Utilization of Millet Seed Flour (*Panicum miliaceum L*), Chia Seed Flour (*Salvia hispanica*), and Sesame Seeds (*Sesamum indicum*) on Making High-fibre Flakes

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Keywords: Chia Seeds, Dietary Fibre, Millet Seeds, Sesame Seeds.

Abstract: Millet seeds have the potential a raw materials food with protein and fibre content. One of the very popular food is flakes which can be made by combining millet seeds, chia seeds, and sesame seeds. The purpose of this study was to produce high-fibre flakes that have a good sensory property and to identify the physical and chemical properties. The design of this study used a completely randomized design of one factor and two replications. The treatment factors in this study were flakes formulation with ratio of millet and chia seed flour (4 levels), namely F1 (90%:5%), F2 (85%:10%), F3 (80%:15%), F4 (75%:20%). The results of this study showed that millet seed flour obtained water content 16.3%, ash content 2.17%, protein 9.74%, fat 0.11%, carbohydrates 71.7%, dietary fibre 12.5%, and 72.2% yield. The results of the organoleptic test showed that flakes were not significantly different from the hedonic test ($p>0.05$), while the hedonic quality of colour and aroma were significantly different ($p\leq 0.05$). The best formula is F4 with ash content 3.07%, water content 1.96%, protein content 6.74%, fat content 14.1%, carbohydrate content 74.2%, dietary fibre content 26.1%, and 450.7 kcal. These flakes are claimed to be high-fibre foods.

1 INTRODUCTION

Proso millet *(Panicum miliaceum L)* or white millet is one of the small seed cereals that is usually for bird feed. The low use of millet seeds in food products is due to the lack of references and knowledge about the characteristics and content of millet seeds (Marta, 2016). The result of chemical analysis in research Prabowo (2010) nutrient content of white millet seed flour is 9.19% of water, 1.80% of ash, 2.58% of fat, 11.29% of protein, 56.53% of starch, 74.52% of carbohydrate, and 2.01% of crude fibre. According Kumar et al., (2018) that proso millet has a higher content of essential amino acids (leucine, isoleucine, and methionine) than wheat, and is rich in vitamins and minerals such as copper and magnesium, vitamin B6 and folic acid. India, Russia, Nigeria, and China used Millet seeds as a food source of carbohydrates (Amadou et al., 2014). The products made include bread, pasta, porridge, biscuits and drink fermentation, both of whole millet seeds or combined with other grains (Das et al., 2019). Several recent studies develop millet seeds in the manufacture of product such as instant baby porridge, dry noodles, snack bar, and millet sprout flour (Husna et al., 2012; Atmaja and Sari, 2017; Adi Sarno et al., 2018; Dewi et al., 2018).

Chia seeds have been approved as a novel food by the European Parliament and of the Council (E.U Commission, 2015). Chia seeds are report be a safe as food because it has no side effects or allergen (EFSA, 2009). Chia seeds are a good source of omega-3 and omega-6 fatty acids. In addition, chia seeds have a high protein content (16-26%) and are rich in essential amino acids, especially leucine, lysine, isoleucine, and valine, as well as a source of dietary fibre (23-35%) and antioxidants (Vázquez-Ovando et al., 2010; Marcinek et al., 2017). Chia seeds have to used as a staple food by the Aztecs and Mayans (Muñoz et al., 2013). Recent research has shown that chia seeds can using to produce foods such as biscuits, pasta, and bread (Borneo, 2012; Oliveira et al., 2015; Romankiewicz et al., 2017).

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Sesame seeds are known as the "Queen of oilseed" due to their high oil content and resistance to oxidation and rancidity (Myint, 2020). Traditionally, sesame seeds have to be used as a health food in Asian countries and is use to enhance taste and aroma of food, including as a topping for soups, salad, cereals and yoghurt (Asghar et al., 2014). Sesame seeds contain large amounts of oil, protein, carbohydrates, essential mineral, methionine, and tryptophan, as well as secondary metabolites such as lignans, saponins, flavonoids, and phenolic compounds. In addition, as a source of calcium, phosphorus, and iron, and rich in vitamins B and vitamin E (Hegde, 2012).

