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Characteristics of Healthy Cornflakes (Study of the Proportion of Pre-Cooked White Corn Flour: Pre-Cooked Red Bean Flour and the Proportion of Tapioca)

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ABSTRACT

Flakes are a convenient type of food that can be developed to meet the body's nutritional needs. Cornflakes, which have a high starch content, can be combined with protein and fat from red beans and snakehead fish, as well as tapioca as a source of amylopectin that affects the texture of cornflakes. The purpose of this research is to determine the effect of the proportion of white corn flour to red bean flour and the proportion of tapioca. The Randomized Block Design (RBD) method was used with Factor I being the proportion of white corn flour to red bean flour (80:20, 75:25, and 70:30), and Factor II being different proportions of tapioca (5%, 10%, and 15%). The observational data were analyzed using ANOVA and followed by Duncan's test. The best treatment determination was carried out using the De Garmo method. The best cornflakes were obtained with a proportion of 70% pre-cooked white corn flour, 30% pre-cooked red bean flour, and 10% tapioca, resulting in a moisture content of 3.13%, ash content of 2.88%, protein content of 8.26%, carbohydrate content of 80.88%, fat content of 4.90%, starch content of 33.11%, rehydration capacity of 46.54%, and breaking strength of 15.25 N.

1. INTRODUCTION

1.1. Research Background

Nutritional status is one of the indicators and aspects of health development achievements in Indonesia. Nutrition plays an important role in human resource development [1]. Ready-to-eat convenience foods like flakes, which contain nutrients such as energy and protein to meet the needs of adolescents, are one way to prevent an increase in nutritional deficiencies. Flakes are a ready-to-eat cereal product in the form of thin, brownish-yellow flakes, usually consumed with the addition of milk as a breakfast menu [2].

The raw material used in this study is white corn flour, which has a starch content of 72–73% [3]. Due to the low protein and fat content in white corn flour, it is necessary to combine it with other food ingredients to enhance the nutritional content of the flakes produced. In this study, red bean flour and snakehead fish flour were added to complement the nutritional content of the flakes. Animal protein sources were used to complete the essential amino acid content that is not present in plant-based proteins [4]. Tapioca flour was used to achieve optimal crispiness, chosen for its high starch content. The starch content will affect the crispiness of the resulting flakes [5].

The raw materials used in this study were subjected to pre-cooking treatment. The purpose of this treatment is to shorten the cooking time [6], form flour characteristics that easily create a stable suspension, and have high digestibility so that nutrients can be optimally absorbed by the body [7]. Based on the description above, it is necessary to research the proportion of pre-cooked white corn flour with pre-cooked red bean flour and the proportion of tapioca flour about the physical and chemical characteristics as well as the nutritional value of healthy cornflake products.

1.2. Literature Review

Malnutrition or undernutrition refers to a condition in which a person experiences a deficiency in nutrients, with their nutrient intake falling below the recommended standards. Undernutrition

occurs due to a lack of essential nutrients such as protein, carbohydrates, fats, and vitamins that the body needs [8].

Flakes are a cereal product in the form of thin, brownish-yellow flakes, usually eaten for breakfast with milk. Strong and non-fragile flakes are typically made from ingredients with a high starch content [2]. Flakes can be made from various carbohydrate-rich food ingredients. Additionally, other nutrient-rich food ingredients can be added to meet nutritional needs [10].

Pre-cooked flour is flour that has undergone a cooking or gelatinization process before being dried, making it easier to disperse in cold water and form a stable suspension. Pre-cooked flour must possess functional properties such as high solubility, good dispersion, and ease of digestion. The pre-gelatinization process affects the physicochemical properties of the resulting flour. The longer the pre-gelatinization process, the higher the starch content in the flour due to the level of macro-molecule disorganization and starch degradation [7].

White Corn (Zea mays var. Amylacea) contains 74.76% carbohydrates, 8.93% protein, 4.92% fat, and 2.08% crude fiber. The protein and fat content in white corn is higher than in rice, making white corn recommended for individuals suffering from malnutrition or kwashiorkor [11]. Tapioca has a relatively high carbohydrate content. Due to its high amylopectin content, products made from tapioca flour have a crispy texture [12].

Red beans processed into flour contain 12.83 grams of carbohydrates, 4.57 grams of protein, 0.48 grams of fat, 86.04 mg of phosphorus, and 39.15 mg of calcium. The protein found in red beans can help regenerate damaged body cells [13]. The protein content in snakehead fish is higher than that in carp, tawes, and catfish. Fresh snakehead fish contains 16.2% protein, dried snakehead fish has 58.0% protein, and snakehead fish flour contains 79.62% protein [14].

