cookies.

Cookies are processed products in the form of pastries that have high economic value with a crunchy texture and do not crumble easily like pastries in general [5]. This research aims to produce calcium-rich healthy cookies with the addition of catfish bone flour and tuna bone flour. These healthy cookies are calcium-rich healthy foods that are enjoyed by all of age groups, from children and adults so that through healthy eating it is expected to prevent osteoporosis, besides that the manufacture of calcium-rich cookies is done to reduce the presence of by-products that pollute the environment.

II. RESEARCH METHOD

Research Location

This research was conducted from January to February 2022 at the Fisheries Laboratory and Chemistry Laboratory of Ganesha University of Education, Bali.

Tools and Materials

The main material used in this study was tuna fish bones obtained from Kalibukbuk Village Harbor, Buleleng, Bali while the chemicals used were n-hexane (MERCK), H2SO4, NaOH, bromocresol green indicator 0.1% methyl red and others. The equipment used were oven (KIRIN), soxhlet flask, distillator, erlemeyer and other glassware.

Research Stages

The implementation of this research was carried out in 2 (two) stages, namely the stage of making tuna fish bone flour and the stage of making healthy cookies, then analyzing the quality of cookies which included chemical tests (water content, ash, protein, fat, carbohydrates) and sensory tests (color, taste, aroma, texture, and overall acceptability) with 30 untrained panelists.

Preparation of Modified Tuna Fish Bone Flour Modified from Daeng [6]

The making of tuna fish bone flour begins with the process of cleaning and washing fish bones and then cutting them roughly. Clean tuna fish bones are boiled for 2 hours at 100^0C and washed again to remove the meat parts that are still attached to the fish bones. After that, the bones were then soaked using lime for 1 hour to remove the fishy aroma in the fish. The fish bones were washed again and drained in a container, then dried using oven with 110^0C oven ± 1 hour. Then the process of grinding tuna fish bones using a mixer and sieving using a sieve with a size of 100 mesh to get the same flour particle size. The flowchart of making tuna bone flour can be seen in Figure 1.

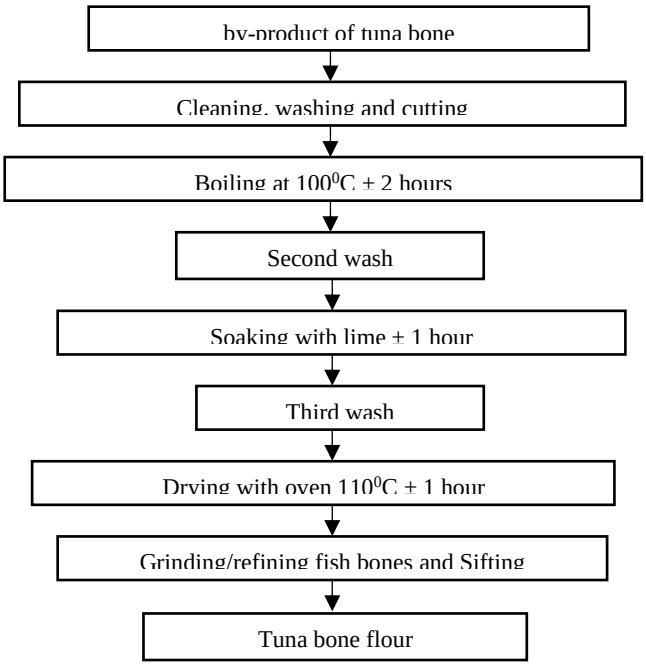

Fig 1. Flowchart of tuna bone flour preparation

TABLE 1
INGREDIENT COMPOSITION OF COOKIES WITHOUT FISH BONES AND COOKIES WITH ADDED TUNA BONE FLOUR

Ingredients Name	Weight of ingredients used (g)	
	C1	C2
Tuna bone flour (6%)	0,00	7,50
Non-gluten flour	100,00	94,00
Cornstarch	25,00	23,50
Powdered sugar	43,75	43,75
Margarine	68,75	68,75
Skim milk	9,38	9,38
Egg yolk	15,63	15,63
Salt	0,31	0,31
Baking soda	0,25	0,25

Modified from Hunaefi[7]

Preparation of Modified Tuna Bone Flour Modified from Hunaefi et al. [7]

Cookies were prepared following from Hunaefi (7) with modification. Ingredients such as: margarine, egg yolks, powdered sugar and skim milk according to the dose were mixed (Table 1). After that, non-gluten flour, cornstarch, fish flour and baking soda were added then mixed evenly. The dough is formed in a circle according to the size consistently, then the cookies are baked using an oven at 150^0C ± 15 minutes until brownish yellow. Cookies that have been cooked, were cooled and stored in an airtight container. Then chemical testing and sensory testing were carried out. The composition of cookies without fish bones and cookies with the addition of tuna bone flour is presented in Table 1 and the flow chart for making cookies is presented in Figure 2.

