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*Original Paper*

# Characteristics of Crispy Brownies from Diversified Arrowroot Starch and Black Soldier Fly Larvae (BSFL) Flour and its Potential as a Snack Food for Stunting

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***Abstract*— Stunting is a condition regarding malnutrition, especially in children, which can cause a child to experience slow growth, decreased muscle mass, and weight loss. Protein is one of the important nutrients consumed by children so as not to cause stunting. High protein consumption is the most appropriate step to improve nutrition in stunted children. One of the ingredients high in protein content is Black Soldier Fly Larvae (BSFL) flour. This study aims to determine the characteristics of crispy brownies resulting from the diversification of arrowroot starch and BSFL flour and its potential as a snack for stunted patients. The design used in this study was a Randomized Group Design with treatment of the ratio of arrowroot starch and BSFL flour consisting of five treatment levels, namely (50:5), (50:10), (50:15), (50:20), and (50:25). The parameters observed were sensory characteristics and the best treatment followed by testing protein content, moisture content, ash content, fat content, carbohydrate content and energy. The results showed that the best treatment of sensory characteristics was obtained in the treatment of the ratio of arrowroot starch and BSFL flour (50:10) with sensory properties of color attributes 4.44 (like), aroma 3.94 (somewhat like), texture 4.38 (like), taste 4.19 (like), and overall acceptance 4.38 (like) with water content 1.37%, ash content 1.95%, protein content 8.04%, fat content 21.48%, carbohydrates 67.16%, and energy 494.14 Kcal. The developed diversified crispy brownie product also has the potential as a distraction food for stunting sufferers. It is expected to be a development in utilising local food ingredients combined with insects to support food security in Indonesia.***

***Keywords*— Arrowroot Starch, BSFL, Stunting***

## I. INTRODUCTION

Stunting is a condition related to malnutrition, especially in children. Malnutrition in stunting can cause a child to experience slow growth, decreased muscle mass, and weight loss. The World Health Organization (WHO) defines stunting as a condition of children under the age of five who have a height ratio that is not proportional to their age. The stunting prevalence rate in Indonesia had decreased to 27.67%. Still, this figure has not met the standards according to the World Health Organization (WHO), which has a requirement that the stunting prevalence value must be <20% [1]. The problem of stunting in Indonesia is a serious threat. This led the government to form the National Strategy for Accelerating Stunting Reduction in Indonesia. This strategy involves several sectors including government, private sector, academia, community, philanthropy, and mass media. Cooperation between these sectors is very important for the formation of the strategy. By 2024, the President targets to reduce the prevalence value to 14%, which is higher than the prevalence value targeted by Bappenas which is 19% [2].

One of the factors that cause children to be stunted is heredity, but heredity only accounts for 15% of the causes of stunting in children. The main factors that cause children to be stunted are problems with children's nutritional intake, growth hormones, and the occurrence of recurrent diseases. [2]. Protein is one of the important nutrients consumed by children so as not to cause stunting. Protein is very important, especially in the growth process in children.

Protein intake affects plasma levels of insulin growth factor I (IGF-I), bone matrix proteins, and calcium and phosphorus, which play important roles in bone formation [3]. In addition, protein intake is also associated with serum transthyretin (TTR), serum amino acids and serum insulin-like growth factor-1 (IGF-1), which are protein has a role in linear growth and development in children [4]. If protein intake in children is lacking, it can increase the risk of stunting up to 5.160 times compared to adequate protein intake in children. This is following research [5], which states that stunted children have lower protein intake compared to normal children. Therefore, quality protein intake is needed to increase linear growth in stunted children.