1.3. Research Objective

The purpose of this research is to determine the effect of varying proportions of white corn flour and red bean flour, as well as the proportion of tapioca, and to identify the best treatment from these variations.

2. MATERIALS AND METHODS

2.1. Material and Tools

The main raw materials used in this research are white corn (Zea mays var. Amylacea), tapioca flour, red beans (Phaseolus vulgaris L.), snakehead fish (Channa striata), salt, sugar, and margarine. The chemicals used include distilled water and petroleum ether. The equipment used for flour production includes a digital scale, knife, blender, 60 mesh sieve, and oven. The equipment used for making flakes includes a digital scale, mixing bowl, baking tray, oven, extruder, and other processing tools. The tools used for the analysis process include an analytical balance, desiccator, oven, furnace, analytical scale, tongs, filter paper, beakers, measuring cylinders, Soxhlet extractor, and mortar.

2.2. Research Desain and Implementation

The experimental design used is a completely randomized design with a factorial pattern consisting of 2 factors. Factor I is the proportion of white corn flour and red bean flour (80:20, 75:25, and 70:30), and Factor II is the different proportions of tapioca (5%, 10%, and 15%). The constant factors in this study are the proportions of snakehead fish flour, salt, water, sugar, and margarine. The data obtained will be analyzed using Analysis of Variance (ANOVA). If the analysis shows significant differences, further testing will be conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

2.2.1. Production of Pre-Cooked Corn Flour

The corn kernels are sorted to remove impurities. The sorted corn is then soaked in water for 4 hours. The corn undergoes a pre-cooking process by steaming at 100°C for 30 minutes. The corn is dried at 75°C for approximately 8 hours using a cabinet dryer, followed by sieving through a 60-mesh sieve.

2.2.2. Production of Pre-Cooked Red Bean Flour

The red beans are sorted to remove impurities. The beans are soaked in water for 48 hours, with water being changed every 12 hours. The red beans are then steamed at 100°C for 30 minutes. The beans are dried using a cabinet dryer for 8 hours at 75°C until the moisture content reaches less than 10%, followed by manual peeling. The red beans are roasted at 80°C-90°C for 5 minutes. The beans are then ground using a blender and sieved through an 80-mesh sieve.

2.2.3. Production of Snakehead Fish Flour

The snakehead fish is cleaned and gutted, with the scales, gills, and entrails removed. The fish is then washed thoroughly until all blood and mucus are removed. After draining, the fish is weighed. The fish undergoes steaming (pasteurization) for 30 minutes at a temperature of 85–90°C. The fish is drained again and cooled, then shredded into smaller pieces. The shredded fish is dried using a cabinet dryer at 75°C for 4 hours. The dried fish is then ground using a blender and sieved through an 80-mesh sieve.

2.2.4. Production of Cornflakes

Mixing of pre-cooked corn flour and pre-cooked red bean flour is done in ratios of (80:20), (75:25), and (70:30), with the addition of tapioca at 5%, 10%, and 15%. Other supporting ingredients include 10% pre-cooked snakehead fish flour, 20% sugar (w/w), 1% salt (w/w), 4.5% margarine (w/w), and 70% water (v/w). The dough is steamed for 10 minutes at 95°C. The dough is then rolled into sheets using a rolling machine until it reaches a thickness of approximately 2 mm. The flattened dough is cut into squares measuring 2x2 cm, and the pieces are arranged on a baking tray. Baking is done in an oven for about 25 minutes at 150°C.

3. RESULT AND DISCUSSION

3.1. Raw Material Analysis Results

The analysis performed on the raw materials includes moisture content, ash content, fat content, protein content, starch content, amylose content, amylopectin content, and carbohydrate content by difference. The results of the raw material analysis can be seen in Table 1.

Table 1. Cornflakes Raw Material Analysis Results

Parameters	Pre-Cooked White Corn Flour	Pre-Cooked Red Bean Flour	Tapioca
Moisture	7.59	10.30	7.23
Ash	2.12	3.07	0.27
Carbohydrate	77.45	73.24	91.01
Protein	7.65	17.15	0.80
Fat	5.19	2.13	0.71
Crude Fiber	6.35	4.97	1.02
Starch	71.85	44.75	85.32
Amylose	28.29	22.78	26.49
Amylopectin	43.56	21.97	58.83

The nutritional content of raw materials is influenced by factors such as variety, harvest age, and post-harvest handling, which result in different physicochemical properties [15]. The location where the raw materials are grown can also lead to variations in nutrient content [16]. Additionally, differences in the analytical methods used can contribute to variations in the analysis results.

