

CHARACTERIZATION OF FLAKES MADE IN CORN FLOUR (ZEA MAYS) AND PUMPKIN (CUCURBITA MOSHCATA) WITH ADDITION OF SOYBEAN FLOUR (GLICINE MAX)

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ABSTRACT

This study aims to determine the effect of adding soybean flour (Glicine max) to the chemical, physical, and organoleptic characteristics of flakes from a combination of corn (*Zea mays*) and pumpkin (*Cucurbita moschata*) and to determine the best treatment for flakes produced based on chemical, physical characteristics, and its organoleptic. The research method used is an experimental method with descriptive data analysis. This study used 5 treatments and 3 replications: A = (addition of 0 grams of soybean flour), B = (addition of 15 grams of soybean flour), C = (addition of 30 grams of soybean flour), D = (addition of 45 grams of soybean flour), and E = (addition of 60 grams of soybean flour). Observations made were chemical analysis in the form of water content, ash content, protein content, fat content, carbohydrate content, crude fiber content, and total amino acids in treatment C, as well as physical tests in the form of water absorption tests, color tests, and organoleptic tests in the form of color, aroma, taste, and texture. The results showed that the addition of soybean flour in the study of corn and pumpkin flour flakes affected water content, ash content, protein content, fat content, carbohydrate content, crude fiber content, water absorption, brightness (color), and preference level based on the color, flavor, taste, and texture of the resulting flakes. The best treatment of flakes produced was treatment C (addition of 30 grams of soybean flour) based on the panelists' preference level with quality characteristics, is: water content ($6.43\% \pm 0.41$), ash content ($1.76\% \pm 0.19$), protein content ($9.78\% \pm 0.29$), fat content ($11.25\% \pm 0.69$), carbohydrate content ($70.89\% \pm 0.57$), crude fiber content ($2.81\% \pm 0.29$), water absorption $368.31\% \pm 2.49$, °Hue (78.57 ± 0.01) and organoleptic values (color 4.35; aroma 3.65; taste 4.10; texture 3, 70) with a total value of 9.72% amino acids and the types of amino acids identified are glutamic acids, leucine, aspartic acid, arginine, alanine, phenylalanine, valine, serine, isoleucine, tyrosine, threonine, lysine, histidine, glycine, and methionine. . threonine, lysine, histidine, glycine, and methionine. . threonine, lysine, histidine, glycine, and methionine.

Keywords : Flakes, soybean flour, corn flour, pumpkin, characteristics, protein, amino acids.

INTRODUCTION

Breakfast is important for the body because it can control blood sugar to remain normal so that passion and work concentration become good. The density of community activities and time demands cause breakfast to be neglected so that it creates a tendency to consume foods that are all practical.

Instant cereal breakfast is one of the choices of nutritious ready-to-eat food that is quite popular among the people of Indonesia (Girsang, 2015).

Cereal flakes are one type of food with low water content and crunchy texture. Cereal flakes are usually in the form of cereal flakes served using liquid milk as a complement or can be consumed directly (Hanawati, 2011). Cereals are generally consumed at breakfast. Cereal flakes are made from the basic ingredients of the endosperm of wheat, rice, oats, and corn with various innovations in raw materials and processing (Utama et al., 2019).

Corn (*Zea mays*) is one of the most potential cereal commodities in Indonesia because it is easy to cultivate. According to Suarni and Yasin (2015), in terms of nutritional value, corn can be declared a functional food because it has dietary fiber, essential fatty acids, isoflavones, minerals (Ca, Mg, K, Na, P, and Fe), and carotene (pro-vitamin A). Although corn has good nutritional value, corn flakes cereal with 100% corn flour content still has shortcomings in terms of preference level and low protein content (< 5%).

In overcoming the deficiency in terms of preference level, Gian (2012) has developed the use of pumpkin (*Cucurbita moshcata*) to obtain a preference level of 75% and increase levels of antioxidants (carotenoids) which contribute to improving the color of the product. Meanwhile, to increase the protein, it is necessary to add a protein source such as soybeans (*Glycine max*).

Soybeans (*Glycine max*) have high protein (31-38%) even higher than other types of beans. In addition, soybeans have a complementary effect when mixed with cereals such as corn. This is because according to Purawisastra et al. (2012), soybeans have a high amino acid lysine (45.58 mg/g protein) which is the limiting amino acid in the cereal group it can increase protein digestibility and can improve protein quality in cereal flakes later. In addition, soybeans are also equipped with isoflavone compounds that play a role in improving bone health (Aminah et al., 2014).

Previous research according to Thomas et al. (2017) proved that the addition of 25% soy flour was able to increase the protein content of gluten-free and casein-free biscuits to 6.42%. In addition, the research of Hariadi et al. (2017), stated that the addition of soybean flour to a mixture of banana cob and corn flour had a greater effect on water content, ash content, and protein content.

In this study, soybean flour was added to cereal flakes, a combination of corn flour and pumpkin to determine the chemical, physical, and organoleptic properties and determine the best formula from the research conducted.

MATERIALS AND METHODS

A. Research Time and Place

This research was conducted from February 2022 to April 2022 at the Laboratory of Chemical Biochemistry of Agricultural Products and Food Nutrition, Laboratory of Instruments, Laboratory of Technology and Process Engineering of Agricultural Products, Department of Food Technology and Agricultural Products, Faculty of Agricultural Technology, Andalas University, Padang and Laboratory of Services. Testing, Calibration, and Certification (LJPKS), Bogor Agricultural University.

B. Research Materials and Tools

The raw material used for the manufacture of the product in this research is Fit's brand corn flour obtained from PT. Fits Mandiri, Bogor, Indonesia. Pumpkins were obtained from the Pasar Baru traders in the city of Padang. Soybean flour brand Tani Kepyar, Yogyakarta, Indonesia and additional ingredients in the form of sugar, salt, margarine, and water obtained from the nearest shops and supermarkets. While other materials are used in the chemical and physical analysis in form of H_2SO_4 , $NaOH$, K_2SO_4 , H_3BO_3 , HCl , distilled water, alcohol, and other chemicals used for analysis.

The equipment used during the research is a tray, mixer, digital scale, dough pan, rolling pin, electric oven, blender, and spoon. The tools used for analysis are Supertek glassware, non-glass laboratory equipment, a set of heating devices, soxletation circuits, an upright cooler, and kjeldahl circuits.