Consumption of foods that contain high protein is the most appropriate step to improve nutrition in stunted children. One food ingredient that is rarely used but has a high protein content is Black Soldier Fly Larvae (BSFL) flour. BSFL is one of the insects that has a high animal protein content of around 30-45% [6]. The results of research conducted by [7] showed that the protein content in BSFL flour was 57.86%, higher than that of corn grits at 11.24%. BSFL flour contains several essential amino acids in sufficient quantities. [8] stated that 15 amino acids were found in BSFL flour, consisting of 8 essential amino acids and 7 non-essential amino acids. Essential amino acids in BSFL flour include leucine, arginine, isoleucine, phenylalanine,

valine, threonine, lysine and histidine. In contrast, non-essential amino acids found in BSFL flour are aspartic acid, serine, glutamic acid, glycine, alanine, proline and tyrosine. According to [8], protein sourced from insects is more economical, environmentally friendly, and important in nature. Based on the research results [9], BSFL contains several minerals that are good for the body and children who suffer from stunting. Some of the minerals possessed by BSFL are Ca (4.7 g/kg DM), P (16.0 g/kg DM), K (5.7 g/kg DM), Na (5.2 g/kg DM), Mg (3.4 g/kg DM), Fe (1.0 g/kg DM), Mn (91 mg/kg DM), Cu (27.0 mg/kg DM), and Zn (119.0 mg/kg DM).

Insect farming can also reduce organic waste that has the potential to pollute the environment, such as food waste. BSFL can be cultivated by feeding BSFL in the form of vegetable and fruit food waste to help reduce food waste. Cultivated BSFL can be utilized as high-protein BSFL flour. Furthermore, BSFL flour can be utilized in various food and non-food products. In addition to BSFL, food ingredients that contain high protein are arrowroot tubers. Arrowroot tubers have the potential to be developed into functional foods because they have good nutritional content such as carbohydrates, protein, and fiber and have a low glycemic index [11]. According to [12], the chemical composition of arrowroot starch is water 8.6%, ash 0.2%; protein 0.65%; fat 0.26%, crude fiber 0.125%, and amylose 31.35%. Utilization of arrowroot starch and BSFL flour can be done with food diversification. One of the food products that can be made with arrowroot starch diversification and BSFL flour substitution is crispy brownies. Crispy brownies are one of the popular foods in various circles so the diversification of the ingredients for making Crispy Brownies with ingredients arrowroot starch base and BSFL flour substitution are good for stunted patients.

Crispy brownies are a food diversification product that utilises arrowroot starch and BSFL flour substitution. The utilization of arrowroot starch and BSFL flour as food diversification in crispy brownie products can be a solution for stunted children. Crispy brownies are included in one type of chocolate cake with a crunchy texture, which in the manufacturing process does not require high development. The manufacturing process is also relatively easy so all groups can make it and be used as a snack for children. When viewed from the ingredients used, it has the potential to be developed into a snack for people with stunting. This is because all the diversification ingredients contain high enough protein. Based on this, it is necessary to research the development of crispy brownie characteristics from the diversification of arrowroot starch and BSFL flour to get the best sensory properties and its potential as a snack for stunting sufferers.

## II. Materials And Methods

### A. Materials

The tools used in the research process are a bowl, spoon, spatula, whisk, pan, baking sheet, gas stove (Rinnai), oven (Kirin), digital scales (Fuji), knife, sieve, plastic box, plastic cup, porcelain cup, aluminum cup, dry oven (Glotech), desiccator, analytical balance (Pioneer), sample burner, muffle furnace/burning furnace (Wisetherm), tweezers, texture analyzer, wool thread, latex gloves, fat flask (Pyrex), erlenmeyer flask (Pyrex), beaker (Pyrex), measuring cup (Pyrex), soxhlet (Behrotest), plastic funnel, water bath (Thermology).

The materials used in the research process are arrowroot starch flour, BSFL flour obtained from PT Bala Biotech Indonesia, wheat flour (blue triangle), dark compound chocolate (Alfa), butter (Blue band), vanilla extract (Koepoe-koepoe), eggs, powdered sugar (Saljuku), cocoa powder (Windmolen), hexane (Merck), H2SO4 (Merck), NaOH (Merck), alcohol (Merck), distilled water (Rofa), baking paper, filter paper, tissue, aluminum foil.

### B. Experimental Design

The experimental design used in this research is a simple Randomized Group Design (RAK) with the treatment of adding various BSFL flour formulations. Each sample was repeated 4 times to obtain 16 experimental units, which were then tested according to the parameters observed and continued with the data analysis process.

