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Analysis of Nutritional Value and Organoleptic Quality of Cookies Made From Sacha Inchi Nuts With A Combination Of Arrowroot Flour and Banana Flour As A Protein-Rich Food

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Abstract

Background: Cookies are a staple food alternative with rich nutritional characteristics. Cookies have a delicious taste and crunchy texture. Objective: To produce cookie products with a combination of sacha inchi flour, banana flour and arrowroot flour that are high in protein, omega-3, 6, and 9 and high in fibre that can be accepted organoleptically.

Method: Experimental research with a Completely Randomised Design (CRD). The treatment consisted of substituting sacha inchi flour with a combination of flours (banana, arrowroot, and wheat) to produce Formulas 01A, 02B, and 03C. With acomparison of sacha inchi nuts at 30% in formula 01A, 40% in formula 02B, and 50% in formula 03C. The nutritional values tested included water content, ash content, fat content, protein content, carbohydrate content, energy content, fibre content, total sugar content, and omega-3, 6, and 9 content. Organoleptic quality was tested using the Hedonic Test (preference test) with 30 consumer panellists who regularly consume cookies.

Result: Based on the analysis of nutritional value (energy, fat, protein, carbohydrates, saturated fatty acids, unsaturated fatty acids, omega-3, 6, 9) and organoleptic quality, sacha inchi beans have the potential to be used at 50% in the formulation of cookies. That is, the cookies made with formula Sacha inchi cookie products, combined with arrowroot and banana flours, are an alternative source of protein with high nutritional value and omega-9 fatty acids, offering health benefits.

Keywords: cookies, sacha inchi, banana, arrowroot, flour, protein, omega-3, omega-6, and omega-9

1. INTRODUCTION

Cookies are a type of snack that is widely enjoyed by people of all ages, including children, teenagers, and adults. They have a delicious taste and a crunchy texture. The average consumption of dry cakes (including cookies) in Indonesia was relatively high between 2011 and 2015, with an average growth rate of about 24.22%, which was higher than that of wet cakes (boiled or steamed cakes), which reached only 17.78% (Setjen Pertanian, 2015).

Cookies can be consumed at any time and are often considered snacks or treats. Sacha inchi (*Plukenetia volubilis*), also known as the Inca nut or mountain peanut, is a nut native to the tropical forests of the Amazon. However, it is now cultivated in China, Vietnam, Malaysia, Thailand, and, more recently, Indonesia. Morphologically, the sacha inchi fruit has a star shape, with each star containing about 4 to 5 seeds. The young fruit is green.

The mature fruit, on the other hand, is dark brown. Sacha inchi is a type of legume that has not yet been widely cultivated by Indonesian farmers. However, it is rich in fatty acids, including omega-3, omega-6, and omega-9, which are highly beneficial for children's brain development (Kemendikbud, 2022).

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Various parts of this plant can be utilised. The leaves contain antioxidants and can be consumed as vegetables or processed into tea. The seeds are rich in unsaturated fatty acids, with omega-3 content ranging from 47–51% and omega-6 from 34–37%, compared to olive oil, which contains only about 1% omega-3 and 9% omega-9. According to Ningrum & Halimah (2022), the sacha inchi plant contains several beneficial compounds, including fatty acids, tocopherols, phytosterols, triglycerides, and polysaccharides, which support health.

The compounds in sacha inchi exhibit antioxidant, anti-inflammatory, antibacterial, antidiabetic, and immunomodulatory activities and also serve as a nutritional source. This indicates that sacha inchi can be utilised as a food source, medicinal ingredient, cosmetic material, and for other commercial products. Because public knowledge about sacha inchi remains limited, its high nutritional content has prompted researchers to utilise its seeds as a raw material for producing cookies.

Arrowroot (*Maranta arundinacea*) is a potential food source that can be developed as a wheat-flour substitute, as its tubers contain a high level of carbohydrates. Moreover, arrowroot has a low glycemic index (GI = 14) compared to other tubers, making it highly beneficial for health, especially for people with diabetes. Arrowroot flour contributes to the crispiness and flakiness of food products during processing.

This research used arrowroot tubers processed into arrowroot flour. Arrowroot flour can substitute wheat flour in foods like cookies, noodles, baby porridge, and even diet foods as a rice replacement (Budi Setyawan, 2015:67). In this study, arrowroot flour was added to enhance the final product's crispiness.

Banana (*Musa paradisiaca*) is a highly nutritious fruit and a good source of vitamins and minerals, including potassium, magnesium, iron, phosphorus, and calcium. It also contains vitamins A, B6, and C, as well as serotonin, a neurotransmitter that supports brain function (Kaleka, N., 2013).