Analisys Procedure

In this study, chemical tests were carried out which included water content, ash content, protein content, fat content, carbohydrates by difference, and sensory tests including color, taste, aroma, texture, and overall.

Proximate Analysis [8]

The procedure for analyzing water content was carried out by putting the cup into a desiccator and weighing it using an analytical balance, then weighing a sample of 1 g and putting it in a porcelain cup. The porcelain cup was put into the oven at 105^0C for 5 to 6 hours or until the weight was constant. The porcelain cup was then placed in a desiccator for 30 minutes and the final weight was weighed. Ash content was done by putting 5 g of sample into a porcelain cup. The cup was heated on an electric stove until the smoke disappeared and then put into a muffle furnace at 600^0C for 7 hours.

Fat content was analyzed by the sokhlet method in which the sokhlet flask to be used was dried in an oven at 110^0C overnight. The sample is weighed as much as 5 g and then wrapped in fine filter paper and put into a sokhlet that has been filled with a nonpolar solvent. The flask was then heated in the oven at 105^0C until the weight was constant. The flask was put in a desiccator for 30 minutes and the final weight was weighed. The basic principle of protein content analysis is to determine the amount of crude protein in the form of total nitrogen compounds in the sample. This analysis includes 3 stages, namely deconstruction, distillation, and titration. Carbohydrate analysis is done by difference, which is the result of subtraction from 100% with water content, ash content, protein content and fat content, so that the carbohydrate content depends on the reduction factor.

Sensory Testing [9]

Sensory testing of control cookies (C1) and cookies with the addition of tuna fish flour bones (C2) was carried out by means of hedonic tests. Sensory testing is carried out by 30 untrained panelists, then each panelist will provide a score assessment from a scale of 1-5 (dislike, somewhat dislike, neutral, somewhat like, and like) on the sensory attributes tested, namely color, taste, aroma, texture, and overall acceptability.