C. Research Design

This study uses an experimental method with descriptive data analysis to see the size of data concentration and data distribution. The results of observations of each parameter were analyzed statistically using Microsoft Excel software. This study consisted of 5 levels of treatment with 3 replications of 100 grams of total raw materials as follows:

- A = Without the addition of soybean flour.
- B = With the addition of 15 g of soybean flour.
- C = With the addition of 30 g of soybean flour.
- D = With the addition of 45 g of soybean flour.
- E = With the addition of 60 g of soybean flour.

D. Research Implementation

Pumpkin Steaming Process

Pumpkin with the good quality washed and peeled. Then the pumpkin flesh is cut into pieces of 2×2 cm. The steaming process is carried out by steaming the pumpkin meat for 5 minutes at a temperature of 100 to soften the pumpkin flesh and inactivate the enzyme. After blanching, the pumpkin flesh is crushed using a chopper to obtain pumpkin puree.

Making Cereal Flakes

All dry ingredients in the form of 80 g of corn flour and soybean flour according to treatment (0 g, 15 g, 30 g, 45 g, 60 g) were mixed then added 1 g of salt and 30 g sugar and stirred until evenly mixed. After all the dry ingredients are evenly mixed, add 25 g of margarine. Then add 20 g of pumpkin that has been blanched and add water and mix again until the dough becomes smooth.

The next step is to flatten the dough using a rolling pin with a thickness of approximately 1 mm then the dough is printed. After the dough is molded to the desired size, the oven process is carried out at 140 for approximately 20 minutes to form a porous (hollow) texture. The ripe flakes were then tempered at room temperature to lower the temperature and then stored in a closed container. Flakes cereal has been analyzed chemically, physically, and organoleptically. °C

The formulation of the ingredients used in the process of making cereal flakes can be seen in Table 1 below:

Table1. Flakes Cereal Ingredients

Material (g)	Treatment				
	A	B	C	D	E
Raw material :					
Corn Flour (g)	80	80	80	80	80
Pumpkin (g)	20	20	20	20	20
Additional Ingredients:					
Soybeans (g)	0	15	30	45	60
Sugar	30	30	30	30	30
Salt (g)	1	1	1	1	1
Margarine (g)	25	25	25	25	25
Water (ml)*					

Note: * Water is added to as much as 25% of the total flour and pumpkin (corn flour, pumpkin, and soybean flour)

Observations

Observations on the product were in the form of chemical analysis consisting of water content analysis using the gravimetric method (Syukri, 2021), ash content using the gravimetric method (Syukri, 2021), protein content using the Kjeldahl method (Syukri, 2021), fat content using the soxletation method (Syukri, 2021), carbohydrate content by different method (Winarno, 2008), crude fiber content (Syukri, 2021) and amino acid analysis using HPLC method (Sumarno, 2002). Then the physical analysis includes a water absorption test (Jumanah et al., 2018 modification) and a color test (Kaemba et al., 2017), and an organoleptic test (AOAC, 2005) in the form of a hedonic test which includes color, aroma, taste, texture, and appearance on cereal flakes.

RESULTS AND DISCUSSION

A. Flakes Cereal Products

The cereal flakes produced in this study were round and flat with a reddish yellow color range. This flakes cereal product characteristically has differences in each treatment, both chemically (water content, ash, protein, fat, carbohydrates, and crude fiber), physics (water absorption and color), and the average organoleptic value (color, aroma, taste, and texture) that affect the quality and level of preference of the panelists. The appearance of the resulting flakes cereal can be seen in Figure 1 below:



Figure 1. Cereal Flakes

B. Chemical analysis

Water Content

Water functions as a dispersing agent for various compounds in food and can act as a solvent (Winarno, 2008). The addition of the right amount of water will form a dough with optimal viscoelastic properties. Therefore, in this study, water was added to each formula to produce a compact dough structure.

According to Rauf (2015), if the amount of water added is less, it will inhibit the interaction between components. However, if the amount of water added is excessive, it will cause damage to the interaction between components. The results showed that the addition of soybean flour treatment resulted in differences in water content. The average value of water content at each concentration of the addition of soybeans can be shown in Figure 2 below:

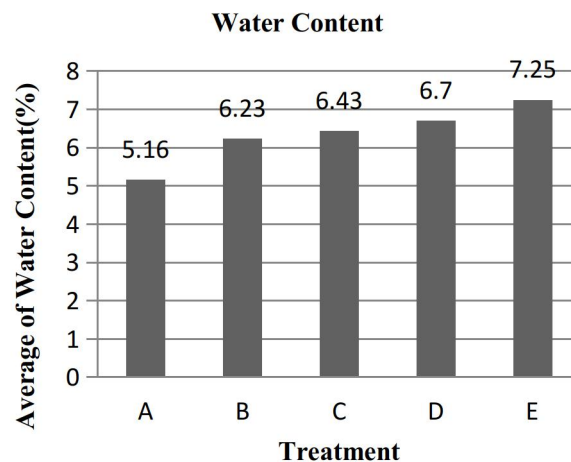


Figure 2. The Average Water Content of Flakes Cereal Produced

In testing the water content, the results obtained ranged from 5.16 to 7.25%. The water content obtained increased with the amount of soy flour concentration added. This is caused by an increase in the amount of water along with the addition of soy flour and the effect of the nature of the water bound to the food. Soybeans contain fat that is high enough to prevent water from evaporating during the starch gelatinization process (Situmorang et al., 2017).

In Polnaya et al. (2015), fat that interacts with starch will interfere with gelatinization because it will form a complex with amylose thereby inhibiting the release of amylose from starch granules. Fat will also be absorbed by the granules so that a hydrophobic fat layer is formed around the granules which will inhibit the binding of water by the starch granules. In addition, the lipid components are capable of forming hydrophobic membranes on strong water-resistant materials. So that when roasting there is still water bound to the material.

This is reinforced by Widyastuti et al., (2008), that the addition of hydrophobic groups (lipids) into hydrophilic groups (carbohydrates and proteins) will form lipid emulsion stability which will increase the ability to prevent water evaporation. So with this, the rate of evaporation of water when roasting cereal flakes decreases with more soy flour added so that the trapped water is still high.

This is in line with previous research that applied soy flour to cookies. Hariyadi (2017) reported that the addition of 30% soybean flour resulted in the highest water content compared to concentrations of 15%, 20%, and 25%. In addition, the study by Purnama et al. (2015) stated that the interaction of corn and beans on flakes was found that the lower the proportion of corn used the matrix formed was not strong so the water content would be higher.

