Formulating Ginger Extract, Modified Cassava Flour (Mocaf) and Wheat Flour in Crispy Ginger

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Abstract
This study aims to determine the best composition related to the proportion of wheat flour and mocaf in processing crispy ginger and developing gluten-free food products. The study used factorial experiments with the first factor being proportion of mocaf and wheat flour (P1) consisting of three treatment levels are P1 (mocaf: wheat flour= 50:50), P2 (mocaf: wheat flour= 75:25), and P3 (mocaf : wheat flour= 100:0). The second factor was the concentration of ginger extract (J), consisting of three treatment levels are J1 (ginger extract concentration 20%), J2 (ginger extract concentration 30%), and J3 (ginger extract concentration 40%). The results of the study showed that the proportion of mocaf and wheat flour decreased protein, fat, and water content, but increased carbohydrate and antioxidant content in the crispy ginger. The concentration of ginger extract increased protein, fat, water, and antioxidant content but decreased carbohydrate content in the crispy ginger. Organoleptic testing showed that colour, aroma, taste, and texture were undesirable. The findings of this study indicate that the production of crispy ginger has potential, but improvements are needed for colour, aroma, taste, and texture parameters. The selected treatment alternative was the P2J2 treatment.

Keywords: *Crispy Ginger, Mocaf, Gluten-Free.*

Abstrak
Penelitian ini bertujuan untuk mengetahui komposisi terbaik terkait proporsi tepung terigu dan mocaf dalam pengolahan jahe krispi dan mengembangkan produk pangan bebas gluten. Penelitian ini menggunakan eksperimen faktorial dengan faktor pertama adalah proporsi mocaf dan tepung terigu (P1) yang terdiri dari tiga taraf perlakuan yaitu P1 (mocaf : tepung terigu = 50:50), P2 (mocaf : tepung terigu = 75:25), dan P3 (mocaf : tepung terigu = 100:0). Faktor kedua adalah konsentrasi sari jahe (J) yang terdiri dari tiga taraf perlakuan yaitu J1 (konsentrasi sari jahe 20%), J2 (konsentrasi sari jahe 30%), dan J3 (konsentrasi sari jahe 40%). Hasil penelitian menunjukkan bahwa proporsi mocaf dan tepung terigu

menurunkan kadar protein, lemak, dan air, tetapi meningkatkan kadar karbohidrat dan antioksidan pada jahe krispi. Konsentrasi sari jahe meningkatkan kadar protein, lemak, air, dan antioksidan tetapi menurunkan kadar karbohidrat pada jahe krispi. Pengujian organoleptik menunjukkan bahwa warna, aroma, rasa, dan teksturnya tidak disukai. Temuan penelitian ini menunjukkan bahwa produksi jahe krispi berpotensi, namun diperlukan perbaikan untuk parameter warna, aroma, rasa, dan tekstur. Alternatif perlakuan yang dipilih adalah perlakuan P2J2.

***Keywords*: *Jahe Krispi, Mocaf, Bebas Gluten*.**

1. Introduction

Ginger (*Zingiber officinale Roscoe*) is a spice rich in phenolic compounds, terpenes, polysaccharides, lipids, organic acids, and fiber. Ginger's health benefits primarily come from its phenolic compounds, including gingerol and shogaol. Ginger has a wide range of biological activities, such as antioxidant, anti-inflammatory, antimicrobial, anticancer, neuroprotective, cardiovascular protective, respiratory protective, antiobesity, antidiabetic, anti-nausea, and antiemetic activities (Mao et al., 2021; Ersedo et al., 2023; Hasanela et al., 2023). Ginger is commonly used as a spice and traditional medicine for various health issues, including diabetes, intestinal colic, bloating, indigestion, sterility, inflammation, insomnia, memory enhancement, nausea, rheumatism, stomach pain, and urinary tract infections (Unuofin et al., 2021).

Ginger products on the market are available in powder and sliced ginger. Consumers will buy dried ginger if the quality, which includes flavor, aroma, and cleanliness, is guaranteed. Ginger powder is preferred over sliced dried ginger (Amoah et al., 2022). Ginger is a natural spice used in various regions to add a spicy flavor to food. The clinical effects of ginger have been recognized in six functions, viz: nausea, vomiting, gastrointestinal function, pain, inflammation, and metabolic syndrome (Anh et al., 2019). Ginger contains gingerol, shogaol, and paradols that can prevent various types of cancer (anticancer) (Mashhadi et al., 2012; Nutakor et al., 2020; Gonzales-Gonzales et al., 2023). Ginger can promote healthy aging, reduce morbidity, and extend healthy life (Ozkur et al., 2022).