### C. Sampel Preparation

The process of making brownie chips with arrowroot starch flour substitution includes several stages that refer to [13] which have been modified. Making Crispy Brownies begins with melting dark compound chocolate and margarine, then cooling for 5 minutes to reach a temperature of 35o C. Followed by making wet dough from the eggs, powdered sugar, and vanilla extract are then beaten until evenly distributed. After that, wheat flour and arrowroot starch are added according to the ratio, as well as cocoa powder, melted chocolate, and margarine. Next, the brownie batter is poured onto a baking sheet lined with paper and flattened to 2mm thick. The brownie dough is baked using an oven at 150°C for 10 minutes. Brownies are removed and cut using a knife, then put back into the oven at 150 ° C for 5 minutes. Brownies are removed and allowed to stand until they reach room temperature, then stored in a closed container. Crispy Brownies formulation can be seen in (Table I).

TABLE I. CRISPY BROWNIE FORMULATION

| Treatment | Garut | BSFL | Butter | Eggs | Sugar | Vanilla |
|---|---|---|---|---|---|---|
| B1 | 50 | 5 | 40 | 50 | 40 | 2 |
| B2 | 50 | 10 | 40 | 50 | 40 | 2 |
| B3 | 50 | 15 | 40 | 50 | 40 | 2 |
| B4 | 50 | 20 | 40 | 50 | 40 | 2 |
| B5 | 50 | 25 | 40 | 50 | 40 | 2 |

Notes :
B1 : 50 g arrowroot starch + 5 g BSFL flour
B2 : 50 g arrowroot starch + 10 g BSFL flour
B3 : 50 arrowroot starch + 15 g BSFL flour
B4 : 50 g arrowroot starch + 20 g BSFL flour
B5 : 50 g arrowroot starch + 25 g BSFL flour

### D. Data Analyzed

Data obtained from the observations will be analyzed statistically using variance analysis with the help of Minitab 19. If treatment affects the variable P <0.05, then the test is continued with Tukey's Difference Test.

### E. Sensory Evaluation

The variables observed in this study were sensory characteristics which included hedonic tests of color, taste, aroma, texture and overall acceptance [14]. Sensory testing was

conducted on 16 panelists with the assessment criteria of 5 = very like, 4 = rather like, 3 = neutral, 2 = rather dislike, 1 = very dislike. Samples were served with plastic plates that were randomly coded to ensure panelists did not see all samples. The samples presented were samples of Crispy Brownies that had been prepared previously.

*F. Protein Content*

Crispy brownies with the best sensory characteristics were followed by protein testing with the kjeldahl method referring to [15], which was modified. Protein testing begins with the deconstruction stage. In the destruction stage, the sample that has been mashed is weighed as much as 0.1 gram, and then 0.5 gram of Kjeldahl powder is added. Enter 5 ml of concentrated H2SO4 and deconstruct for 1.5 hours. Cool the sample for 15 minutes and add 25 ml of distilled water. The next stage is the distillation stage.

$$\%N = \frac{(ml\ sampel - ml\ blanko) x\ N\ HCL\ x\ 14{,}008}{W\ sampel\ x\ 1000}\ X\ 100\% \quad \text{.....(1)}$$

$$\%\text{Protein} = \%\text{N x Conversion Factor} \quad \text{.....(2)}$$

$$Moisture\ Content = \frac{initial\ weight\ (g) - final\ weight\ (g)}{initial\ weight\ (g)} x100\% \quad \text{.....(3)}$$

$$\text{Fat Content (\%)} = \frac{(C-B)}{A}\ x\ 100\% \quad \text{.....(4)}$$

$$\text{Ash Content (\%)} = \frac{(W2-W1)}{(W-W1}\ x\ 100\% \quad \text{.....(5)}$$