Moisture content will affect the shelf life of the product. According to SNI for cereal milk, the water content produced is a maximum of 3%, while the test results have no formulation that meets SNI. However, the water content produced is still relatively low, ranging from 4-7% so that it can minimize the growth of spoilage microorganisms, and chemical reactions that can damage food such as browning, hydrolysis, or fat oxidation (Winarno, 2008).

The water content that does not meet this SNI can also be caused by the nature of the dry matter. Foodstuffs are hygroscopic which are naturally able to absorb and release some of the water in the air. This form of isothermic absorption is typical for each food depending on the state of the water in the material with the rate of absorption from the air and the rate of release of water into the air do not coincide with each other (hysteresis phenomenon) (Rusmono et al., 2011) so that a suitable packaging method is needed to keep the ingredients from absorbing water from the surrounding environment.

Ash Content

Analysis of ash content in this study used the gravimetric method. The results of the analysis of ash content in this study showed an increase along with the addition of soybean flour. The average value of ash content can be seen in Figure 3 below:

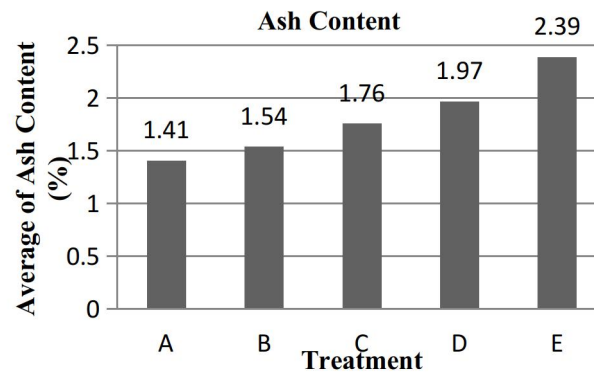


Figure 3. Average Value of Ash Content of Cereal Flakes Produced

In testing the ash content, the value obtained already meets SNI (min 4%) with a range of values ranging from 1.41-2.39%. Ash content is an inorganic substance in materials that cannot be burned in the combustion process at a temperature of 600°C (Winarno, 2008). The addition of soybean flour will increase the ash content of cereal flakes. This is because the ash content in soybean flour is quite high, namely 3.88% (Fanzurna and Taufika, 2020). While the ash content of corn flour is 0.27% (Aini, 2016), and the ash content of pumpkin is 0.7%.

In line with previous research according to Jariyah (2017), the higher the addition of soybean flour to the food bar, the greater the ash content due to the high mineral content such as Ca, Fe, Cu, Mg, and Na in soybeans. So that by increasing the concentration of added soybean flour, it will enrich the minerals in the resulting product. In addition, research by Hariadi et al. (2017) showed that the more addition of soybean flour, the higher the ash content of cookies.

Protein Content

Protein in food can be determined by various methods. One of the common methods used is the Kjeldahl method (Rauf, 2015). This method has a weakness because all detected components have nitrogen calculated as protein.

Based on the results of the analysis, the addition of soy flour to corn flour and pumpkin flakes cereals had a significant effect on protein content. The average value of protein content can be seen in Figure 4 below:

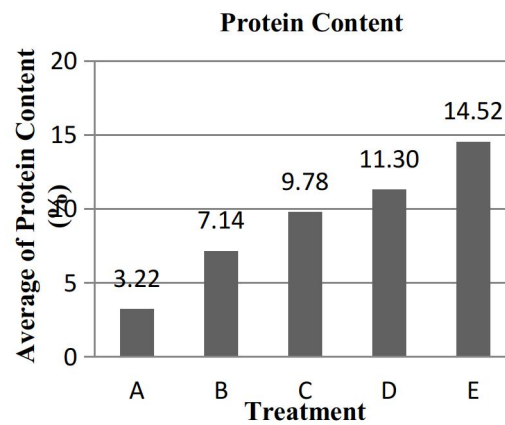


Figure 4. The Average Value of Protein Levels of Cereal Flakes Produced

From the results of protein analysis using the Kjeldahl method, it was found that protein levels ranged from 3.22% to 14.52%. The value of this protein content with the addition of soybean flour treatments B, C, D, and E (addition of soybean flour 15-60 g) succeeded in meeting the SNI for cereal milk, which is at least 5% protein. The protein content obtained is directly proportional to the increase in the concentration of added soy flour. In this study, the higher the concentration of added soybean flour, the higher the total protein value.

This is because soybeans have a high protein content of 35.9% (TKPI, 2017). While the protein content of Fit's brand corn flour is 0.3% and pumpkin protein 0.207% (Santoso, 2013). In line with Hariadi (2017), namely the addition of 30% soybean flour in cookies increased the protein content to 8.63% and Jariyah's research (2017) succeeded in increasing the protein content of taro and soybean composite food bars.

In this study, the high percentage of protein obtained affected the non-enzymatic browning reaction (maillard) formed during the roasting process so that cereal flakes with a higher concentration of soy flour resulted in darker cereal products or chocolate produced by the formation of melanoidin compounds which also calculated as protein content using Kjeldahl.

This Maillard reaction is a complex reaction involving reducing sugars and amine groups from proteins to produce a new brown compound, namely melanoidin which is formed through a polymerization reaction (Rauf, 2015). The color difference will increase with increasing heating temperature, pH, and water activity (aw) between 0.3-0.7 (Hustiany, 2016).

In principle, the melanoidin structure as a result of the Maillard reaction is a polymer compound (spreading bands) where the position and absorbance characteristics cannot be affected by different reaction conditions. In melanoidin, the group $-N=C-$ or $>N=C$ gives the hypothesis that the main element in the melanoidin structure is the incorporation of nitrogen in the melanoidin polymer. The chemical structure of melanoidin has not been fully explained, although in general the structure of melanoidin consists of repeating aromatic groups similar to amaldori reaction products (Dedin, 2006). So it can be stated that in the presence of N atoms in melanoidin, melanoidin is also considered a protein if analyzed by the Kjeldahl method.

Maillard's reaction gave the desired positive impact as well as negative impact. The desired Maillard reaction gives the preferred effect in terms of attractive color and flavor and can be used as an antioxidant for example in cocoa and coffee products. However, it can also change unwanted colors and flavors during storage, loss of protein and sugar nutrients, and is carcinogenic due to the formation of acrylamide compounds (Rauf, 2015).