The ingredients used in the processing of crispy ginger are mocaf and ginger extract. Mocaf is used as a substitute for wheat flour, while ginger extract functions as an antioxidant source. People use ginger for food, drinks, spices, medicine, and ornamental plants. Red ginger is consumed to improve endurance and prevent COVID-19 pandemic infection (Windarsih et al., 2023). Ginger is commonly found in processed foods like gingerbread, biscuits, cookies, and crispy. Ginger is a unique traditional food known for its warm and spicy flavor (Bag, 2018). Gingerbread cookies have a crunchy texture, brownish color, sweet and distinctive taste of ginger, and the smell of ginger, pH 7, so it can be said that ginger cookies have an alkaline pH, so they tend to be safe and good for health (Rahajeng et al., 2021). The quality of the antioxidant properties of ginger cookies can be improved by fermenting the dough (Przygodzka and Zielinski, 2015).

Wheat flour is the most commonly used raw material in processed foods in Indonesia. Wheat flour should be substituted with alternative ingredients to minimize Indonesia's reliance on imported products. Research by Meenakumari et al. (2023) concluded that sweet potato composite flour can produce biscuits with superior nutritional, antioxidant, and sensory qualities compared to regular wheat biscuits. Research by Kulkarni and Joshi (2013) stated that substituting wheat flour with pumpkin flour produced biscuits with a more yellow color and increased carotene (antioxidant) levels in biscuits. The remaining leaves and stalks of cabbage flowers contain high antioxidant ingredients. Substituting wheat flour with cauliflower plant flour produces biscuits with high fiber content, and the acceptability index of all attributes reaches above 70% (Ribeiro et al., 2015).

Mocaf is a locally produced flour made from cassava through a fermentation process that can eventually be used to substitute wheat flour. Consumption of mocaf-based processed products prioritizes product price over quality (Isaskar et al., 2019). The chemical and physical properties of mocaf have changed from the basic properties of cassava flour (Aprilliani and Mulyadi, 2022). Mocaf can be made into delicious products, but it is low in protein, fat, and minerals, so it can be fortified with moringa (*Moringa oleifera*), katuk (*Sauropus androgynus*), and kale (*Brassica oleracea var. sabellica*), which are rich in calcium, magnesium, potassium, iron, manganese, and zinc (Hasrini et al., 2021).

Mocaf serves as a cost-effective and locally sourced alternative for wheat flour substitution, offering the potential to substitute wheat flour in various food products and thereby reducing dependence on imports. (Rizta and Zukryandry, 2021). For example, it can be used as an alternative to wheat flour in producing steamed sponge cake (Mustika and Kartika, 2020). Wheat flour with mocaf can be formulated to produce high-protein noodles (Agustia et al., 2019). Mocaf can be a healthy alternative to wheat flour, primarily due to its low gluten content, making it a suitable choice for individuals with autism and celiac disease. Mocaf also contains high fiber and low sugar levels, making it suitable for people with diabetes (Firdaus et al., 2017).

Ginger-based food products, such as gingerbread, biscuits, cookies, and crisps, typically contain wheat flour. Besides being imported, wheat flour contains gluten, unsuitable for individuals with diabetes and celiac disease. To reduce dependence on imports and cater to dietary restrictions, there is a need to substitute wheat flour with locally sourced alternatives. Mocaf is cassava flour modified by a fermentation process using lactic acid bacteria that can change its functional properties so that it can be used to substitute wheat flour in food processing. The study aims to (1) get the right ratio in substituting wheat flour with mocaf but does not affect the quality of crispy ginger, (2) get the right formulation between mocaf, wheat flour and ginger extract concentration in making crispy ginger, and (3) developing mocaf flour products as a food ingredient aimed at consumers who do not consume gluten.

2. Method

2.1 Research Design

This study used factorial experiment with two factor treatments: substitution percentage (comparing mocaf (modified cassava flour) to wheat flour) and ginger extract concentration.