Food sources of fibre are commonly found in plant foods such as cereals, fruits, vegetables, grains, and nuts. Based on Riskesdas (2018), it is state that 95.5% of the population aged ≥ 5 years lack fibre consumption (vegetables and fruits). WHO recommends dietary fibre intake in the range of 25-30 g/person/day. Meanwhile, based on the RDA, in 2019 the average dietary fibre recommendation for Indonesians was 30 g/person/day. Dietary fibre is able to provide a feeling of fullness for longer, because foods with high fibre content take longer to digest so it is good as a food source at breakfast. One of the popular alternative breakfast products is flakes, especially for children (Aulia et al., 2017). The limited time in preparing breakfast made the interest in flakes increased. This makes flakes as one of the right choices for the ready to eat product category that is easy, fast, and practical to serve. Flakes are generally made from corn (corn flakes) and wheat (wheat flakes) (Situmorang et al., 2017). Commercial flakes have nutritional value per 100 g ranging 310-367 kcal of energy, 1.7 g of fat, 80-83 g carbohydrates, 3.3-17 g of fibre, and 6.7 -10.3 g of protein.

In this study, the millet seeds are selected as raw material for flakes to replace corn flour because the protein content of millet seed flour is higher (11.29 g/100g) than corn flour (8.78 g/100g), and product based on millet seed flour have a glycemic index content (50.2-64.7) which is lower than product from corn flour (78.5-86.3) (Mcsweeney, 2014). In addition, millet seed flour is gluten-free so it is safe for people has disability from celiac disease (gluten-intolerance) from which they cannot consume gluten-containing foods such as wheat (Sarita and Singh, 2016). Dietary fibre in millet seeds also has positive effects on health, such as anti-inflammatory, antidiabetic, anti-hypercholesterolemia, and antiradiation (Sulistyaningrum and Aqil, 2017).

In improving the nutritional value of flakes, required other ingredients besides flour millet seeds like chia seeds and sesame seeds which is a functional food ingredient with bioactive components. Chia seeds flour has a high protein content (26.2%), high dietary fibre (30.24%), and high levels of alpha-linolenic acid (68.0%) which are good for health (Ayza and Coates, 2011). Sesame seeds are high in protein (19.3 g/100 g), rich in calcium (1125 mg/100 g) and iron (9.5 mg/100 g) in the Indonesian food composition table (Zulfianto, 2017). The sesame seeds used in this study were roasted sesame seeds as a sprinkling on the flakes to produce a nutty aroma which is expected to increase acceptance of the product. Product flakes-based millet, chia, and sesame seeds are expected to be an alternative for nutritional needs at breakfast. In addition, efforts to create products with a low glycemic index, rich in fibre, and gluten-free.

2 MATERIAL AND METHODS

2.1 Material

Millet seeds, chia seeds, sesame seeds, tapioca flour, milk powder, sugar and salt were purchased commercially from local market.

2.2 Methods

2.2.1 Millet Seed Flour

Millet seeds were cleaned for extraneous materials, and then soaked in water for 24 hours. The water soaking needs to be replaced with clean water every 12 hours. After that, blanching for 2 minutes and continued drying in an oven at 100℃ for 30 minutes. After obtaining the dry millet seeds, they were milled and sieved of 60 mesh with two repetitions in order to obtain more optimal millet seed flour.

2.2.2 Chia Seed Flour

The chia seeds are roasting for 6 minutes, stirring frequently. Then roasted chia seeds are milled using blander and sieved using a sieve of 60 mesh.

2.2.3 Sesame Seed Roasted

The sesame seeds in this study were not made into flour, but only through a roasting process. The sesame seeds are roasting for 5 minutes while stirring then removed.