Fat Content

The results of the analysis of the fat content of corn and pumpkin flakes cereals, with the addition of soybean flour, showed a significant difference in results. This can be seen in Figure 5 below:

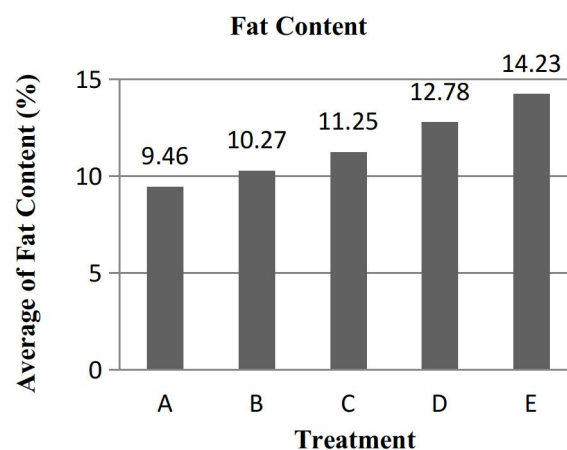


Figure 5. Average Value of Fat Content of Cereal Flakes Produced

Based on the results of the tests carried out, the fat content of the cereal flakes was found to be around 9.46-15.12% with the data increasing with the addition of soy flour to the formula. The higher the concentration of soy flour added, the higher the fat content of the cereal flakes produced. The fat content of soybean flour is much higher than that of corn and pumpkin flour. The fat content of soybean flour is 18.1% (Hariadi, 2017) and 20.6% (TKPI, 2017). The fat content of Fit's brand corn flour is 0.1% and pumpkin fat content is 0.5% (TKPI, 2017).

This is in line with previous literature by Hariadi (2017) which states that the more addition of soybean flour, the higher the fat content of cookies. Overall, the fat content of flakes cereal has met the SNI, which is at least 7%. According to Ghaman and Sherington (1992), fat plays a role in giving a delicious taste and crunchy texture to baked goods because fat has a shortening effect.

Carbohydrate Level

The total carbohydrate analysis method used in this study is the by-difference method so that the carbohydrate content in this method depends on the reduction factor so that it is strongly influenced by other nutrients (Suparni, 2021). The results of the analysis of total carbohydrates can be seen in Figure 6 below:

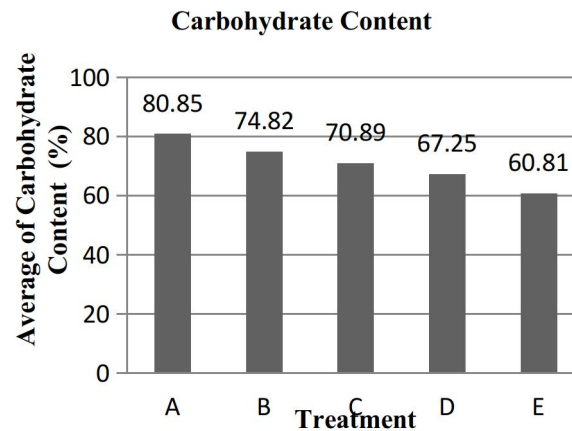


Figure 6. Average Value of Carbohydrate Levels of Cereal Flakes Produced

Carbohydrate analysis data found that carbohydrate levels ranged from 60.81-80.85%. This value indicates that the higher the addition of soy flour, the lower the carbohydrate content of the cereal flakes. According to Lawalata et al., (2019), the carbohydrate content of corn flour is 86.35%. In pumpkins, carbohydrates are also high at 70.52% (Santoso, 2013). While the carbohydrate content of soybean flour is 34.8% (Wiranata et al., 2017).

Carbohydrate content in the form of starch will cause gelatinization which affects the texture and ability of the flakes to absorb water and swelling power. Based on Ratnawati's research (2019), the higher the use of legume flour in mocaf composite flour, the lower its gelatinization and swelling power. This is because peanuts have lower carbohydrates while protein and fat are high enough to affect the ability of starch granules to enlarge.

According to Kusnandar (2020), this gelatinization occurs in 3 stages in the form of water absorption of starch granules to a limit that will expand slowly where there is an alternating reaction of water imbibed into the starch granules so that the hydrogen bonds between the starch granule molecules will be broken. In the next stage, the granules will expand rapidly because they absorb water until they lose their birefringence properties and then proceed to the last stage in the form of breaking of the starch granules due to the continuous increase in temperature and water concentration so that the amylose molecules will come out of the starch granules.

This is in line with Tanuwijaya's research (2016), the higher the proportion of soybean flour, the higher the protein, fat, and energy levels, but will lower the carbohydrate content. Fakturahman (2012) stated that carbohydrate content calculated by the by difference method was influenced by other nutrients (water, ash, fat, and protein). So that the higher the other macronutrients, the lower the carbohydrate content in the product, conversely, the lower the content of other nutrients, the higher the carbohydrate content.

Crude Fiber Content

A lot of fiber comes from the cell walls of various vegetables and fruits in the form of cellulose, hemicellulose, pectin, and other non-carbohydrate compounds such as lignin, some gum, and mucilage. In this study, a total crude fiber analysis was carried out. The results of the crude fiber analysis of flakes cereal can be seen in Figure 7 below:

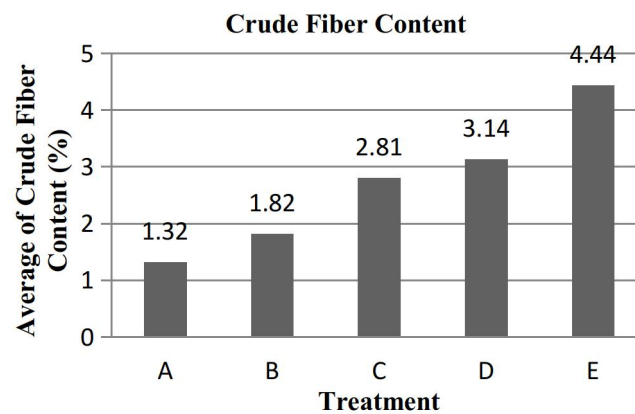


Figure 7. Average Value of Crude Fiber Content of Cereal Flakes Produced

In the table, the results of the analysis show that the crude fiber obtained from cereal flakes ranges from 1.32-4.44%. It can be concluded that the higher the addition of soybean flour, the higher the crude fiber content. Soybeans have a fairly high crude fiber content of 11.27% (Indrawan et al., 2018), higher than the crude fiber of corn and pumpkin. The crude fiber content in flakes cereal comes from raw materials such as corn, pumpkin, and soybeans.