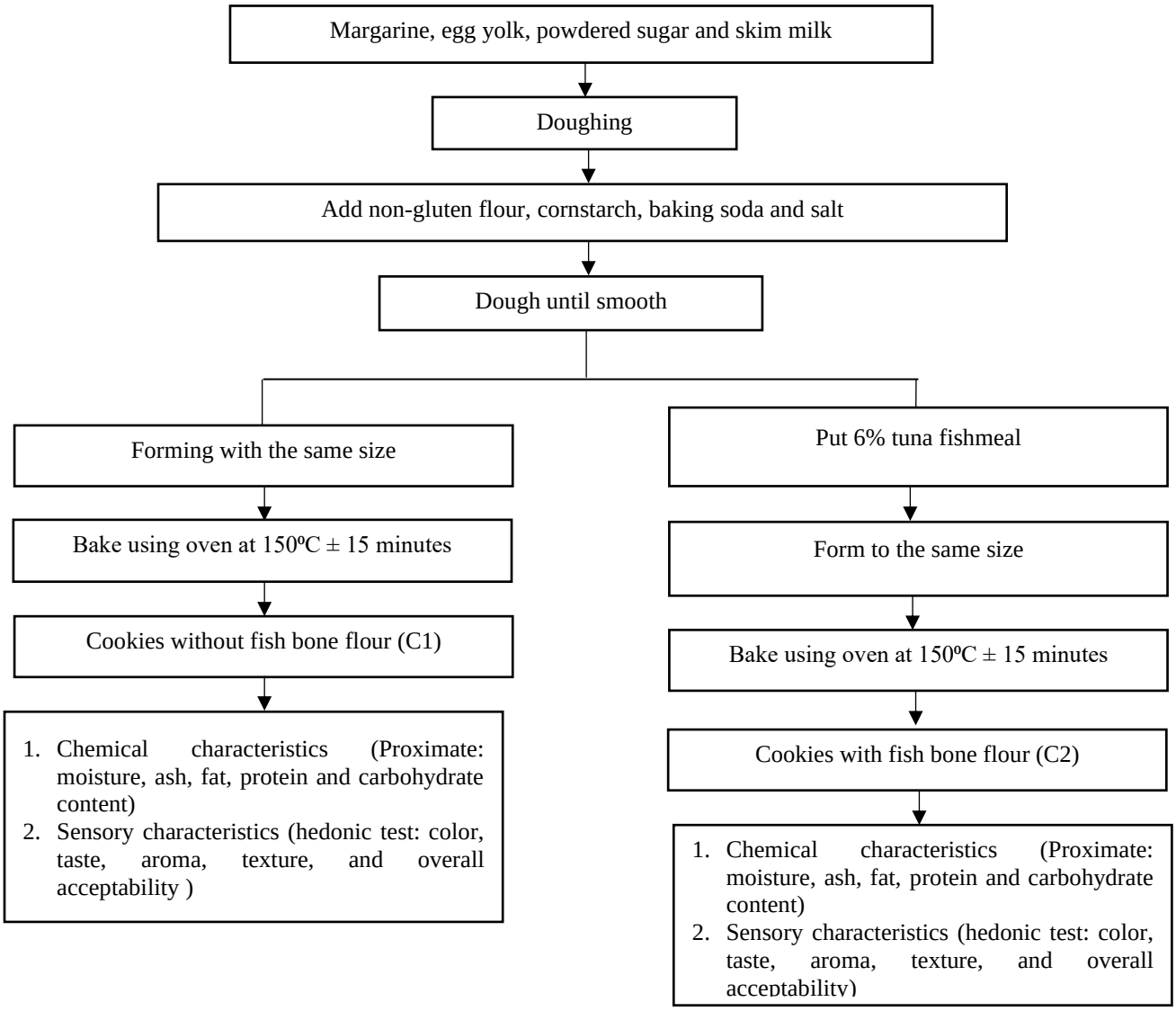

Fig 2. Flow chart for making cookies without fish bones and cookies with the addition of tuna bone flour Modified by [9]

III. RESULTS AND DISCUSSION

Chemical characteristics of tuna-fish bone flour, cookies with and without tuna fish bone flour

Proximate analysis aims to determine the chemical content (moisture, ash, protein, fat and carbohydrate content) contained in tuna fish bone flour, cookies without fish bone flour and cookies with the addition of tuna fish bone flour. The results of the proximate test or chemical characteristics can be seen in Table 2.

Water Content

Astiana [10] and Chen [10] stated that the water content in the material determines the acceptability, freshness, and durability of the material. Water also functions as a pH balancer, maintaining the texture and flexibility of an ingredient. Based on Table 2 tuna bone flour, cookies C1, cookies C2 have a water content of 6.297%, 5.326%, 5.488% respectively. This value shows that the moisture content of fish bone flour is slightly outside of requirements of SNI 01-2715-1992[12] (maximum 5%) so that it can maintain the freshness and durability of the product. According to

SNI [13] moisture content in food is closely related to product durability because it can reduce the growth of spoilage bacteria so that it is resistant to chemical and microbiological damage. The water content produced in boneless cookies and cookies with the addition of tuna bones is also still within the requirements of SNI 01-2973-1992[14] (max 5%), so the water content with the addition of tuna fish bone flour fullfill the SNI requirements for cookie quality.

Table 2 also explains that the results of the analysis of variance for the addition of tuna fish bone flour have a significant effect on the moisture content of tuna fish bone flour cookies. The moisture content of cookies C1, cookies C2 shows a lower value than tuna fish bone flour, this is thought to be due to the process of baking cookies with high temperatures using an oven. Junianto [15] stated that the moisture content value of a material is strongly influenced by the drying temperature factor.