2.2.4 Blend Formulation and Preparation of Flakes

The flakes formula used consisted of 4 levels of treatment using a ratio of millet seed flour to chia seed flour are F1 (90%:5%), F2 (85%:10%), F3 (80%:15%), dan F4 (75%:20%). Roasted sesame seeds added a fixed amount of 10 grams of each formulation. The formulation for making these flakes refers to Khairunissa et al. (2018). The main ingredients were mixed according to the treatment and added 5 grams of tapioca flour as a binder for the dough. Then add 10 grams of powdered milk, 15 grams of sugar, and 1 gram of salt to give the flakes a taste. The entire dough is mixing with water as much as 45% of the total dough until completely homogeneous. Furthermore, the dough is steamed to help pre-gelatinize the starch for 10 minutes, in this process there is a change in the starch granules and the breakdown of hydrogen bonds that function to maintain the structure so that it cannot return to its original shape (Muflihani, 2016). Then the dough is flattened with a noodle maker on a scale of 3 and printed manually using a knife, then baked using an oven at 120°C for 10 minutes.

2.2.5 Physical Properties of Flour

Physical properties that can be seen is the yield of flour. Yield is the percentage of the main raw material that can be used as a final product. The purpose of the yield is to find out how much flour is produced from the raw materials used. The measurement of flour yield is calculated based on the ratio of the weight of flour obtained with the weight of the raw material expressed in percent (%).

2.2.6 Proximate Analysis of Ingredients and Flakes Samples

The protein, fat, ash, moisture content of the flour and flakes with the best formula determined by the SNI 01-2891-1992 proximate analysis. Carbohydrate content was estimate by difference and caloric value was calculated by using Atwater factor (4 × protein, 9 × fat, and 4 × carbohydrate). Dietary fibre with AOAC 1990.9855.29 proximate analysis.

2.2.7 Sensory Evaluation

Sensory evaluation was carried out by 50 consumer panelists. Sensory analysis of flakes includes hedonic test and hedonic quality test. The hedonic test was carried out to determine the most preferred flakes formula by the panelists. The assessed attributes include color, texture, taste, aroma, and overall. The score scale used is a score of 1 (very dislike) to a score of 7 (very much like). The hedonic quality test is more specific, not just likes or dislikes. The score scale used to determine the color quality is a score of 1 (very not strong dark cream color) to a score of 7 (very strong dark cream color), for the aroma used a score of 1 (very not strong nutty aroma) to 7 (very strong nutty aroma), for the taste used a score of 1 (not very strong sweet/savory taste) to 7 (very strong sweet/ savory taste), for the texture used a score of 1 (very not crispy) to 7 (very crispy).

2.2.8 Statistical Analysis

Data were analysed statistically by Analysis of Variance (ANOVA) when the data were normally distributed, and if there were significant differences then conducted a further test using Duncan's Multiple Range Test (DMRT). Meanwhile, data that were not normally distributed were analysed using the Kruskal Wallis test, and if there were significant differences, then carried out further using the Mann Whitney test.

3 RESULT AND DISCUSSION

3.1 Physical Properties of Flour

The yield of millet seed flour of 72.2% is not much different from Mahendra (2019) studies ranged between 65.27% - 84.60%. This is related to the processing method carried out such as the soaking process in this study which reduces water-soluble components such as potassium, sodium, and tannin in millet seeds, so the yield of millet seed flour produced is not much different from previous studies (Mahendra, 2019). The yield of chia seed flour produced was 85.0% is no different from Riernersman (2016) study of 94.0%. The high and low yields produced are due to the evaporation of substances contained in chia seeds during the roasting process, such as evaporation of water and the process of browning the seed (Purnamayanti et al., 2017).

3.2 Chemical Composition of Millet Flour

The chemical composition of millet flour is shown in table 1. Millet flour produced in this study has a moisture content of 16.3% was higher than millet flour produced at the research Prabowo (2010) and Dewi et al (2018) respectively by 9.19% and 8.35%. The protein content of millet seed flour produced was

9.74% lower than the research conducted by Prabowo (2010) at 11.29% but not much different from the research conducted by Dewi et al (2018) which was 9.77%. This decrease is due to protein denaturation by high heating. The heating process can damage amino acids as protein-forming so that the heating temperature can reduce protein levels (Yuniarti et al., 2013). The fat content of millet seed flour produced was 0.11% lower than that of millet seed flour in Prabowo (2010) study of 2.58% and Dewi et al (2018) of 7.57%. The decrease in fat content was caused by the active lipase enzyme during the soaking process which was secreted by lactic acid bacteria. Lipase enzymes will hydrolyse fats into simpler compounds such as fatty acids and glycerol (Mahendra, 2019). According to Rani et al (2013) fat content can also decrease due to the soaking process followed by blanching. The dietary fibre content of millet seed flour produced was 12.5% higher than the research conducted by Dewi et al (2018) which was 5.93%. The dominant dietary fibre content in millet seeds is insoluble dietary fibre (Manish, 2018).