According to Suarni and Firmansyah (2005), the crude fiber content of refined corn flour is about 3.12%. The husk on corn kernels contains high fiber. The level of consumer preference for the use of refined corn flour is quite high because the fiber content is not too high so it is easy to apply to food. Apart from corn, another ingredient used is pumpkin. According to Prayitno et al., (2009), pumpkin has a fiber content of about 2.9%. Of all the treatments tested, the crude fiber content in each treatment did not meet the SNI, which was a maximum of 0.7%. This is because all the materials used have high fiber.

Amino Acid Analysis

Proteins are composed of various amino acids, although the types are incomplete as many as 20 types. Differences in structure and function in proteins are caused by differences in amino acids and the sequence of their constituent amino acids. These amino acids will bind with peptide bonds to form proteins so that each of these arrangements has a uniqueness between proteins that are formed from different sources (Rauf, 2015). For example, cereals have a small amount of the amino acid lysine, and legume proteins have a small amount of the amino acids methionine and cysteine (Estiasih et al., 2018).

Amino acid analysis was performed using HPLC. The total value of amino acids can be linked in Table 2 below:

Table 2. Amino Acid Levels Cereal Flakes Treatment C

No	Types of Amino Acids	Amino Acid Value Treatment C (%)
1	Aspartic Acid	1.09
2	Glutamic Acid	2.16
3	serine	0.55
4	histidine	0.31
5	Glycine	0.27
6	Threonine	0.35
7	Arginine	0.66
8	Alanine	0.63
9	Tyrosine	0.38
10	Methionine	0.14
11	Valin	0.56
12	Phenylalanine	0.61
13	Isoleucine	0.52
14	Leucine	1.16
15	Lysine	0.33
Total Amino Acid		9.72

Amino acids obtained from the flakes cereal treatment C had 9 essential amino acids including isoleucine, leucine, methionine, phenylalanine, threonine, valine, lysine, histidine, and arginine, and contained 6 non-essential amino acids including glycine, alanine, serine, tyrosine, and amino acids. aspartic acid and glutamic acid. This amino acid is sourced from soy flour, corn flour, and a little pumpkin.

According to Sukria (2015), protein quality depends on the completeness and balance of essential amino acids. The balance of essential amino acids is not only determined by the essential amino acids of the ingredients but is also determined by the balance of essential amino acids of the protein.

These detected amino acids will affect the characteristics of the resulting cereal. For example, glutamic acid and aspartic acid are important in creating the characteristic taste and aroma of food (Sukria, 2015). And the presence of the amino acid lysine will affect the color change of the product because lysine is the fastest to produce color while the amino acid cysteine is the slowest to produce color.

In the study, it was found that the total value of amino acids in treatment C was 9.72%, close to the total protein content tested by the Kjeldahl method, which was 9.78%. Calculation of protein content based on the Kjeldahl method not only shows the protein content in the sample but also includes various non-protein compounds containing nitrogen. The nitrogen content of protein foods depends on the variation of specific amino acids. In general, proteins composed of many basic amino acids have a higher amount of nitrogen. In addition, the proportion of nitrogen in dry weight is also influenced by the presence of lipid content (Dedin, 2006).

The highest amino acid in this flakes cereal is glutamic acid and the lowest amino acid is methionine. In line with the amino acids in soybeans, the most abundant amino acids are glutamic acid and the lowest amino acids are methionine and cysteine (Purawisastra et al., 2012). The high content of glutamic acid in the product plays a role in providing a savory taste to food.

Therefore, glutamic acid is often used as a flavor enhancer that provides a strong savory taste because of the hydrogen group in glutamic acid which can be substituted with sodium to form monosodium glutamate (Kusnandar, 2020). In addition, the addition of soy flour is very beneficial because soybeans contain the amino acids tyrosine, methionine, histidine, lysine, and tryptophan which function as antioxidants. Kanetro, 2017).

C. Physics Analysis

Water Absorption Test

In flake cereal products, it is necessary to measure water absorption to show the ability of flakes to absorb liquid and the ability to maintain crispness. The greater the amount of water absorbed in a short time after soaking, the more instant the flakes will be in serving.

According to Astarini et al. (2013), stated that a good breakfast cereal product must be able to maintain its crispness. In the absorption test, water is used to replace milk because flakes can not only be consumed with milk, they can also be consumed directly, with water, or even with yogurt. The results of the water absorption test can be seen in Figure 8 below:

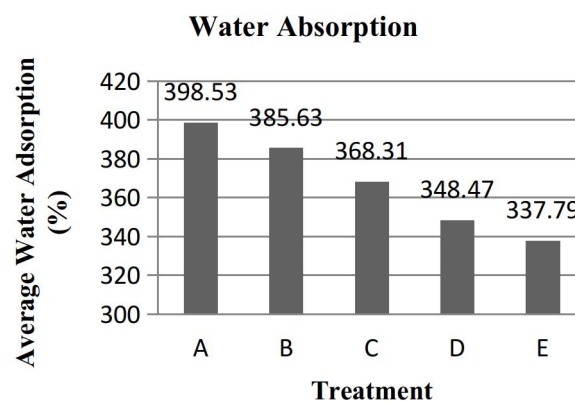


Figure 8. Average Water Absorption Value of Cereal Flakes

The results of the analysis of water absorption showed the value of water absorption ranged from 337.79-398.53%. The results of the analysis showed that the more concentration of soy flour added, the lower the water absorption capacity. This is due to the decrease in starch in the formula. Corn and pumpkin have a high percentage of amylose starch. Water absorption and solubility will be higher in amylose starch because it is polar and able to bind hydrogen.

Amylose has straight chains in the granules so that the hydrogen strength is greater. As a result, the energy required for gelatinization is even higher (Sunarti, 2007). During roasting, the amylose chains are bonded to each other so that it is a polymer. This will later affect the crispness of the resulting flakes.

In addition, according to Harijono et al. (2001), crude fiber will reduce the gelatinization ability of starch because fiber is a water-insoluble compound and will strengthen the material network so that it can strengthen the texture so that it contributes to reducing the rehydration ability of the product. During the texture formation process, the presence of starch, protein, and fiber components will contribute to each other's ability to bind water to the product (Paramita and Putri, 2015).