TABLE 2
CHEMICAL CHARACTERISTICS OF TUNA FISH BONE FLOUR, COOKIES WITHOUT FISH BONE FLOUR AND COOKIES WITH THE ADDITION OF TUNA FISH BONE FLOUR

Parameter	**Tuna fish bone flour**	***Cookies* C1**	***Cookies* C2**	**Quality standard *cookies* (SNI 01-2973-1992)**
Water content (% b/b)	6,297 ± 0,110	5,326 ± 0,173[a]	5,488 ± 0,112 [b]	Maximum 5
Ash content (% b/b)	57,251 ± 1,821	1,086 ± 0,011 [a]	3,170 ± 0,304 [a]	Maxmum 1.5
Protein content (% b/b)	20,472 ± 2,133	13,311 ± 7,462 [a]	25,878 ± 3,143 [b]	Minimum 9
Fat content (% b/b)	4,102 ± 0,473	22,570 ± 1,947 [a]	43,865 ± 0,257 [a]	Minimum 9.5
carbohydrate (% b/b)*	11,878 ± 0,051	57,707 ± 5,331 [a]	21,599 ± 3,078 [a]	Minimum 7

Description: Cookies without tuna fish bones (C1); Cookies with tuna fish bones (C2); *counted by difference.

Ash Content

Ash content is an analysis to determine the amount of crude mineral content in a material. The ash content of tuna bone flour showed a high value of 57.251%. Some researchers also reported that fish bone flour tends to be high, namely tilapia bone flour of 75.83% [16]; tuna bone flour of 84.22% [3]; belida fish bone flour of 88.13% [17]; catfish bone flour of 59.49% [18]; cob fish flour of 60.97% [19]. Tababaka [20] reported that the high ash content of fish bones is caused by the main constituent component of fish bones, namely minerals. Mineral salts are components consisting of calcium phosphate as much as 80% and the rest consists of calcium carbonate and magnesium phosphate.

Table 2 also explains that the level of cookies C1 (cookies without the addition of tuna fish bone flour) is in accordance with the standards set by the Indonesian National Standards Agency (SNI 01-2973-1992) [13] regarding ash content in cookies, which is a maximum of 1.5%, while the ash content value of cookies C2 (cookies with the addition of tuna fish bone flour) increases and does not fullfill SNI standards because the value is above 1.5%. This is due to the addition of tuna fish bone flour. According to Pratama [20] the ash content of a product will be influenced by the mineral content contained in the raw material.

Protein Content

Protein is a major nutritional component that is found in many plant and animal cells. Proteins from different sources have distinctive functional properties that affect the characteristics of food products [14]. Table 2 explains that the value of tuna bone flour protein content is quite high at 20.472%. This is in line with the results of Harlia's [22] research which obtained a value of tuna fish bone flour of 21.39%. The protein content of cookies C1 and cookies C2 are 13.311% and 25.878% respectively, based on these data it can be seen that there is an increase in the value of protein content in cookies added with fish bone flour. This is in accordance with the results of the analysis of variance that the addition of tuna fish bone flour has a significant effect on the protein content of tuna fish bone flour cookies. According to Pratama [21] the protein content of cookies will be influenced

by the protein content of the fish bone flour added, the high or low measured protein value can be influenced by the amount of water content lost (dehydration) from the material. Daeng [6] also mentioned that the measured protein value will be greater when fish bone flour is added. The value of protein content of cookies C1 and cookies C2 has also met the SNI 01-2973-1992 [13] standard which requires that the protein content of cookies is a minimum of 9%.

Fat Content

Analysis of fat content in an ingredient/food product aims to provide information about the availability of fat that can be applied for various needs [23]. The value of fat content in tuna bone flour is 4.102% and the value of fat content of cookies C1 and cookies C2 shows a significant increase of 22.570% and 43.865% (Table 2). The increase in the value of fat content in cookies is thought to be due to the ingredients used in formulations such as margarine, egg yolks and fish bone flour have a fairly high fat content. Daeng [6] explained that margarine and fish flour are ingredients used in making cookies with high fat content.

Based on SNI 01-2715-1992[12] requires that the quality standard of fish flour is a maximum of 8% and SNI 01-2973-1992 requires that the quality standard of cookies is a minimum of 9.5%, so the fat content value of tuna fish bone flour, cookies C1 (cookies without the addition of fish flour) and cookies C2 (cookies with the addition of tuna fish bone flour) has met the standards set by the National Standardization Agency.

Carbohydrate content by difference

Carbohydrate content is determined by difference, which is the result of subtraction from 100% with water content, ash content, protein content and fat content so that carbohydrate content depends on the reduction factor. The results of carbohydrate content in tuna fish bone flour, cookies C1, cookies C2 are 11.878%, 57.707%, 21.599% respectively. Based on SNI 01-2715-1992[12] and SNI 01-2973-1992[13], it shows that tuna bone flour, cookies C1 (cookies without the addition of fish flour) and cookies C2 (cookies with the addition of tuna bone flour) have met the standards set by the National Standardization Agency, which is at least 7%.