3.2. Cornflakes Analysis Results

Based on the moisture content analysis. it is observed that the higher the proportion of pre-cooked white corn flour the lower the proportion of pre-cooked red bean flour. the higher the moisture content of the flakes. An increase in moisture content also occurs with the addition of more tapioca flour. The moisture content of the flakes is influenced by the starch and fiber content of the raw materials used. Starch can absorb water because its molecules contain hydroxyl groups. which allows the starch granules to absorb a significant amount of water [17]. Fibre has a strong water-absorbing capacity, so more fiber is present. the higher the moisture content will be [18].

Table 2. Analysis of moisture content, ash content, fat content, and protein content of cornflakes

Formulation	Moisture	Ash	Fat	Protein
A1B1	3.36	2.79	6.02	12.39
A1B2	3.41	2.77	6.02	12.43
A1B3	3.47	2.76	6.02	12.46
A2B1	3.29	2.83	5.46	14.31
A2B2	3.32	2.83	5.95	14.37
A2B3	3.35	2.82	5.46	14.41
A3B1	3.06	2.88	4.85	16.47
A3B2	3.13	2.88	4.90	16.51
A3B3	3.23	2.86	5.35	16.55

The ash content in the flakes is influenced by the ash content of the raw materials. According to the analysis. a lower proportion of pre-cooked white corn flour and a higher proportion of pre-cooked red bean flour result in an increased ash content in the flakes. This is because red bean flour has a higher ash content than corn flour. The addition of tapioca does not significantly affect the ash content of the flakes due to the very low ash content in tapioca. The ash content in a product is affected by the mineral content of the raw materials [19].

The analysis of fat content shows that the higher the proportion of pre-cooked white corn flour the lower the proportion of pre-cooked red bean flour. the higher the fat content in the flakes. The use of corn flour as a raw material can increase the fat content in the final product [20]. The addition of tapioca does not significantly affect the fat content of the flakes. as tapioca flour has a very low fat content (0.71%). meaning that its addition does not have a noticeable impact on the fat content of the flakes.

The protein analysis indicates that the higher the proportion of pre-cooked red bean flour the lower the proportion of pre-cooked white corn flour. the higher the protein content in the flakes. Legumes generally have a higher content of plant-based protein compared to other plant-based ingredients. so increasing the amount of legumes increases protein levels [21]. The variation in tapioca flour concentration does not have a significant impact on the protein content of the flakes. but adding more tapioca flour does lead to an increase in protein content.

Table 3. Analysis of starch. rehydration capacity. beraking strength. carbohydrate content

Formulation	Starch	Rehydration Capacity	Breaking Strength	Carbohydrate
A1B1	31.31	46.954	19.30	81.59
A1B2	33.79	47.249	20.05	81.57
A1B3	34.16	48.753	22.15	81.53
A2B1	31.20	45.872	16.75	81.24
A2B2	33.50	46.552	17.35	80.71
A2B3	34.31	48.562	17.65	81.17
A3B1	31.03	45.763	14.95	80.88
A3B2	33.11	46.538	15.25	80.88
A3B3	33.99	47.343	15.75	80.31

The analysis of starch content indicates that a higher proportion of pre-cooked white corn flour and a lower proportion of pre-cooked red bean flour result in an increase in starch content. This is because pre-cooked white corn flour has a higher starch content (71.85%). so as the proportion of corn flour increases. the starch content in the flakes also increases. Conversely. increasing the proportion of red beans in the flakes reduces the starch content [18]. Additionally. a higher concentration of tapioca flour leads to an increase in starch content in the flakes. as tapioca flour has a high starch content (85.32%). Thus. the more tapioca flour added. the higher the starch content in the flakes.

The analysis of the rehydration capacity of the flakes shows that a higher proportion of pre-cooked white corn flour and a lower proportion of pre-cooked red bean flour result in an increased rehydration capacity of the flakes. The rehydration capacity of the flakes is influenced by the starch and fiber content. Starch forms cavities within the flakes. leading to higher rehydration capacity. The hydroxyl groups in the starch present in the product have a greater ability to absorb water [17]. Additionally. increasing the proportion of tapioca flour also enhances the rehydration capacity of the flakes. The more porous structure of the flakes contributes to the increased rehydration ability [22]. The crude fibre content in the raw materials of a product swells during processing. which affects the water absorption index [23].