At this stage, the sample is put into the distillation flask, and then 25 ml of NaOH and 3 drops of PP indicator are added. Next, prepare an Erlenmeyer containing 10 ml of boric acid, and the distillation process begins until you get the following the distillate liquid is collected in an Erlenmeyer. The last stage is titration. The solution used in the titration process is 0.1 N HCl solution. The titration process ends until the color of the solution in Erlenmeyer turns light purple, indicating that all N elements react with Cl. Protein calculation Eq (1) and (2)

*G. Moisture Content*

Determination of the moisture content of crispy brownies was carried out using the Gravimetric method referred to [16], which was modified. A sample of 2 grams was put into an aluminium cup that had been weighed. The sample in the cup was dried in an oven at 105°C for 4 hours. After that, it was cooled in a desiccator for 15 minutes and weighed. After obtaining the first weighing results, the cup containing the sample was dried for 30 minutes, then cooled in an applicator for 15 minutes and weighed. This treatment was repeated until a constant weight was reached. The result of reducing the weight of the material is the amount of water in the material. Moisture content can be calculated using Eq (3)

*H. Fat Content*

Determination of the fat content of crispy brownies was carried out by Soxhlet extraction method [17]. The sample was mashed and then weighed as much as 1 gram. Next, the sample is put into a lead made of filter paper (A gram). Cover the top of the lead with fat-free cotton and fold the ends of the lead tightly. Then, the lead is inserted into the Soxhlet microtube. The lower end of the micro-tube is then connected to a fat flask of known weight (B grams). Furthermore, the top of the Soxhlet micro-extractor was connected to a counter-cooler assembled on a water bath. After that, pour the n- hexane solvent. Extraction was carried out for ± 4 hours. After the extraction, the flask containing the fat extract was then dried in an oven at 105o C. The dried flask was cooled in a desiccator and weighed to obtain a constant weight (C grams). The formula (4) can calculate fat content :

*I. Ash Content*

Ash content testing was carried out using the Gravimetric method [18]. Ash content testing begins with baking the cup for as long as possible. 1 hour in an oven at 105o C. Then, the cup was cooled in a desiccator for 15 minutes and weighed (W1). Next, the sample that has been mashed weighed in a cup as much as 2 grams (W). The sample was heated on a heater until it became charcoal, then ignited in a furnace at 550o C for 5 hours. After the charring stage, the cup was cooled, put into a desiccator for 15 minutes, and then weighed to obtain the final weight (W2). The formula (5) can calculate ash content :

## III. Results And Discussion

The crispy brownie sensory characteristics test results and proximate analysis can be seen in (Figure 1) and (Table II).

