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Chemical characteristics of butter cookies with knife-fish (*Chitalla* sp.) bone flour addition as a healthy snack of high calcium

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Abstract

Butter cookies are generally made from wheat flour as a carbohydrate source which is high energy. Nowadays, fortified snacks are preferred because of their important nutrients. The purpose of this research was to compare the physicochemical properties of butter cookies with fortified knife-fish bone powder. The design of this experiment used a completely randomized design single factor-experimental study by using four formulations, F1 (0%), F2 (2%), F3 (4%), and F4 (6%). Data were analyzed using the One -Way ANOVA test and Duncan's multiple range test if they were significant. The results showed that the butter cookies had a total energy range of 454.37 – 473.11 kcal/100 g, carbohydrate range of 48.27 – 51.17%, protein ranged of 4.98 – 5.55%, fat content ranged of 26.79 – 27.60%, moisture content ranged of 2.69 – 3.67%, ash content ranged of 0.76 – 3.21%, calcium content ranged of 1.85 – 2.50% and phosphorus content ranged of 0.13 – 0.33%. The recommended butter cookies by knife-fish bone added were F4 (6%) with the highest calcium content (2.5%), the lowest moisture content (2.69%), and the lowest calorie (454.37 kcal).

1. Introduction

Bakery products are often high in energy and fat and the most consumed bakery product is cookies (Mustika and Kartika, 2020). Cookies are favored and popular snack food in the world by all ages, and various types can be found. Cookies are a type of dry food because of their low moisture content. Cookies are widely consumed and generally, they are rich in carbohydrates, fats, and calories, but low in fiber, vitamins, and minerals (Loza *et al.*, 2017) long storage life and it has the potential to contain high nutritional ingredients (Aziah *et al.*, 2012). Cookie types and ingredients vary greatly, so physical and chemical changes may occur simultaneously (Sung and Chen, 2017).

Cookies are made from different flours that are characterized by a formula with sugar, shortenings, and relatively low water content (Hawa *et al.*, 2018). Currently, the fortification and supplementation of cookies with a variety of proteins and minerals might enhance the nutritional value of the cookies (Ghoshal and Kaushik, 2020). The fortification of cookies has evolved to improve their nutritional and functional qualities (Awolu *et al.*, 2016). Food fortification is the process of adding micronutrients to foods (Whiting *et al.*, 2016).

The addition of minerals is one way to increase the nutrition of cookies. The human body needs minerals for a healthy life to build strong bones. Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes that are essential to life. Minerals are chemical constituents used by the body in many ways (Soetan *et al*., 2010). Dietary calcium deficiency has been linked epidemiologically to several chronic diseases including osteoporosis, osteomalacia, hypertension, colon cancer, and obesity (Kaushik *et al*., 2014).

Calcium presence is very important to build and maintain strong bones. Phosphorus with calcium has a role for infants and children in preventing calcification of bone and teeth (Manik *et al.,* 2020). According to Amnah and Alsuhaibani (2018), calcium-rich foods include dairy products (milk, cheese, and yoghurt), leafy green vegetables, fish with soft bones (canned sardines and salmon), and calcium-enriched foods (breakfast

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cereals, fruit juices, and soy and rice drinks).

Fishbone is a very potent source of calcium and it is a waste of fish processing plan that have not been utilized optimally. The calcium content of fishbone powder varies depending on the type of fish and the processing method. The fishbone powder of knife- fish (*Chitala* sp.) with protein hydrolysis method containing calcium 29.29 – 31.31% (Kusumaningrum *et al*., 2016), the fishbone powder of tuna fish with protein hydrolysis method containing calcium 34.24% (Trilaksani *et al.,* 2006).

The usage of fishbone powder in food processing has been widely used. Wardani *et al.* (2012) added tuna fishbone powder to doughnut processing, Kusumaningrum *et al.* (2016) added knife-fish bone powder to krupuk processing, Asikin *et al.* (2019) added knife-fish bone powder and seaweed to krupuk processing, and Melyasa and Tarigan (2020) added tuna fish bone powder as a calcium source to processing of seaweed stick. Sari (2013) has studied the fortification of catfish bone powder to the milk of Zea mays processing. Pratama (2014) also studied the fortification of Janglius fish to biscuit processing. Kusumaningrum *et al.* (2016) reported that the addition of knife-fish bone powder to fish crackers (kerupuk in Indonesian) increases the content of ash, calcium, phosphor and whiteness, but decreases the content of protein and fat. Njoroge and Lokuruka (2020) also reported that cookies were fortified fish bone powder that is sensorially acceptable and can be consumed as supplementary food for dietary calcium.