The mocaf to wheat flour ratios included P1 (mocaf : wheat flour= 50:50), P2 (mocaf : wheat flour= 75:25), and P3 (mocaf : wheat flour= 100:0). The ginger extract concentrations included J1 (ginger extract concentration 20%), J2 (ginger extract concentration 30%), and J3 (ginger extract concentration 40%). The experiment with 9 treatments was done using a completely randomized design (CRD). Completely Randomized Design is a design in a homogeneous location, it is said to be random because each experimental unit has the same chance of getting treatment, while it is said to be complete because all treatments designed in the experiment are used. The sources of diversity observed in this design are only treatments and errors. The advantages of a completely randomized design are that it is flexible, easy to analyze, and the maximum estimated degree of freedom is in the error (Hasdar, Wadli, and Delia, 2021).

2.2 Crispy Gingers Processing

Making crispy ginger needs mocaf, ginger, egg yolk, margarine, powdered sugar, a mixer, a baking sheet, an oven (Oxone brand), and scales. The first step is mixing 200 g of powdered sugar and 111.3 g of egg whites in a mixer for 10 minutes until the dough is frothy and white. After adding salt 4 g, margarine 60 g, vanilla 4.7 g, mocaf, wheat flour, and ginger extract, the dough was stirred for 5 minutes and mixed for 30 seconds to prevent clumping. Dough molding involves measuring the dough in a small round mold and filling each Silpat-lined hole with the same dough. The dough is spoon-flattened into an 8-cm-diameter, 2-mm-thick circle. Then bake at 70°C for 50 minutes. After baking, let it cool at room temperature for 2 minutes to avoid steam when packaging the ginger crisps. The packaged ginger crisps are placed in jars with a diameter of 8.5 cm and a height of 15 cm

2.3 E-ServQual Attributes

Chemical Analysis

The experimental variable is the nutritional content of crispy ginger products, measured by chemical analysis which includes moisture content (AOAC, 1995, Nielsen, 2019), ash content (AOAC, 1995, Nielsen, 2019), fat Content (AOAC, 1995, Nielsen, 2019), protein content (AOAC, 1995, Nielsen, 2019), and carbohydrate content by Difference (Winarno, 2008), and antioxidant content (Nielsen, 2019).

Organoleptic Analysis

The crispy ginger products made by substituting wheat flour with mocaf and using different concentrations of ginger extract were sensory tested using a five-point hedonic scale (5=very like; 1=very dislike) following organoleptic test guidelines (Stone and Joel, 2004). The sensory responses of crispy ginger for various properties were color, flavor, texture, and taste.

2.4 Data Analysis

ANOVA was used to analyse the chemical content of crispy ginger data. A multiple comparison test using the Least Significant Difference Test (LSD) with $\alpha = 5\%$ was conducted if the F test showed a significant treatment effect to determine the mean value of significantly different treatments. The Friedman Test and descriptive analysis were used to assess ordinal sensory test data.

2.5 Alternative Selection

The weight test was conducted to determine the importance of product quality parameters. The parameters used as the basis for assessment include antioxidant content, protein content, flavor, texture, and aroma. Based on the weight test, the importance of each assessment parameter can be seen.

Alternative selection is based on product quality and assessment parameter relevance. According to Siagian (1997), the concept of expected value decisions is to choose a decision that has maximum payoff (profit or utility) or minimum cost (loss or sacrifice).

3. Result and Discussion

3.1 Crispy Ginger Chemical Characteristics

The analysis of variance results for the protein content in crispy ginger showed an interaction between the wheat flour substitution percentage treatment factors and ginger extract concentration, as shown in Figure 1(a). The graph lines are not parallel and do not intersect, suggesting that the treatment factor of wheat flour substitution percentage has a more dominant effect on the interaction. Furthermore, according to Haryanta (2023), conclusions are formulated based on individual factors. The substitution of wheat flour with mocaf affects the protein content, with higher mocaf substitution resulting in lower protein levels (Table 1). Meanwhile, in the case of ginger extract concentration treatment, higher concentrations lead to increased protein content in ginger crisps (Table 2).

The analysis found a significant interaction between wheat flour substitution and ginger extract concentration in the fat content of crispy ginger. As seen in Figure 1(b), the graph lines are not parallel and do not intersect, indicating that the treatment factor of wheat flour substitution percentage has a more dominant effect on the interaction. Higher levels of wheat flour substitution with mocaf led to lower fat content (Table 1), while increased ginger extract concentration correlated with higher fat content in crispy ginger (Table 2).