The breaking strength of flakes indicates the texture or crispness of the resulting flakes product. A higher proportion of pre-cooked white corn flour. a lower proportion of pre-cooked red

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bean flour. and an increased concentration of pre-cooked tapioca flour leads to a higher breaking strength of the flakes. The breaking strength is influenced by the amylopectin content in the raw materials. The crispness of the flakes is affected by the amylopectin content. as amylopectin promotes expansion. leading to a porous texture in flakes made from starch with a relatively high amylopectin content [24].

The analysis of carbohydrate content shows that a higher proportion of pre-cooked white corn flour and a lower proportion of pre-cooked red bean flour result in an increase in the carbohydrate content of the flakes. The addition of more tapioca flour during flake production also leads to an increase in carbohydrate content. However. the addition of tapioca flour does not have a significant effect on the flakes. possibly due to the small difference in tapioca flour concentrations. which does not result in a noticeable change. Carbohydrate content is influenced by other proximate components; as the levels of other proximate components decrease. the carbohydrate content increases. and vice versa—higher levels of other proximate components lead to lower carbohydrate content [25].

3.3. Analysis of the Best Cornflakes Treatment

The analysis of the best treatment was conducted on cornflakes A3B2. which used a proportion of 70:30 for corn flour to red bean flour and included a 10% addition of tapioca. The analysis for this best treatment includes assessments of starch digestibility. protein digestibility. dietary fiber. and total calories. The results of this analysis can be seen in Table 4.

Table 4. Results of the Best Treatment Analysis for Cornflakes

Parameters	Analysis Results
Starch Digestibility (%)	74.38
Protein Digestibility (%)	83.40
Dietary Fiber (%)	6.50
Total Calories (Kkal/g)	443.9

Starch digestibility analysis is used to determine how much starch can be digested by the body. Starch digestibility indicates how easily the starch can be hydrolyzed by starch-breaking enzymes into smaller components within the body [26]. The analysis results show that the cornflakes in this study have a high starch digestibility of 74.38%. The starch digestibility of the cornflake product is influenced by the digestibility of the raw materials; corn flour has a digestibility of 63.45% [27].

Protein digestibility analysis measures the ability to convert protein into amino acids through hydrolysis by digestive enzymes. The analysis of the protein digestibility for the best treatment sample revealed a protein digestibility of 83.40%. The nutritional value of protein is influenced by its digestibility. as it relates to the amount of biologically produced amino acids. A product with low protein digestibility can lead to protein malnutrition for consumers. as the protein consumed may not be fully digested. resulting in some amino acids not being absorbed by the body [28].

The dietary fiber content in the flakes is 6.50%. The dietary fiber content in a product is influenced by the fiber content of the raw materials used to make the flakes. The dietary fiber content in corn flour is 2.2% [29]. while in red bean flour it is 3.6% [30]. A product can be considered a source of fiber if it contains at least 3 grams of dietary fiber per 100 grams [31].

The analysis of total calories is used to determine how many calories are contained in cornflakes. The calorie calculation is used to assess nutritional adequacy based on the number of calories that correspond to the total energy required by the body [32]. The total calories produced by the cornflakes with the best treatment in this study amount to 443.9 kcal per 100 grams. According to the Ministry of Health Regulation No. 28 of 2019 on Nutritional Adequacy Figures (AKG) for the Indonesian population. the general calorie requirement for Indonesians is 2000 kcal. and the amount of energy intake needed at breakfast is estimated to be in the range of 400-500 kcal.

4. CONCLUSION

The proportion of pre-cooked white corn flour and pre-cooked red bean flour. along with the addition of tapioca. significantly affected the moisture content. starch content. rehydration capacity. breaking strength. taste. and crispiness of the resulting cornflakes. However. there was no significant interaction with the ash content. fat content. protein content. carbohydrate content. aroma. and color of the cornflakes. The best treatment in this study was cornflakes made with 70% pre-cooked white corn flour. 30% pre-cooked red bean flour. and 10% tapioca. resulting in cornflakes with a moisture content of 3.13%. ash content of 2.88%. protein content of 8.26%. carbohydrate content of 80.88%. fat content of 4.90%. starch content of 33.11%. rehydration capacity of 46.54%. and breaking strength of 15.25 N.

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