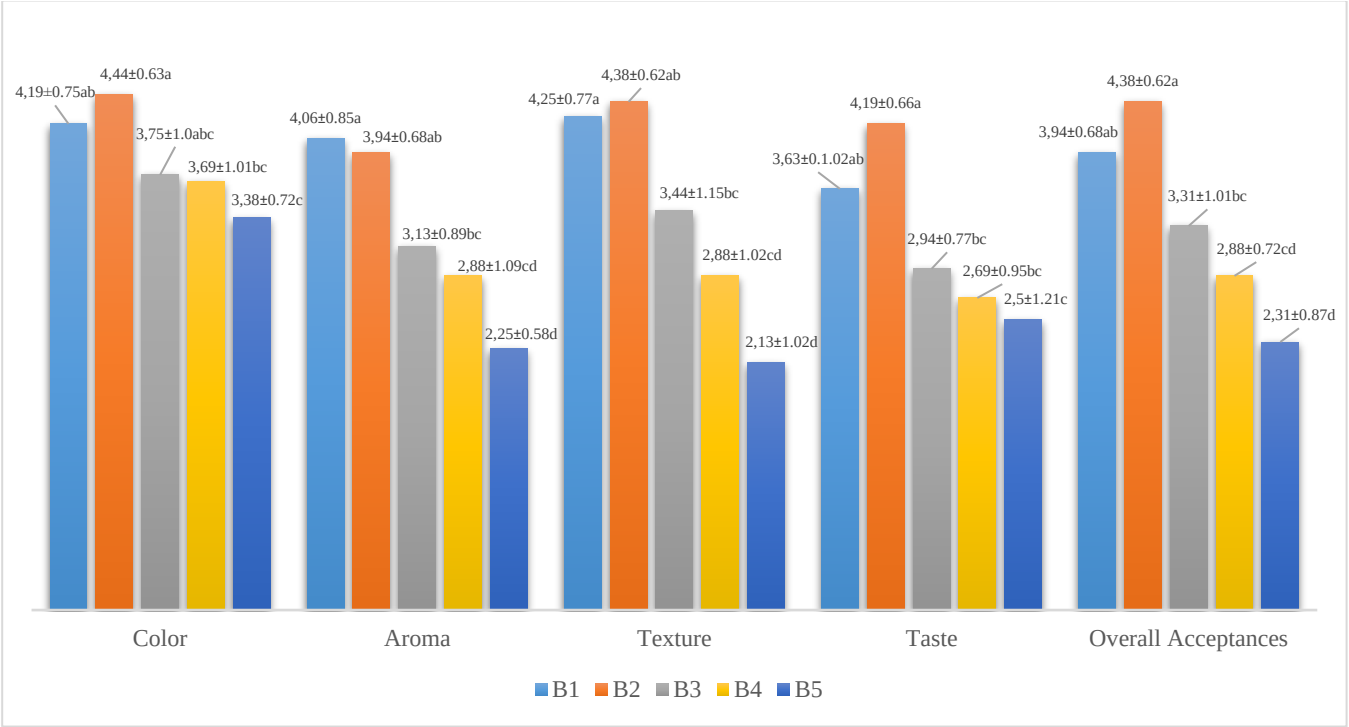


Fig. 1. Sensorist Characteristic

Notes: B1 : 50 g arrowroot starch + 5 g BSFL flour, B2 : 50 g arrowroot starch + 10 g BSFL flour, B3 : 50 arrowroot starch + 15 g BSFL flour, B4 : 50 g arrowroot starch + 20 g BSFL flour, B5 : 50 g arrowroot starch + 25 g BSFL flour. The same notation behind the mean value in the same column determines the difference that is not significant (P>0.05). Hedonic Test Criteria: 5 = Very Like, 4 = Somewhat Like, 3 = Neutral, 2 = Somewhat Dislike, and 1 = Very Dislike.

(TABLE II). PROXIMATE ANALYSIS

| Sample | Moisture Content (%bb) | Ash Content (%bb) | Protein Content (%bb) | Fat Content (%bb) | Carbohydrate (%bb) | Energy (Kcal) |
|---|---|---|---|---|---|---|
| Brownies Crispy | 1.37±0.20 | 1.95±0.07 | 8.04±0.97 | 21.48±0.19 | 67.16±3.17 | 494.14±0.97 |

*A. Color*

The analysis of variance results showed that diversification of arrowroot starch and substitution of BSFL flour had a significant effect (P < 0.01) on the color of the Crispy Brownies. The average value of the color hedonic test on Crispy Brownies ranges from 3.38 (neutral) to 4.44 (like), as seen in (Table II). The highest results were obtained in Crispy Brownies with treatment B2 (arrowroot starch: BSFL flour = 50: 10) which was 4.44 (like), which was not statistically different from treatment B1 (arrowroot starch: BSFL flour = 50: 5) and B3 (arrowroot starch: BSFL flour = 50: 15). The lowest average value was obtained in Crispy Brownies with Treatment B5 (arrowroot starch: BSFL flour = 50:25) which was 3.38 (neutral), which statistically was not significantly different from treatment B3 (arrowroot starch: BSFL flour = 50:15) and B4 (arrowroot starch: BSFL flour = 50:20). Based on Table 3. Color test results of Crispy Brownies formulation (50:10) with a colorimeter resulted in average L*, a*, b* values of 17.1, 14.8, and 5.9 with Havana Brown color characteristics.