An analysis of variance for carbohydrate content in crispy ginger showed a significant interaction between the percentage of wheat flour substitution and ginger extract concentration treatments. Non-parallel lines without intersection in Figure 1(c) showed that the wheat flour substitution treatment factor dominated the interaction. Higher levels of wheat flour substitution with mocaf resulted in increased carbohydrate content (Table 1). Furthermore, higher ginger extract concentration has been related to higher carbohydrate content in crispy ginger (Table 2).

The analysis of variance results for the antioxidant content in crispy ginger shows an interaction between the wheat flour substitution percentage treatment factors and ginger extract concentration. As seen in Figure 1(d), the graph lines are not parallel or intersect, indicating that the wheat flour substitution percentage treatment factor has a more dominant effect on the interaction. Wheat flour substitution with mocaf influences the antioxidant content, with higher mocaf substitution resulting in higher antioxidant levels (Table 1). Meanwhile, with the treatment of ginger extract concentration, higher concentrations lead to increased antioxidant content in ginger crispy (Table 2).

Protein, fat, carbohydrate, antioxidant, water, and ash content in crispy ginger data are presented in Table 1.

Table 1. Protein, Fat, Carbohydrate, Antioxidant, Moisture, and Ash Contents of Crispy Gingers with Various Mocaf Flour Substitutions

Treatment	Protein Content (%)	Fat Content (%)	Content of carbohydrate (%)	Antioxidant content mg/100 g	Water Content %	Ash Content (%)
P1	15.146 a	8.122 a	74.481 c	71.017 c	0.413 a	1.838 c
P2	14.000 b	7.437 b	76.182 b	75.576 b	0.351 b	2.030 b
P3	12.639 c	6.879 c	78.009 a	76.429 a	0.284 c	2.189 a
BNT	0.294	0.125	0.415	0.750	0.030	0.105

Description: The letters a, b, and c in the parameter values in the same column indicate a significant difference between treatments.
P1: mocaf:wheat = 50:50
P2: mocaf:wheat = 75:25
P3: mocaf:wheat = 100:0

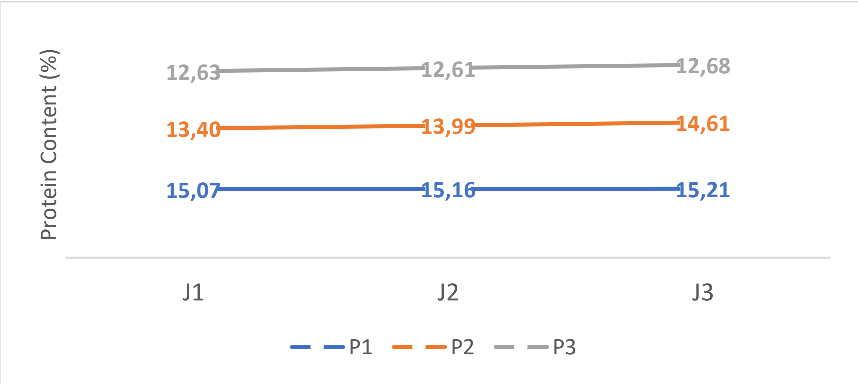
Table 2. Protein, Fat, Carbohydrate, Antioxidant, Moisture, and Ash Contents of Crispy Gingers with Different Concentrations of Ginger Extract.

Treatment	Protein Content (%)	Fat Content (%)	Content of carbohydrate (%)	Antioxidant content mg/100 g	Water Content %	Ash Content (%)
J1	13.699 b	7.254 b	76.751 a	72.263 c	0.323 b	1.972 a
J2	13.920 ab	7.583 a	76.098 b	74.596 b	0.353 ab	2.045 a
J3	14.166 a	7.600 a	75.823 b	76.161 a	0.372 a	2.039 a
BNT	0.294	0.125	0.415	0.750	0.030	0.105