Fortification of knife-fish bone powder in the processing of cookies needs to be done. In addition to providing added value to fishbone, it can also reduce waste from krupuk processing which can cause environmental pollution. The research aimed to determine the chemical characteristics of butter cookies by adding the difference in knife-fish bone powder percentage.

2. Materials and methods

2.1 Knife-fish bone flour preparation

Knife-fish bone (KFB) flour was made according to the method of Kusumaningrum *et al.* (2016). Frozen knife-fish bone was thawed in tap water and washed. Then, KFB was cooked in a pressure cooker for 2 hrs. After pressure cooking, it was boiled at 100°C for about 30 mins and was repeated 4 times. The boiling repetition aimed to optimize for removing soluble protein from the fishbone. After that, the fishbone was cut into pieces and extracted in NaOH solution 1.5 N at 60°C for 2 hrs. The alkaline solution would be more effective to solubilize and leach out more meat tissue and proteins from fishbone (Hemung, 2013). After alkaline extraction, the fishbone was separated with a filter cloth and then washed with tap water until neutral (pH approximately 7.0). The fishbone was dried at 65°C in an oven for 48 hrs. Dried bone solid was milled using a blender and sifted to obtain the flour. Then the knife fish bone flour was packed and stored at room temperature until used.

2.2 Butter cookies preparation

Cookies were prepared in four treatments of knife-fish bone (KFB) percentage whereby F1 (KFB 0%), F2 (KFB 2%), F3 (KFB 4%) and F4 (KFB 6%). The main ingredients of these cookies were wheat flour and knife-fish bone (KFB) flour. Other ingredients were cornstarch, margarine, butter, egg yolk, powdered sugar, baking powder, and skim milk. The formulations of cookies are shown in Table 1.

Table 1. Ingredients of butter cookies in various formulations (F).

Ingredients	F1 (KFB 0%)	F2 (KFB 2%)	F3 (KFB 4%)	F4 (KFB 6%)
Knife-fish bone (KFB) flour (g)	0	4	8	12
Wheat flour (g)	200	200	200	200
Cornstarch (g)	30	30	30	30
Egg yolk	1	1	1	1
Butter (g)	60	60	60	60
Margarine (g)	80	80	80	80
Powder sugar (g)	80	80	80	80
Skim milk (g)	10	10	10	10
Baking powder (g)	2	2	2	2

Ingredients A: wheat flour, cornstarch, skim milk, baking powder. Ingredients B: margarine, butter, egg yolk.

Butter cookies were made by mixing the group of ingredients that were dry ingredients (A) and wet ingredients (B). Some dry ingredients were sifted, including 200 g wheat flour, 30 g cornstarch, 10 g skim milk, and 2 g baking powder (A). Other ingredients such as margarine, butter, and egg yolk were mixed using a mixer until homogenous and thicky (B). Then KFB flour was added to the mixture of ingredients A and B and stirred together until homogeneous to make a dough. The KFB flour was added with different levels as treatments: 0%, 2%, 4%, and 6% based on wheat flour. The firm dough was formed into a circle (0.5 cm of thickness and 4.0 cm of diameter) placed on an aluminium tray and baked immediately. The cookies were baked in the oven at a low temperature (100°C) for about 30 mins until cooked.

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2.3 Chemical analysis

Butter cookies obtained were analyzed for ash and moisture content by the gravimetric method, protein using the Kjeldahl method, fat using the Soxhlet method, and carbohydrate content using the difference method (AOAC, 2011). Total energy was calculated by converting protein, fat and carbohydrate into calories and summing them up. The calcium, phosphorus, and iron content of butter cookies were determined by the spectrophotometry method (AOAC, 2011).

2.4 Statistical analysis

The treatment carried out in this study was the percentage of knife fish bone (KFB) with four treatments and three replications. The experimental design of this research used the Completely Randomized Design (CRD). Data collected were analyzed using a one-way ANOVA statistical test with a 95% confidence level followed by Duncan's Multiple Range Test (DMRT) to find out the significant difference between treatments.

3. Results and discussion

3.1 Knife-fish bone flour specification

The specifications of the KFB flour used in this research have chemical specifications as shown in Table 2. KFB flour in this research is one of the primary grades of specification based on The National Standard of Indonesia (SNI 01-3158-1992) which has more than 30% calcium content. The protein of KFB flour is too low (9.87 %) compared to SNI because the processing method uses the alkaline method. KFB flour processing uses NaOH to hydrolyze protein. That is how the amount of protein content in KFB flour is low but the calcium content is getting higher.