This shows that the more the addition of BSFL flour is indicated can reduce the level of panelist preference for the color of the Crispy Brownies produced. This is following the report from [7], which reported the same thing, namely that the higher the addition of BSFL flour, the level of panelist preference for color attributes tended to decrease. The same thing was also reported by [19]: BSFL flour has brown color characteristics. The brown color of BSFL flour causes Crispy Brownies to be dark brown in color, making it less attractive to panelists. In addition, according to [20], the color of the raw materials used will affect the final color of the product. However, when viewed from the average color hedonic test value of Brownies Crispy with the addition of BSFL flour in all treatments, it shows that the crispy brownies produced are still acceptable to the panelists.

*B. Aroma*

The analysis of variance results showed that diversification of arrowroot flour and substitution of BSFL flour had a very significant effect (P < 0.01) on the aroma of Crispy Brownies. The average value of the aroma hedonic test on Crispy Brownies ranges from 2.25 (somewhat dislike) - 4.06 (somewhat like), which can be seen in (Table II). The highest results were obtained in Crispy Brownies with treatment B1

(arrowroot starch: BSFL flour = 50: 5) which was 4.06 (somewhat like) which was not significantly different from treatment B2 (arrowroot starch: BSFL flour = 50: 10). The lowest average value was obtained in Crispy Brownies with Treatment B5 (arrowroot starch: BSFL flour = 50:25) which was 2.25 (somewhat dislike) which was not significantly different from treatment B4 (arrowroot starch: BSFL flour = 50:20). This shows that the more BSFL flour added, the stronger the aroma of BSFL flour will be in the resulting Crispy Brownies. According to [19], BSFL flour has a rancid aroma.

The rancid aroma in maggot flour is due to the high fat content, which causes fat to oxidize more quickly. Based on research conducted by [21], the fat content in BSFL ranges from 12.8%- 39.6%. When viewed from the average value of the aroma hedonic test, Crispy Brownies diversified from arrowroot starch and BSFL flour produced are still acceptable to panelists.

*C. Texture*

The analysis of variance results showed that diversification of arrowroot flour and substitution of BSFL flour had a very significant effect (P<0.01) on the texture of Crispy Brownies. The average value of the aroma hedonic test on Crispy Brownies ranged from 2.13 (somewhat dislike) - 4.38 (like). The highest result was obtained in Crispy Brownies with treatment B2 (arrowroot starch: BSFL flour = 50:10) which is 4.38 (like). In contrast, the lowest average value was obtained in Crispy Brownies with Treatment B5 (arrowroot starch: BSFL flour = 50:25) which is 2.13 (rather dislike).

According to [7], the raw materials used affect the final texture of a product. This is in line with research conducted by [19], which states that flour's fat content is higher than flour's fat content. BSFL can increase crispness. During the kneading process, the fat will envelop the surface of the starch and protein to produce crispy Brownies [22]. In addition to fat content, the thickness at the time of making Crispy Brownies also affects the texture of the resulting Crispy Brownies.

*D. Taste*

The analysis of variance results showed that diversification of arrowroot flour and substitution of BSFL flour had a very significant effect (P<0.01) on the taste hedonic test of Crispy Brownies. The average value of the taste hedonic test for Crispy Brownies ranged from 2.50 (somewhat dislike) - 4.19 (like). The highest result was obtained in Brownies Crispy with treatment B2 (arrowroot starch: BSFL flour = 50:10) which was 4.19 (like) which was not significantly different from treatment B1 (arrowroot starch: BSFL flour = 50:5). Furthermore, the lowest average value was obtained in Crispy Brownies with Treatment B5 (arrowroot starch: BSFL flour = 50:25) which is 2.50 (somewhat dislike) which is not significantly different from treatment B3 (arrowroot starch: BSFL flour = 50:15) and treatment B4 (arrowroot starch: BSFL flour = 50:20). This shows that the more the addition of BSFL flour in Crispy Brownies, the more the panelists' level of liking will decrease. According to [19], BSFL flour has a bitter aftertaste, so the more the addition of BSFL flour causes Brownies Crispy to be less favored.