Sensory characteristics of cookies without fish bones (C1) and cookies with the addition of tuna bone flour (C2)

Sensory test is a subjective test implemented by consumers on the acceptance of cookie products. Sensory observations on cookies C1 and cookies C2 products involved 30 untrained panelists with sensory attributes tested, namely color, taste, aroma, texture, and overall acceptability. The results of hedonic sensory assessment of cookie C1 and cookie C2 products can be seen in Figure 3.

Color

According to Seveline [24] color is one of the important parameters in sensory assessment because it is the part that consumers see or judge first regarding the appearance of the product. The color of cookies C1 and cookies C2 is brown and based on Figure 3 it can be seen that both cookies C1 and cookies C2 have good acceptance from the panelist penalist, namely a value of 4 (good) from a scale of 1 to 5, but cookies C1 without the addition of tuna bone flour has a slightly better acceptance level, because the color of cookies C2 is darker than cookies C1. This is thought to be due to the roasting process and the addition of raw materials in the form of fish bone flour into cookies. Andayani [19] stated that the color intensity of cookies can be influenced by several factors such as baking time, weight and size of cookies, and raw materials used.

Aroma

Aroma (odor) is one of the parameters that attract consumers to a product. The results show that the aroma of C1 cookies is better than C2 cookies because there is a fishy aroma in C2 cookies added with tuna fish flour. According to Hermanto and Susanty [25] the addition of fish flour to biscuits will give a distinctive aroma of fish (slightly fishy) because the distinctive aroma in fish flour is difficult to remove even though other additives are added to the process. Fera [26] explained that the distinctive aroma of fish is due to the protein content that breaks down into amino acids, especially glutamic acid, so that it can strengthen the sharp aroma in processed products.

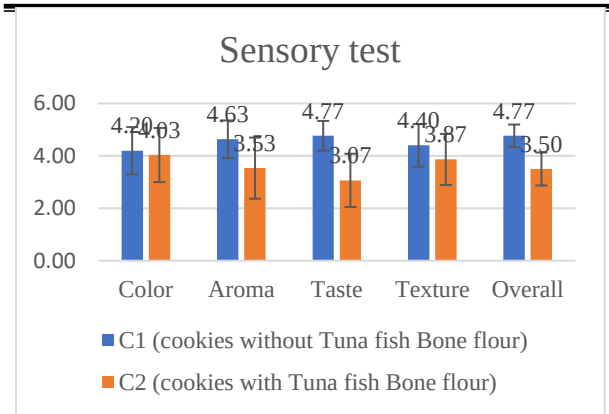

Figure 3. Sensory characteristics of cookies C1 and cookies C2

Taste

Taste is an factor in consumer acceptance of a product. The taste of cookies C1 and cookies C2 is still within the assessment standards that can be accepted by panelists but the value of cookies C2 is lower. This is thought to be due to the savory taste of fish which contrasts slightly with the taste of the cookies. According to Winarno [27] fish meat contains amino acids glutamate and glycine, causing a savory taste.

Texture

Texture is one of the sensory assessment parameters in cookie products. Seveline [24] stated that the crispness of a cookie can be measured by whether or not the cookie crumbles when bitten. Based on Figure 3, it can be seen that the panelists' assessment is better on C1 cookies than C2 cookies. This is thought to be due to the addition of protein-rich fish bone flour which causes C2 cookies to crumble more easily. Andayani [19] stated that the addition of fish bone flour which contains higher protein than mocaf flour is one of the factors that cookies are more easily destroyed and slightly less favored by panelists.

Overall acceptability

Overall acceptability (aroma, taste, aroma and texture), panelists' assessment of cookies C1 is better than cookies C2. This can be seen from the weight of the assessment given by the panelists (Figure 3), namely cookies C1 on average scored approximately 4 and cookies C2 approximately 3, but for both cookies this is still in the "good" and "neutral" assessment categories so that it is still acceptable to the panelists.

IV. CONCLUSION

The conclusion of this study is that cookies with the addition of 6% fish bone flour have higher moisture, ash, fat and protein content than cookies without the addition of fish bone flour. The results of panelist testing of the color and texture of cookies are "good" and the assessment of taste, aroma and overall is "neutral", so these cookies are suitable as an alternative snack for people with osteoporosis.

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