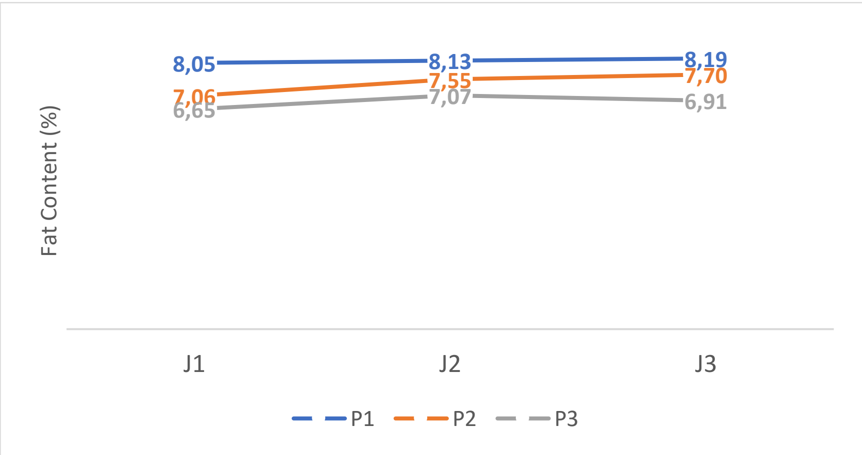
Description: The letters a, b, and c in the parameter values in the same column indicate a significant difference between treatments.
J1: Ginger Concentration 20%
J2: Ginger Concentration 30%
J3: Ginger Concentration 40%

The moisture content data for crispy ginger showed no interaction between mocaf flour substitution and ginger extract concentration treatments. However, each treatment factor significantly influenced the moisture content of the products, shown in Figure 2(a), with nearly parallel graph lines. The processed crispy ginger showed moisture content ranging from 0.284% to 0.413%, as shown in Table 1. Treatment P5 (100% mocaf) had the lowest water content, while treatment P1 (50% mocaf substitution) produced the highest water content, indicating an inverse relationship with mocaf substitution. Table 2 showed the highest water content (0.372%) in the 40% ginger concentration treatment, and the lowest (0.323%) in the 20% ginger concentration treatment, indicating a positive correlation between ginger concentration and water content.

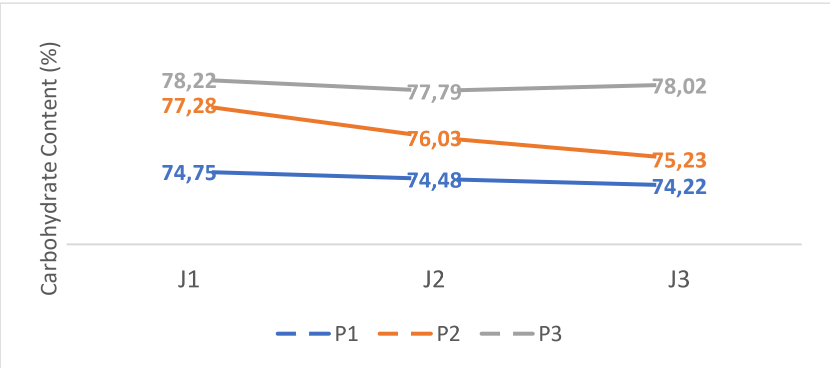
The analysis of variance for the ash content of crispy ginger showed no interaction between the wheat flour substitution percentage treatment factors and ginger extract concentration, as seen in Figure 2(b), where the graph lines are closely parallel and do not intersect. The treatment of wheat flour substitution with mocaf affected the ash content, i.e., the higher the substitution, the higher the ash content (Table 1), while the treatment of ginger extract concentration did not affect the ash content in crispy ginger (Table 2).