*E. Overall Acceptance*

Arrowroot flour and substitution of BSFL flour had a significant effect (P<0.01) on the hedonic test of the overall acceptance of Crispy Brownies. The average value of overall acceptance of Crispy Brownies ranged from 2.31 (somewhat dislike) - 4.38 (like). The highest results were obtained in Crispy Brownies with treatment B2 (arrowroot starch: BSFL flour = 50: 10), namely 4.38 (like), while the lowest average value was obtained in Crispy Brownies with Treatment B5 (arrowroot starch: BSFL flour = 50: 25) namely 2.31 (rather dislike). Assessment of the overall acceptance of panelists is influenced by several factors such as color, aroma, texture, and taste.

Based on the sensory test, it can be seen that the best Crispy Brownies are produced in formula B2 (arrowroot starch: BSFL flour = 50:10). This determination is based on an assessment of the color, aroma, taste, texture, and overall acceptance of the panelists on Crispy Brownies. Crispy Brownies with formula B2 were tested for protein content using the kjeldahl method.

*F. Proximate Analysis*

Proximate analysis of crispy brownies resulting from diversification of arrowroot starch and the addition of maggot flour was carried out on the best treatment based on sensory characteristics with the hedonic test, namely in treatment B2 which can be seen in (Table II).

After obtaining the best sensory characteristics, Crispy Brownies testing was continued with proximate analysis, including protein, fat, moisture, and ash. The average protein content in Crispy Brownies is by 8.04%. Nowadays, the making of brownies as a result of food diversification has been widely carried out with various raw materials. Brownie diversification generally uses flour-flour raw materials, such as mocaf flour, corn flour, rice bran flour, tempe flour, moringa leaf flour, and so on. The research results [23] on brownies made from mocaf flour and rice bran flour produced protein levels of 5.29%. Similar research was also conducted by [24] regarding the manufacture of moringa and tempeh flour brownies, resulting in protein levels of 5.53%. [25] I also researched crispy brownies with mocaf flour and seaweed pulp, which produced protein levels of 4.92%. This proves that the ability to make crispy brownies from the diversification of arrowroot starch with BSFL flour has higher protein levels. The composition of the constituent ingredients influences the protein contained in crispy brownies. The high protein content of the crispy brownies produced is due to the addition of BSFL flour. According to [7], the protein content in BSFL reaches 57.86%, the content is still higher when compared to other protein sources such as black bean flour 24.32% [26], red bean flour 23.46% [27], and soy flour 45.27% [28]. The high protein content of BSFL flour is due to the fact that BSFL flour contains many amino acids. The protein contained in Crispy Brownies is influenced by the composition of the constituent ingredients, namely BSFL flour, which contains 67.7% protein according to

the study results. The high protein content in BSFL flour is because BSFL flour contains many amino acids. According to [29], BSFL flour contains amino acids in the form of L-Glutamic acid, glycine, L-Leucine, L-Arginine, L- Tyrosine, L-Valin, L-Aspartic acid, L-Proline, L- Phenylalanine, L-Alanine, L-Serine, L-Isoleucine, L- Threonine, L-Lysine, L-Cytisine, L-Histidine, L-Tryptophan, and L-Methionine. This is in line with research conducted by [30] which states that the amino acids of BSFL flour are complete with the highest amino acid content of glutamate (7,685.84 mg/kg), aspartate (5,864.19 mg/kg), and leucine (5,034.31 mg/kg).

The fat content of Crispy Brownies was determined using the Soxhlet extraction method [17]. Based on Table 3. the average fat content in crispy brownies is 21.48%. The fat content in Crispy Brownies is quite high because BSFL flour has a high-fat content. This is in line with research conducted by [31], which states that BSFL flour has a fat content of 32.2%-40.08%. In addition, the high-fat content in Crispy Brownies is due to the high-fat content of BSFL flour and the addition of other ingredients during the manufacturing process, such as chocolate and margarine. According to [32], chocolate bar contains 21.3% fat. Furthermore, according to [33], the fat content in margarine is 80.88%. This causes the high-fat content contained in Crispy Brownies. The fat content of Crispy Brownies still meets the SNI 01-2973-1992 standard with a minimum fat content of 9.5%.