Table 1: Chemical composition of millet flour.

Components	Millet Flour
Moisture (g/ 100 g)	16.3
Ash (g/ 100 g)	2.17
Protein (g/ 100 g)	9.74
Fat (g/ 100 g)	0.11
Carbohydrate (g/ 100 g)	71.7
Dietary fibre (g / 100 g)	12.5

3.3 Sensory Evaluation of Flakes

The hedonic characteristics of flakes made from millet seed flour, chia seed flour, and sesame seeds such as color, aroma, taste, texture and overall acceptability are shown in table 2. There were no significant differences in all sensory properties of flakes. The hedonic quality there are differences in color and aroma attributes, shown in table 3. The color in each formulation is influenced by the percentage of chia seed flour added to the flakes product. The higher the percentage of chia seed flour then the resulting color will be darker. This is also supported by the statement of Pizarro *et al* (2013) that the use of 0% to 30% chia seed flour will reduce the brightness value of pound cake. The aroma of flakes is obtained from millet seed flour which has a nutty aroma and a distinctive aroma of chia seed flour (Casper et al., 2014). Supported by research by Shivakumar et al (2014) the addition of millet seed flour to cheese making gives a nutty aroma. Coorey et al (2012) the addition of 5% chia seed flour can affect the aroma of the chips. According to Hatamian et al (2020) the aroma of chia seed flour is obtained from the process of roasting the seeds before they become flour.

Table 2: Hedonic score of flakes.

	Color	Aroma	Taste	Texture	Overall
F1	4.40± 1.29[a]	4.62± 1.22[a]	4.73± 1.31[a]	5.17± 1.31[a]	4.99± 1.22[a]
F2	4.52± 1.11[a]	4.28± 1.21[a]	4.67± 1.21[a]	4.90± 1.09[a]	4.86± 1.18[a]
F3	4.41± 1.27[a]	4.45± 1.26[a]	4.41± 1.33[a]	4.57± 1.25[a]	4.74± 1.36[a]
F4	4.48± 1.46[a]	4.40± 1.29[a]	4.97± 1.14[a]	4.97± 1.17[a]	5.08± 1.11[a]
LSD 5%	0.98	0.61	0.17	0.09	0.54

Table 3: Hedonic quality score of flakes.

	Color	Aroma	Sweetness	Savory	Texture
F1	3.82± 1.21[a]	3.56± 1.19[a]	4.07± 0.98[a]	3.93± 1.27[a]	5.27± 1.27[a]
F2	4.56 ± 0.97[b]	4.22± 1.33[bc]	3.94± 1.06[a]	4.20± 1.12[a]	5.11± 1.14[a]
F3	4.73 ± 1.12[b]	4.15± 1.29[b]	3.78± 0.95[a]	4.14± 1.01[a]	5.13± 1.19[a]
F4	5.06 ± 1.21[b]	4.71± 1.14[cd]	4.31± 1.03[a]	4.36± 1.23[a]	5.28± 1.20[a]
LSD 5%	0.00	0.00	0.65	0.40	0.83

3.4 Chemical Composition of Flakes

The result of the hedonic and hedonic quality test obtained the selected formulations is F4 be obtained with the use of 75% millet seed flour and 20% chia seed flour. The nutritional content of selected flakes is shown in the table 4. The selected flakes will be compared with commercial flakes and the cereal quality requirements according to SNI No. 01-4270-1996 to determine the suitability of the nutritional quality of the selected formula.

Table 4: Analysis of selected flakes composition.