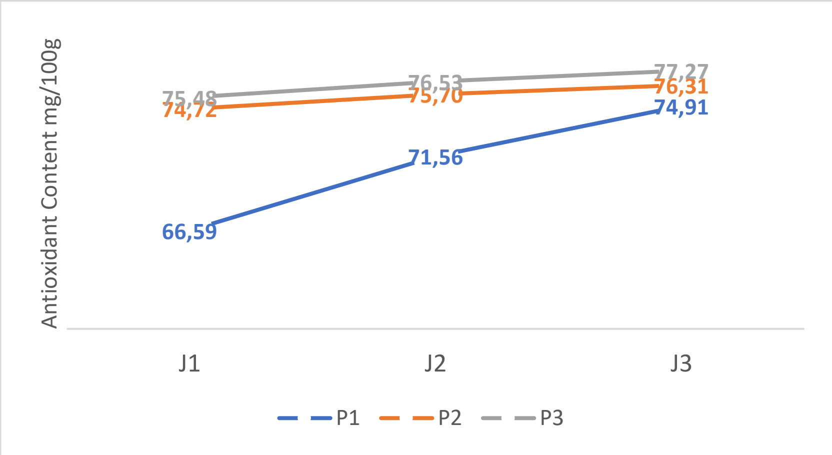
(a) Protein Content



(b) Fat Content



(c) Carbohydrate Content

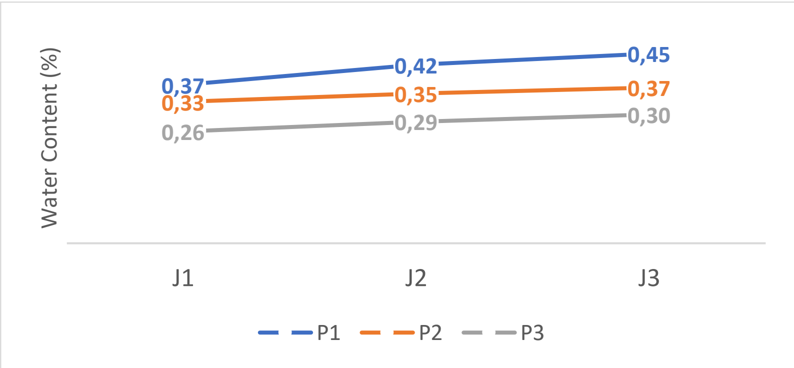


(d) Antioxidant Content

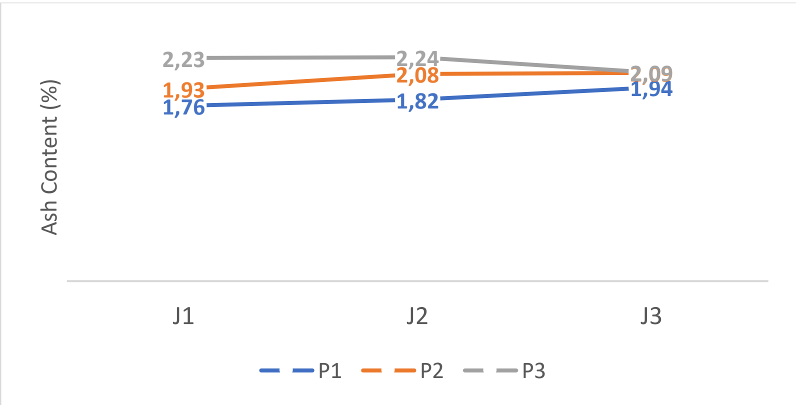
J1: Ginger Extract Concentration 20%
J2: Ginger Extract Concentration 30%
J3: Ginger Extract Concentration 40%

P1: Mocaf:Wheat = 50:50
P2: Mocaf:Wheat = 75:25
P3: Mocaf:Wheat = 100:0

Figure 1. Graphical Relationship Between the Chemical Content of Crispy Ginger and the Concentration of Ginger Extract in Each Treatment of Mocaf to Wheat Ratio; (a) Protein, (b) Fat, (c) Carbohydrate, and (d) Antioxidant Activity.



(a) Water Content



(b) Ash Content

J1: Ginger Extract Concentration 20%
J2: Ginger Extract Concentration 30%
J3: Ginger Extract Concentration 40%

P1: mocaf:wheat = 50:50
P2: mocaf:wheat = 75:25
P3: mocaf:wheat = 100:0

Figure 2. The Relationship Between Moisture Content/Ash Content in Crispy Ginger and Ginger Extract Concentration in Each Treatment of Mocaf to Wheat Ratio

The analysis of variance showed no interaction between mocaf flour substitution and ginger extract concentration treatments. However, each treatment independently influenced the ash content of crispy ginger products (Figure 2(b)). Table 3 shows that the ash content ranged from 1.838% to 2.189%. Treatment P1 (50% mocaf substitution) resulted in the lowest ash content, while treatment P5 (100% mocaf substitution) resulted in the highest ash content, indicating a positive relationship with mocaf substitution. Mocaf contains 1.3% ash, so the higher the mocaf content, the higher the ash content of the resulting product. Table 4 shows the highest ash content (2.039%) in the 40% ginger concentration treatment, while the lowest (1.972%) was observed in the 20% ginger concentration treatment, indicating a positive correlation between ginger concentration and ash content.