This is following previous research by Amanda et al., (2021) that the increasing addition of soy flour will further reduce the water absorption of cereals. According to Novidahlia et al., (2020), the higher carbohydrates containing starch will increase the water absorption of instant cereal drinks and vice versa. Gelatinized starch increases the water absorption time due to the breaking of hydrogen bonds between starch molecules so that water will more easily enter the starch molecules (Santosa, 1998).

Color Test

Color analysis is carried out based on the hunter system with a 3-dimensional principle, namely the L value which indicates nonlinear brightness, the a value indicates redness or greenness, and b* indicates yellowish or bluish. This combination will later be converted into one color (Estiasih et al., 2018). After the conversion, the °Hue can be calculated using the formula ($\tan^{-1} b/a$).

In this study, the values of L, a, b*, and °Hue in each treatment of cereal flakes can be seen in Table 3 below:

Table 3. Color Test

Treatment	L*	a*	b*	°Hue	Color Criteria
A	80.80 ± 0.34	5.37±0.08	36.38±0.19	81.67 ± 0.17	Yellow
B	79.89 ± 0.02	4.63±0.01	29.57 ± 0.04	81.12 ±0.02	Yellow
C	75.17±0.01	6.63±0.01	32.78 ± 0.03	78.57 ± 0.01	Yellow
D	68.37±0.08	9.65±0.01	34.75 ± 0.03	74.48 ± 0.10	Yellow
E	59.41 ± 0.13	13.47±0.02	36.75 ± 0.12	69.87 ± 0.09	Yellow

Note: SD = Standard Deviation

Based on the analysis carried out, the resulting °Hue value ranges from 69-82. Based on research by Rulaningtyas et al., (2015), the value of °Hue in the range 0-60 produces red, 60-120 produces yellow, 120-180 produces green, 180-300 produces cyan, and 300-360 produces the color magenta. So in this study, it was found that the a* value ranged from 5.37-13.47 (red) and the b* value ranged from 36.38-36.75 (yellow) so the resulting flakes cereal was in the reddish yellow position in Figure 9 below. :

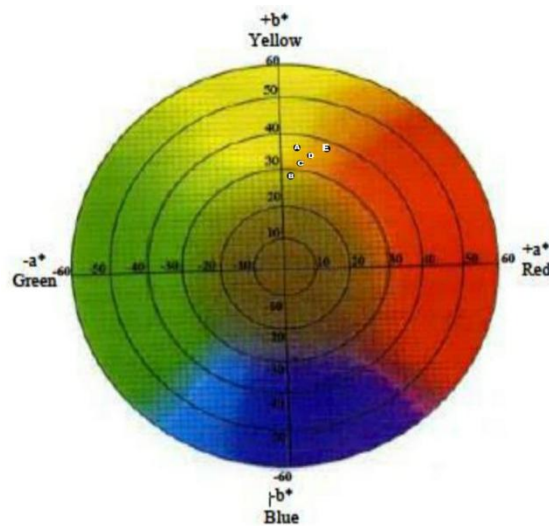


Figure 9. Grade value L, a*, b*

Based on visual observations, it was found that the color produced yellow tends to brown in line with the increase in the concentration of soy flour produced. This is consistent with the decreasing value of L* (lightness) which causes the color of cereal flakes to get darker. The high levels of protein and carbohydrates in soybean flour when other ingredients are added will cause the Maillard reaction to produce a brown melanoidin compound.

The Maillard reaction is divided into stages of formation of glycosylamine and Amadori Rearrangement Product (ARP), followed by an intermediate stage where the decomposition of ARP with starch degradation occurs, as well as the stage of carbonyl compounds such as furfural, fission products, dehydroreductones, or aldehydes resulting from starch degradation which are transformed into melanoidin compounds with high molecular weight (Rauf, 2015).

According to Dedin (2006), the Maillard reaction that causes brown color can be influenced by lipid degradation which reacts with amino acids, peptides, and proteins to produce melanoidin compounds or volatile products such as furan, pyrrole, pyrazine, and their derivatives. The ratio of sugar to amino acids is also very influential in the reaction of color formation. Generally, the smaller sugar molecules react more quickly than the larger sugar molecules. The higher the number of amino acids, the faster the formation of color. The carbonyl group of a reducing sugar reacts with an amine group on an amino acid which is an important component of the Maillard reaction.

D. Organoleptic Analysis

Color Test

Color affects the attractiveness that affects the acceptance of a product. In food products, color depends on the composition, structure, and processing processes that affect pigment color changes. Even though they use the same material, they can produce different rays and light sensations. (Estiasih et al., 2018). The average value of panelists' preference for color can be seen in Figure 10 below:

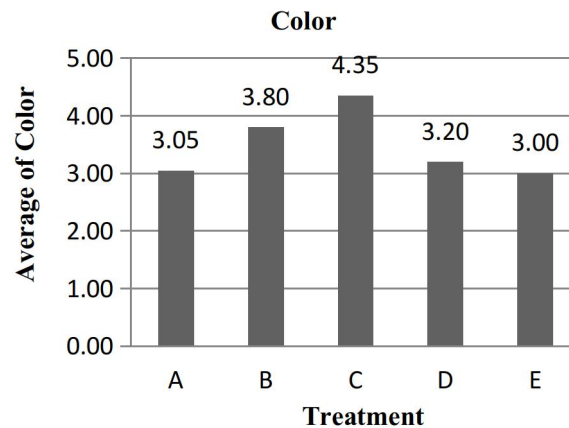


Figure 10. Color Organoleptic Test Average Value

The color organoleptic table shows that treatment C is the most preferred product by the panelists with an average value of 4.35 ± 0.59 with a score of at the level of liking. Meanwhile, the least preferred product was treatment E with an average value of 3.00 ± 0.92 with the score being at the usual level. Product C is the most preferred product by panelists because the ratio of soybean flour to other ingredients is quite high so it produces a brown color with the most preferred brightness level by panelists.

From the results of color organoleptic analysis, it was found that the preference value of treatment A continued to increase until treatment C but again decreased in treatments D and E. This was due to the treatment with the addition of 30 g of soybean flour to produce the best average color value. This color is caused by the Maillard reaction. The Maillard reaction involves the reaction between an amine group and reducing sugar. Maillard reaction sequence of pathway This difference ends at the melanoidin stage which gives it a brown color (Kusnandar, 2020).