Table 2. Specification of KFB flour compared to the National Standard of Indonesia (SNI 01-3158-1992).

Component	Value*	The National Standard of
Moisture (%)	2.91±0.03	max. 8
Ash (%)	86.32±3.57	20-30
Protein (%)	9.87±0.63	45-65
Fat (%)	0.71±0.08	3-6
Calcium (%)	31.31±0.87	20-30
Phosphorus (%)	3.99±0.04	20

* Kusumaningrum *et al.* (2016).

The small amount of fat in KFB flour may also be due to the effect of NaOH. The utilization of NaOH could dissolve and remove the organic materials (Nemati *et al.,* 2017). The fat content of KFB flour may be affected by boiling frequency in its processing used four times boiling here. Pressure cooking was used in KFB flour processing might be also affected to decrease the fat content. The combination processing involving boiling and NaOH could be more effective in removing the fat content from the fish frame (Amitha *et al*., 2019).

3.2 Proximate composition

The result of the chemical composition of butter cookies can be seen in Table 2. The addition of KFB flour in butter cookies significantly (p<0.05) affected the level of energy, protein, fat, moisture, ash, calcium, and phosphorus, but did not significantly influence the level of carbohydrate, fiber, and iron (p>0.05). Table 3 shows that the energy of butter cookies with KFB flour or without KFB flour has fulfilled the requirement based on the Decree of The Minister of Health Republic of Indonesia (minimal energy 400 kcal) (Ministry of Health Republic of Indonesia, 2007).

F1 without KFB flour has the highest energy with 473.11 kcal and a significant difference to F4 (KFB flour 6%) which has the lowest energy with 454.37 kcal. The addition of KFB flour until 4% did not give a significant decrease in the energy of butter cookies. The carbohydrate content of butter cookies ranged from 48.27% to 51.70% which did not show a statistically significant difference between formulas. The result showed that the addition of KFB flour did not affect the carbohydrate content. The carbohydrate content in these cookies is more affected by the ingredients used which were wheat flour and cornstarch.

The fiber content of butter cookies increased with a higher addition of KFB flour, but it was not statistically significant (p>0.05). Table 3 shows that the lowest fiber content was found at F1 (0% KFB flour) and the highest content at F4 (6% KFB flour). This result showed that the addition of KFB flour until 6% did not affect the fiber content of butter cookies.

The protein content of all treatments ranged from 4.98% to 5.55% did not fulfil the requirement on the Decree of the Minister of Indonesia that was 8-12% protein. The addition of KFB flour aimed to make the butter cookies a healthy snack because of calcium-fortified. Based on this result, the usage of KFB flour in butter cookies could decrease other components such as protein.

The fat content was also decreased by the addition of KFB flour. F1 (without KFB flour) had the highest fat content 27.60% and the F4 (KFB flour 6%) had the lowest fat content 26.79%. One of the play roles of the fat on biscuits is as a shortening to make a softer texture (Agustia *et al*., 2017). The fat content of butter cookies in all formulations was higher than the requirement of complementary feeding biscuits 10-18% (Ministry of

Table 3. Chemical composition of butter cookies in various formulations (F).

Chemical composition	F1 (KFB 0%)	F2 (KFB 2%)	F3 (KFB 4%)	F4 (KFB 6%)
Energy (kcal)	473.11±9.35^{b}	466.33±7.80^{ab}	467.13±8.18^{ab}	454.37±3.28^{a}
Carbohydrate (%)	51.17±1.77^{a}	51.70±1.64^{a}	51.39±1.76^{a}	48.27±1.96^{a}
Fiber (%)	11.29±1.96^{a}	11.67±1.39^{a}	12.30±1.84^{a}	13.24±1.37^{a}
Protein (%)	5.13±0.22^{ab}	4.98±0.10^{a}	5.03±0.11^{a}	5.55±0.36^{b}
Fat (%)	27.60±0.47^{b}	27.18±0.28^{ab}	27.32±0.19^{ab}	26.79±0.26^{a}
Moisture (%)	3.67±0.04^{c}	3.03±0.18^{b}	2.80±0.12^{ab}	2.69±0.15^{a}
Ash (%)	0.76±0.05^{a}	1.68±0.09^{b}	2.26±0.13^{c}	3.21±0.06^{d}

Values are presented as mean±SD with three replications. Values with different superscripts are statistically significantly different with Duncan's multiple range test ($p \leq 0.05$). KFB: Knife-fish bone flour.