Components	Selected Flakes	Commercial	SNI
Moisture (g/ 100 g)	1.96	-	Max.3
Ash (g/ 100 g)	3.07	-	Max.4
Protein (g/ 100 g)	6.74	6.7	Max.5
Fat (g/ 100 g)	14.1	1.7	Max.7
Carbohydrate (g/ 100 g)	74.2	80	Min.60
Dietary fibre (g / 100 g)	26.1	3.3	-
Energy (kcal)	450.7	366.7	-

Based on the results of the proximate analysis and dietary fibre, it showed that the fat content and dietary fibre content of the selected flakes were significantly higher than those of commercial flakes made from corn flour. This is due to the use of chia seed flour as much as 20% in selected flakes which is a source of fibre. Based on all the nutritional parameters of the selected flakes product, it has complied with SNI 01-4270-1996 for cereal quality. The fat content of the selected flakes is much higher. This can happen because of the oil content in chia seeds and sesame seeds. The fat content of chia seed flour is 32.59% (Arumsari dan Sofyaningsih, 2020). Research conducted by Rendón-Villalobos *et al* (2012) stated that the manufacture of corn tortillas with the addition of 20% chia seed flour resulted in a much higher fat content (10.95%) than the control (4.08%) which could be attributed to concentration of chia seed oil.. According to Mohd Ali et al., 2012 chia seeds contain 25-40% fat, which is in the form of polyunsaturated fatty acids such as omega-3 (alpha linolenic acid / ALA) and omega-6 (linoleic acid). The dominant fatty acid content in sesame seeds in the form of oleic and linoleic acids ranges from 80-85% of the total amount (Mahmood Biglar, 2012). These fatty acids are included in the essential fatty acids needed by health.

These selected flakes have fulfilled nutritional claims as high-fibre foods because they contain more than 6 g per 100 g solid weight. The high content of dietary fibre in the selected flakes was caused by several ingredients such as chia seed flour and millet seed flour which contain high dietary fibre. In this study, the dietary fibre content of millet seed flour reached 12.5 g per 100 g. While the content of dietary fibre in chia seed flour is 30.24 g per 100 g (Arumsari dan Sofyaningsih, 2020). Increased dietary fibre can also result from the development of resistant starch during the heating and cooling process (Takhellambam et al., 2016). The dietary fibre content of millet seeds and chia seeds is included in the insoluble dietary fibre (Rana, 2019). Insoluble fibre includes lignin, cellulose, and hemicellulose. The main component found in insoluble fibre is lignin, which plays an important role in the protection of unsaturated fats and is responsible for the hypercholesterolemic activity associated with fibre intake (Tolba et al., 2011). Chia seed flour has a much higher fibre content, so it will determine the percentage of fibre content of the flakes.

3.5 Nutrition Facts of Flakes

Determination of the serving size of flakes is adjusted to the suggestion of serving commercial products from corn flakes is 30 g and served with milk. The energy and nutritional contributions of flakes based on millet seed flour, chia seed flour and sesame seeds are shown in table 5.

Table 5: Nutrition facts of flakes.

Nutrition Facts			
serving size 1 cup (30g)			
Servings Per Container About 1			
Amount Per Serving		Flakes	Flakes with 200ml Milk
Calories		135	257
Calorie from Fat		36	99
			% Daily Value
Total Fat	4 g	6%	17%
Total Carbohydrate	22 g	7%	10%
Dietary Fibre	8 g	27%	27%
Protein	2 g	3%	14%

4 CONCLUSIONS

The results showed that the best formulation of flakes from millet seed flour, chia seed flour, and sesame seeds based on the organoleptic test is F4 (75% millet seed flour: 20% chia seed flour). The results of the sensory test analysis in the study of the comparison of millet seed flour and chia seed flour with hedonic parameters of color, aroma, taste, texture and overall showed that there was no significant difference. Meanwhile, the hedonic quality was significantly different to the color and aroma quality of the flakes. Analysis of the nutritional content of the best flakes formula that is ash content of 3.07%, water content of 1.96%, protein content of 6.74%, fat content of 14.1%, carbohydrate content of 74.2%, dietary fibre content of 26.1%, and calories produced 450.7 kcal per 100 grams. The resulting flakes can be claimed as flakes with high dietary fibre.

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