This Maillard reaction can be a desired or undesirable reaction. In cereals, the brown color from roasting tends to be favored but at a certain level, it has decreased. The decrease in the value of color preference in treatments D and E was due to the panelists not liking the color of cereals flakes too brown. This can be related to the color analyzed through the hunter lab where the brightness levels of treatments D and E decreased significantly compared to treatments A, B, and C. So this proves that the color of the flakes cereal products produced is getting darker.

Maillard reactions can be influenced by the type of amino acid, the type of reducing sugar, the ratio between reducing sugars and amino acids, as well as the influence of process factors such as pH, temperature, and water content (Hustiany, 2016). According to Primary et al.(2015), the resulting brown color is due to the interaction between the high lysine amino acid in soybeans and reducing sugar groups. Lysine which consists of 2 amine groups will be more reactive to reducing sugars. So the greater the concentration of soy flour added, the easier it will be to produce a brown color even though the heating temperature and roasting time are the same.

Excessive maillard effects can be minimized by the process of blanching before the process of making soybean flour and corn flour because blanching can inactivate peroxide enzymes, reduce oxygen levels in cells, stabilize nutritional value and improve color (Andriani, 2012).

Aroma Test

Aroma is an important sensory attribute in various baked products. Aroma is influenced by a good sense of smell so that it can increase panelists' preference for a product. In general, the aroma that can be received by the nose and brain is more than a mixture of odors, namely sour, rancid, fragrant, and charred (Winarno, 2008). The average value-The panelists' average preference can be seen in Figure 11 below:

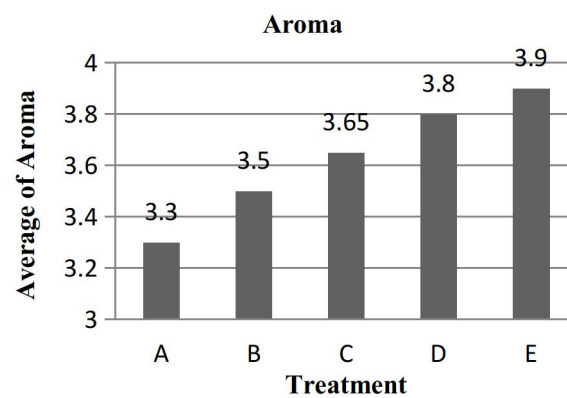


Figure 11. The average value of the Aroma Organoleptic Test

In the results of the level of preference for aroma, it was found that the highest value was in treatment E with a value of 3.90 ± 0.72 with a score value being at the usual level towards liking and the lowest liking value being 3.30 ± 1.17 with a score value being at the usual level. This is caused by the emergence of flavor characteristics after high-temperature roasting which panelists tend to prefer. This preferred aroma is caused by the hydrolyzed protein into amino acids which then react and produces aroma flavors resulting from the Maillard reaction, one of which is Parazin.

Parazine is a compound flavor important in large quantities in cooked, roasted, or baked food products. According to Husniaty (2016), pyrazine compounds are derived from the condensation of 2 amino ketone molecules. By using amino acids and dicarbonyl amino acids were derived through Strecker degradation. Then this compound undergoes aldolization to produce 1-deoxyoson which then becomes alkyl pyrazine. It is this alkyl pyrazine that produces a nutty and roasted aroma. In addition, alkyl pyrazine can also produce the aroma of hydrolyzed soy protein, coffee aroma, and chocolate aroma. Then when the aroma of acetyl pyrazine is formed, it will produce the aroma of popcorn.

Taste Test

The taste parameters were tested with the sense of taste with different levels of sensitivity for each person. The flavor is a browning product in which reducing sugars react with amino compounds to form glycosiamin. The addition of reducing sugar can help optimize the formation of umami taste and the

presence of phosphate compounds can also improve flavor quality. The formation of the taste impression is influenced by the natural flavor of the ingredients and the processing process. The two types of flavoring agents are amino acids or their salts and nucleotides and peptides. With the hydrolysis technique, proteins from these materials will produce L-amino acid compounds, nucleotides, and various peptides with various formations (Witono, 2017). The average value of organoleptic taste by panelists can be seen in Figure 12 below:

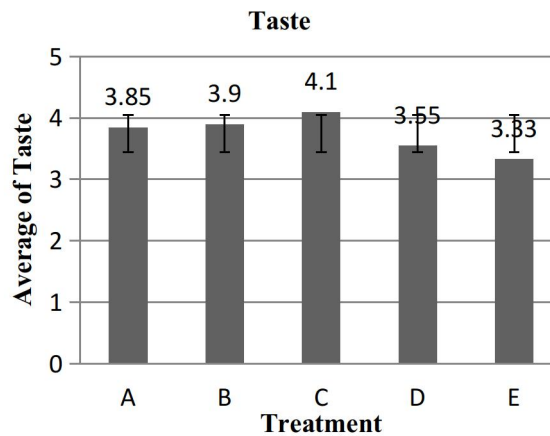


Figure 12. Taste Organoleptic Average

In the results of the panelists' preference for taste, the highest average value in treatment C was 4.10 ± 1.12 with the score being at the level of liking. Meanwhile, the lowest level of preference for panelists in treatment E was 3.33 ± 0.80 with the score being at the usual level. The results of the organoleptic analysis of taste showed an increase in the panelists' preference for taste.

This is due to the roasting effect of soybeans which gives a distinctive taste to the flakes cereal that the panelists like. This grilling effect results from the Maillard reaction between the amine group on the amino acid and the reducing sugar. The more addition of soy flour, the higher the protein content of cereal flakes so that more amino acids can react to form the Maillard reaction. The peptides that makeup amino acids contribute to flavor enhancement according to the type of amino acid. If the peptide chain contains amino acid residues that form a savory taste such as glutamic acid, the product will taste savory. Meanwhile, if the residues of aromatic amino acids such as lysine, the product will taste bitter (Kusnandar, 2020).

In treatment C, it was found that the most amino acid was glutamic acid which gave a savory taste effect so that it was liked and accepted by the panelists. However, the addition of soy flour exceeding 30 grams in treatments D and E decreased the panelists' preference level. This is due to the excess Maillard reaction can be an indicator of a decrease in product quality, one of which is in terms of taste.