The average moisture content produced by Crispy Brownies is 1.37%/. The water content produced by Brownies Crispy still meets the SNI 01-2973-1992 standard with a maximum moisture content of 5%. Furthermore, the average ash content of Crispy Brownies is 1.95%. The mineral content influences the ash content produced in the raw materials used. BSFL flour contains minerals such as K (potassium), Na (sodium), Ca (calcium), Cu (copper), Fe (iron), Zn (zinc), Mn (manganese), and P (phosphorus) [35].

### *G. Potential as a Snack for Stunting*

The World Health Organization (WHO) defines stunting as a form of chronic malnutrition that occurs in children under five years of age and has an impact on delays in growth and development, which is characterized by an inappropriate ratio of height to age [35]. If children experience stunting, they will experience growth delays. Growth delays can affect a child's health status. Stunting in children is caused by unbalanced nutritional problems [36]. One of the important nutrients consumed by children so as not to experience stunting is protein. Protein has a role as a new tissue builder during the growth and development of the body. Lack of protein intake can disrupt linear growth [37]. Another nutrient intake risk factor for stunting is mineral intake such as zinc and iron. Iron and zinc are abundant micronutrients in the body. These two minerals also have a role in the linear growth process [38].

Consuming foods high in protein and rich in minerals can be the right step to improve nutrition in stunted children. One of the diversified foods that can be a snack for people with stunting is Crispy Brownies made from arrowroot starch and BSFL flour. Arrowroot starch has a low glycemic index, making it suitable for consumption by all groups [39]. Furthermore, BSFL flour has a high protein content of 57.86% [7]. Based on research [10], BSFL flour is also known to contain minerals such as Fe (1.0 g/kg DM) and Zn (119.0 mg/kg DM), which are good for the body and also for children who suffer from stunting.

Protein plays a role in stimulating Insulin Growth Factor 1 (IGF-1), which promotes linear growth [40]. Protein deficiency can impair bone growth by altering the production and function

of the osteotropic hormone IGF-1 so protein intake can modulate the genetic potential of achieving peak bone mass. Inadequate protein intake will also inhibit IGF-1 growth hormone, which can compromise the availability of bone mass minerals such as Zn and Fe [37]. Zn functions in nucleic acid metabolism and protein synthesis. Zn also plays a role in cell growth, replica, and immunity [41]. Zn deficiency in toddlers can reduce the production of growth hormones such as Insulin Growth Factor (IGF-1), Growth Hormone (GH) receptor and Growth Hormone (GH) binding protein mRNA in the body [37]. Fe can also affect children's growth because Fe functions as an enzyme and cytochrome components. If the amount of Fe in the body is sufficient, the formation of red blood cells in the bone marrow will be fulfilled [41].

Based on the explanation above, food diversification applied to making Crispy Brownies has the potential to become one of the functional food product developments, precisely as a snack to fulfil the protein content in people who suffer from stunting. In addition, the development of Brownies Crispy products is also expected to support reducing and suppressing the prevalence of stunting in Indonesia. The diversified Brownies Crispy product developed is also expected to develop in utilizing local food ingredients combined with insects to support food security in Indonesia.

## IV. CONCLUSIONS

1. Diversification of arrowroot starch with BSFL flour significantly affects sensory properties, including color taste aroma texture and overall acceptance of crispy brownies.
2. The ratio of arrowroot starch and BSFL flour 50:10 produces the best sensory properties, namely color 4.44 (like), aroma 3.94 (somewhat like), texture 4.38 (like), taste 4.19 (like), overall acceptance 4.38 (like). with 1.37% moisture content, 1.95% ash content, 8.04% protein content, 21.48% fat content, 67.16% carbohydrates, and 494.14 Kcal energy.
3. The crispy brownies resulting from the diversification of arrowroot starch and bsfl flour have the potential as a distraction food for stunting sufferers. The developed diversification results are also expected to be a development in utilising local food ingredients combined with insects to support food security in Indonesia.

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