The effect of wheat substitution with mocaf shows a decrease in protein and fat content, with an increase in carbohydrate and antioxidant content. This aligns with previous research findings on cookies made from mocaf flour, purple sweet potato, and cinnamon powder, highlighting their strong antioxidant activity. A formula with a mocaf, purple sweet potato, and cinnamon powder ratio of 75:24:1 was the most favoured by panellists (Satar and Emilia, 2023). The research results of Mustika and Kartika (2020) show that comparison between pumpkin cookies made with mocaf flour and wheat flour shows differences in protein (1.12 g/100 g vs. 4.79 g/100 g), fat content (36.35 g/100 g vs. 40.87 g/100 g), fiber content (43.59 g/100 g vs. 21.42 g/100 g), and carbohydrate content (31.94 g/100 g vs. 50.19 g/100 g).

In the ginger extract concentration treatment, the higher the concentration of ginger extract, the higher the protein, fat, and antioxidant content, but the carbohydrate content decreased. The drying process of ginger showed a positive effect on antioxidant activity. Dried ginger has better antioxidant performance than fresh ginger extract (Mustafa and Chin, 2023).

3.2 Organoleptic Characteristics

The organoleptic characteristics of crispy ginger products produced by treating the proportion of mocaf and wheat flour and adding ginger extract can be seen in Figure 3.

The Friedman test results showed no significant difference between mocaf flour treatment and ginger extract concentration treatment regarding panellists' preference for the color parameter of crispy ginger. Figure 3 shows that the highest level of panelist preference for the preferred color of crispy ginger (score 3 to 5) was in the P1J1 treatment, which was 100%. Panellists tend to dislike the dark brown color in the crisps. The dark or brownish color in the product increases with the rising substitution of wheat flour with mocaf. This darkening is attributed to the initial darker color of wheat flour compared to mocaf and the increased Maillard reaction intensity, resulting in the formation of brown-colored compounds known as melanoidins (Mazaya, Karseno, and Yanto, 2021).

J1: ginger extract concentration 20% P1: mocaf:wheat = 50:50
J2: ginger extract concentration 30% P2: mocaf:wheat = 75:25
J3: ginger extract concentration 40% P3: mocaf:wheat = 100:0

Figure 3. Consumer Favourability Scores with Organoleptic Parameters of Crispy Ginger Products (%)

The results of the Friedman Test showed a significant difference in the aroma of the product through the treatments, with the crispy ginger product featuring the lowest mocaf substitution being the most preferred. The aroma most preferred by the panelists was in the P1J1 and P2J2 treatments with a frequency of 100% (Figure 3). The wheat flour proportion and the ginger extract concentration positively influenced the aroma. Panellists favoured the addition of ginger extract for its distinctive aroma, health benefits, and its ability to balance the strong aroma of mocaf. Thus, both the proportion of wheat flour and the concentration of ginger extract positively impacted the product's aroma.

The Friedman Test results showed significant differences between treatments, and panelists preferred the product with the lowest mocaf substitution. Figure 3 shows that the highest level of panelists' preference for the taste of crispy ginger (score 3 to 5) was in treatments P1J1, P1J2, P2J2, and P2J3 at 96.7%. The sour taste of mocaf flour was not felt due to the more prominent influence of adding ginger extract, but panellists did not like the greater concentration of ginger extract because of the spicy taste.

Figure 3 shows that the P1J3 treatment produced crispy ginger, which was most preferred by panellists with a panelist frequency of 96.7%. The highest formulation is shown in the highest substitution of wheat flour. Wheat contains high gluten, a type of water-insoluble protein with elastic properties. As the proportion of mocaf increases compared to wheat flour, the elastic properties of gluten decrease, resulting in a harder texture for the product. The moisture content of the product also influences its crispiness. Products with lower moisture content tend to have a crispier texture.

According to Fadiah and Syarif (2022), replacing wheat flour with mocaf has no significant effect on the quality, shape, color, aroma, texture, and taste of kastengel cookies. The formulation of rebon flour and mocaf affects the cookies' color, aroma, and taste but does not change the texture of the cookies. The best formulation is the ratio of mocaf and rebon

90%: 10% (Unayah et al., 2020). The highest preference level when making dry noodle products made from mocaf is replaced by sacha inchi seed pulp flour with a ratio of 85% mocaf and 15% sacha inchi seed pulp flour (Lesmana and Dewantara, 2023). The best hedonic test results or consumer acceptance were obtained in formula F3 (with the smallest portion of mocaf) in terms of taste, aroma, color, and texture, as well as the highest energy and protein content (Harna et al., 2023). The Taiwanese model roll formula with 10% mocaf substitution showed superiority in various aspects such as crust color, porosity, aroma, and crispness, while the 20% mocaf substitution formula excelled in crust texture and bread crispness (Nurfiantoro et al., 2023). Water and oil content contribute to crispness, which is temporal (Tunick et al., 2013).