The decrease in the panelists' preference level may also be due to the bitter and unpleasant taste of soybeans from lipoxygenase compounds which are higher with the addition of soy flour. However, its activity can be reduced by heating at 80°C . Excessive heat is not recommended because soybeans can cause water-insoluble proteins and lose their functional properties (Kanetro, 2017).

Texture Test

The texture is defined as a characteristic of the food consumption process that can be felt mainly through touch. The texture is multidimensional and includes various mechanical properties such as hardness, brittleness, elasticity, flexibility, and cohesiveness. The texture is an important thing in determining product quality so that it can be measured by instrumentation and sensory. The weakness is that the precision of the analysis results depends on the quality and intensity of the panelist training in assessing the texture of a material (Estiasih et al., 2018). The results of the organoleptic analysis of the panelists on texture are presented in Figure 13 below:

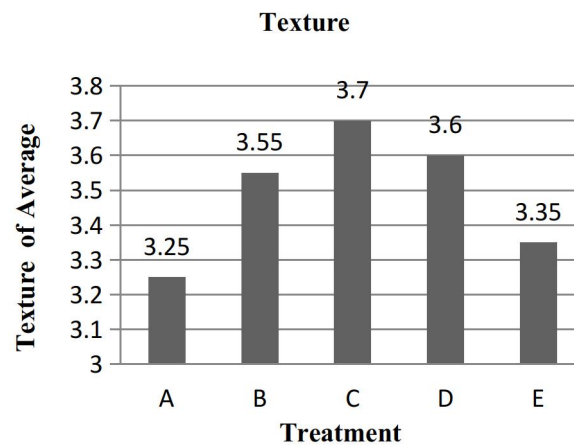


Figure 13. Texture Organoleptic Test Average Score

Based on the panelists' preference for texture, it was found that the highest value was in treatment C, which was 3.70 ± 1.22 with the score being at the usual level of liking. Meanwhile, the lowest level of preference for panelists was in treatment A, which was 3.25 ± 1.21 with the score being at the usual level. The results of the analysis showed that the addition of soy flour affected the panelists' preference for texture. This is related to the hardness and crispness of the resulting product.

Starch forms a gelatinization reaction with water to make the product crispier. While protein has hydrophilic properties that can absorb water the texture with a high concentration of soy flour tends to be harder (Lestari et al., 2018).

According to Sunarti (2007), amylose plays a role in the crispness of the resulting product because the straight chain structure in the granules causes the hydrogen strength to be greater. So that when roasting, the amylose chains are bonded to each other so that the amylose polymer is more difficult to expand. This is what causes the crispness of the resulting flakes.

In addition, soy protein content also affects the hardness of the flake's texture. According to Kusnandar (2020), proteins can bind water in the presence of hydrophilic hydrogen groups so that the viscosity will decrease due to the presence of starch and proteins that form complexes with the surface of the granules so that the gel absorption capacity is low. This protein content will cover the starch particles so that water absorption is inhibited which results in the formation of a hard product.

In addition, high crude fiber content with the addition of soybeans causes an imperfect gelatinization process due to a decrease in water absorption so that the resulting product becomes hard. This is in line with previous research, the addition of soy flour makes the biscuits harder (Puspita et al., 2021).

According to Widyasitoresmi (2010), the desired texture on cereal flakes is crispy or easy to bite, crisp, not easily crushed, and also not hard. This texture is influenced by the composition of the material, water absorption index, temperature, and roasting time which affects making the product dry because free water on the surface of the material evaporates faster than bound water. The crispness itself is caused by the gelatinization of starch which causes a porous and hollow structure.

The best treatment based on the organoleptic test was treatment C (addition of 30 grams of soybean flour) with the average panelist assessment in the like category. The average organoleptic value of corn flour and pumpkin flakes cereal with the addition of soy flour from the categories of color, aroma, taste, and texture can be seen in Figure 14 below:

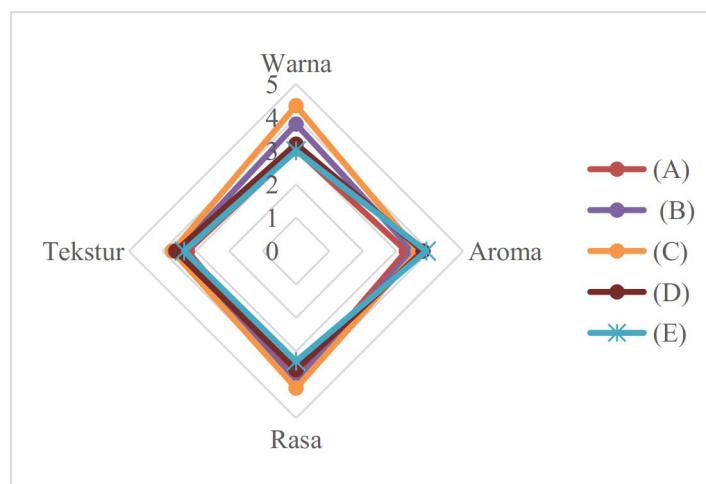


Figure 14. Organoleptic Test Radar

CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on the research conducted, it can be concluded that:

1) The addition of soybean flour in the study of corn flour and pumpkin flakes cereals affected water content, ash content, protein content, fat content, carbohydrate content, crude fiber content, water absorption, brightness (color), and panelists' preference for color, aroma, taste, and texture of the resulting cereal flakes.

2) The best treatment for flakes cereal produced was treatment C (addition of 30 g soybean flour) based on the panelists' preference level with quality characteristics, namely: water content ($6.43\% \pm 0.41$), ash content ($1.76\% \pm 0.19$), protein content ($9.78\% \pm 0.29$), fat content ($11.25\% \pm 0.69$), carbohydrate content ($70.89\% \pm 0.57$), crude fiber ($2.81\% \pm 0.29$), water absorption $368.31\% \pm 2.49$, °Hue (78.57 ± 0.01) and organoleptic value (4.35 color; 3.65 aroma; 4.10 taste; 3.70 texture) with a

total value of 9.72% amino acids and the types of amino acids identified were glutamic acids, leucine, aspartic acid, arginine, alanine, phenylalanine, valine, serine, isoleucine, tyrosine, threonine, lysine, histidine, glycine, and methionine.

Suggestion

- 1) Further research was conducted on the protein digestibility of the resulting flakes cereal.
- 2) Further research was conducted on the shelf life of the product.

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