Health Republic of Indonesia, 2007). Pratama *et al.* (2014) and Jannah *et al.* (2020) explained that the moisture content has a strong correlation with fat content. Muzaki *et al.* (2021) reported that the decrease in fat content may be caused by the decrease in moisture content. Loss of fat and moisture content can occur due to the denaturation of protein and can lead to a reduction in the water-holding capacity. Protein will coagulate if the material is heated causing a lot of fat to break through (Windsor 2001).

The moisture content in all formulations fulfilled the quality requirement based on SNI 2973:2011, a maximum of 5% (The National Standardization Agency of Indonesia, 2011). The highest moisture content (3.67%) was found at F1 (KFB flour 0%), and the lowest moisture content (2.69%) was found at F4 (KFB flour 6%). The addition of KFB flour significantly decreased the moisture content. The decrease in moisture content of these cookies can be affected by the ingredients used and processed. There is the addition of water in the process of making butter cookies here, so that's why the evaporation of water in the ingredients can hold easily during baking cookies. The longer and higher processing temperatures can also evaporate more water (Afifah *et al.*, 2021). On the other hand, KFB flour added to this formula has a lower water content, which is 2.91%. The higher the addition of KFB flour with lower water content, the butter cookies also have lower water content.

The ash content indicated the presence of organic mineral content in the material. The addition of KFB flour significantly affected the ash content in butter cookies. The increase in ash content was shown by the increase of KFB flour. Butter cookies without KFB flour had the lowest ash. The highest ash was found at F4 with a 3.21% of ash content. KFB flour as a calcium source contributed to the increase of ash content.

3.3 Mineral content

The addition of KFB flour made butter cookies rich in high calcium. Table 4 shows that the calcium content is higher with the addition of KFB flour. The calcium content of butter cookies without KFB flour was 1,85%, after the addition of KFB flour, the calcium content increased to 2.50% (F4). Commercial bakery products commonly have a high in carbohydrates and fat (Mishra and Chandra, 2012). They become a source of calories with other nutrients being overlooked, making the cookies low in nutrient density. The addition of fishbone flour made the cookies enrich nutrients, especially calcium content (Abdel-Moemin, 2015). The butter cookies fortified KFB flour has potential as a healthy snack because of its calcium content. Malde *et al.* (2010) explained that the fish bones have a high mineral that can serve as a dietary source of calcium.

The phosphorus content of this result showed significant differences between the formulas. The increase in phosphorus corresponds to an increase in the KFB content of flour. F1 (0% KFB flour) had the lowest phosphorus (0.135) and F4 (6% KFB flour) had the highest phosphorus. Phosphorus is an important nutrient in the growth, maintenance, and repair of damaged body tissue and cooperates with calcium and magnesium in the formation of bone and teeth in infants and children (Sari *et al.*, 2016).

The iron levels of this result increased according to the increase of KFB flour level, but the increase in iron level was not statistically significant (p>0.05). Iron level is important for human health. Inadequate iron intake

Table 4. Chemical composition of butter cookies in various formulations (F).

Mineral composition	F1 (KFB 0%)	F2 (KFB 2%)	F3 (KFB 4%)	F4 (KFB 6%)
Calcium (%)	1.85±0.14^{a}	2.09±0.31^{ab}	2.41±0.16^{bc}	2.50±0.06^{c}
Phosphorus (%)	0.13±0.01^{a}	0.28±0.00^{b}	0.31±0.01^{c}	0.33±0.01^{d}
Iron (%)	95.85±33.74^{a}	112.96±44.56^{a}	115.74±3.25^{a}	137.11±14.30^{a}

Values are presented as mean±SD with three replications. Values with different superscripts are statistically significantly different with Duncan's multiple range test ($p \leq 0.05$). KFB: Knife-fish bone flour.

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will cause iron deficiency. For children, iron deficiency will inhibit the growth and development brain. The deficiency of iron levels can cause a decrease in the immune system so more children get sick (Sakinah and Ayustaningwarno, 2013).

4. Conclusion

The content of carbohydrates, fiber, and iron in butter cookies did not show a significant difference from KFB flour addition. The energy, protein content, fat content, moisture, and ash content had significant differences from the addition of KFB flour. The calcium content and phosphorus were also significantly different from the addition of KFB flour. The increase in KFB flour resulted in a decrease in energy level, fat content, and moisture content. From this result, the butter cookies with the addition of KFB flour until 6% have the potential of a healthy snack which have high calcium and low energy.

Conflict of interest

The authors declare no conflict of interest.

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