The factor of adding red ginger extract with different concentrations (0%, 10%, 15%, 20%) has a significant difference in the analysis of water content and organoleptic taste, but has no significant difference in the organoleptic test of colour, aroma, and texture. Chicken meat jerky with the best acceptance from panelists was obtained by adding 10% red ginger extract (the lowest treatment) (Keumalawaty et al., 2023). Crystal ginger emprit (white ginger) products with various concentrations of ginger extract showed significant differences in aroma, colour, and texture, and no significant differences in taste attributes (Setiawan et al., 2022). The advantages of using ginger powder and ginger extract form in food products are to prevent lipid peroxidation, extend shelf life, and improve organoleptic properties.

The overall acceptance of respondents towards extract-based ginger jam was very good. This indicates the gingerol content in ginger does not adversely affect the sensory response (Tanweer et al., 2018).

3.3 Alternative Selection

Alternative selection is done to choose the best treatment from several existing treatments. Determination of the importance weight of each parameter is done using AHP (Saaty, 2013). Determination of the best treatment selection is based on the Expected Value method (Siagian, 1997).

The analysis used for AHP calculation is protein content, antioxidant content, taste, texture, and aroma. The antioxidant content parameter has the highest value with an importance weight of 35%. The Pie Chart of the quality parameter weight of crispy ginger is shown in Figure 4.

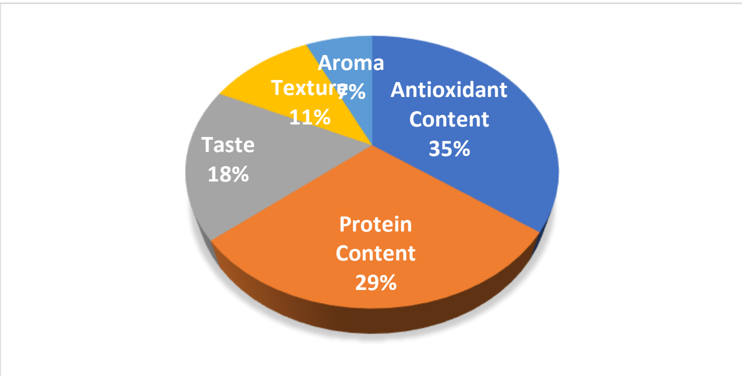


Figure 4. Pie Chart of Weight Parameters of Crispy Ginger Quality

The best alternative is the treatment that has the highest expected value score. The expected value scores for each treatment are shown in Table 3. The selected treatment alternative was the P2J2 treatment (75:25 mocaf to wheat flour ratio, 30% ginger extract concentration).

Table 3. Expected Value of Each Treatment

Treatments	Expected Value
P1J1	3.50
P1J2	3.99
P1J3	7.83
P2J1	6.67
P2J2	9.01
P2J3	8.25
P3J1	6.70
P3J2	7.43
P3J3	7.46

Description:

J1: Ginger Extract Concentration 20% P1: mocaf:wheat = 50:50
J2: Ginger Extract Concentration 30% P2: mocaf:wheat = 75:25
J3: Ginger Extract Concentration 40% P3: mocaf:wheat = 100:0

4. Conclusion

The substitution of wheat flour with mocaf in crispy ginger processing aims to minimize Indonesia's dependence on other wheat-producing countries. This change decreases protein, fat, and moisture content while increasing carbohydrate and antioxidant content in ginger crispy. Ginger extract concentration improves protein, fat, moisture, and antioxidant content while decreasing carbohydrate content in crispy ginger. Organoleptic test results for ginger crispy with wheat flour substitution show a darker color, less preferred by panellists. Additionally, aroma, taste, and texture are also less preferred. The study suggests that wheat flour can be substituted for mocaf in crispy ginger processing, but further improvements are needed, particularly in color, aroma, taste, and texture. The decision analysis results show that the selected treatment, P2J2 (75:25 mocaf to wheat flour ratio, 30% ginger extract concentration), has a total expected value of 9.01.

Appreciation

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