Bananas contain about 440 mg of potassium, their most prominent mineral. Potassium helps maintain water balance, supports heart health, regulates blood pressure, and aids oxygen transport to the brain. Bananas also enhance food aroma.

Banana flour is easy to process into high-value products. It blends well with other flours and enhances the aroma of foods. For cookies, combining these three ingredients is beneficial: arrowroot flour adds crispiness, and banana flour enhances aroma.

2. MATERIALS AND METHODS

This study employed a Completely Randomised Design (CRD). The treatments involved substituting sacha inchi flour with a combination flour (banana flour, arrowroot flour, and wheat flour) to produce three formulations: 01A, 02B, and 03C. The study was conducted in three stages: 1) Preparation of Equipment and Materials. 2) Cookie Production – Cookies were prepared using sacha inchi flour and the combination flour according to the respective formula recipes. 3)Evaluation of Nutritional Value and Organoleptic Quality . The nutritional content of the cookies was analysed, and organoleptic properties were assessed.

The nutritional analyses included moisture content, ash content, fat content, protein content, carbohydrate content, energy value, fibre content, total sugar content, and omega-3, -6, and -9 levels. Moisture, ash, and crude fibre were measured using gravimetric methods, while protein content was determined using the Kjeldahl method. Organoleptic quality was assessed through a hedonic test with 30 consumer panellists, all of whom were regular cookie consumers.

The study started after receiving ethical approval from the Ethics Committee of the Faculty of Medicine, Public Health, and Nursing, UGM. It continued until November 2024. Nutritional analyses were performed at Chemix Private Laboratory and LPPT UGM.

Data Types in this study utilised quantitative data. Nutritional data were obtained from laboratory measurements, while organoleptic data were collected via hedonic tests using structured forms. The study used primary data, collected directly, to evaluate the organoleptic

quality of the cookies. Organoleptic data were analysed using SPSS (Statistical Product and Service Solutions).

a. Cookie Production

Cookies were produced at the Nutrition Installation of the Academic Hospital of UGM in accordance with Good Manufacturing Practices (GMP). All equipment was food-grade, staff wore personal protective equipment (PPE), and facilities (water, chiller temperature, freezer temperature) were routinely monitored. Laboratory analysis of food produced at the Nutrition Installation indicated zero E. coli per gram of sample, and no pathogenic microbes were detected in food handlers using rectal swab tests. Cookies were produced in a single batch to minimise potential bias in subsequent analyses.

b. Ethics

Nutritional analyses were performed at Chemix Private Laboratory and LPPT UGM. Nutritional parameters measured included moisture, ash, fat, protein, carbohydrate, energy, fibre, total sugar, and omega-3, -6, and -9 content. Moisture, ash, and crude fibre were determined using gravimetric methods, while protein content was measured using the Kjeldahl method. A 100 g sample from each formula was sent in airtight containers from the Nutrition Installation of the Academic Hospital of UGM to both laboratories.

c. Organoleptic Evaluation of Cookies

Organoleptic evaluation was conducted using a hedonic test to determine consumer preference. A four-point scale was used to measure panellists' preferences, with 1 indicating the least liking and 4 indicating the most. A four-point scale was selected to simplify the interpretation of respondents' attitudes and reduce central-tendency bias.

The number of panellists conducting organoleptic evaluation of the product in this study was 30 people, aged 25–45 years. Data processing for this study was carried out through the following stages:

1) **Editing**
   This is an effort to recheck the accuracy of the data obtained or collected. Editing can be done after data collection is completed.
2) **Data Entry**
   This involves entering the collected data into a computer database and generating simple frequency distributions.
3) **Tabulating**
   Grouping data into tables to facilitate analysis.
4) **Data Analysis**
   Data from the nutritional value tests, dough expansion physical properties, and organoleptic quality evaluation of the cookies were analysed descriptively. Organoleptic data were then statistically tested using the Kruskal-Wallis test to determine differences in panellists' preference levels regarding the colour, aroma, taste, and texture of the cookies.

3. RESULTS

This research produced three formulations of Sacha Inchi cookies combining arrowroot flour and banana flour, with Sacha Inchi percentages of 30% (Formula 01A), 40% (Formula 02B), and 50% (Formula 03C). The banana flour ratio was 3:2:1 for each respective formula, while the arrowroot flour composition remained the same in all formulas. These three cookie formulations were subsequently subjected to chemical analysis and organoleptic quality assessment.

a. Nutritional Value Analysis

The nutritional parameters analysed in this study included moisture content, ash, crude fibre, energy, fat, protein, carbohydrates, and fatty acid content of cookies made with a combination of arrowroot and banana flours. The analysis results are expressed as percentages (%), except for energy, which is expressed in kcal/100g. Testing was conducted in duplicate, and the results were averaged.

The nutritional analysis results indicate that Formula 02 B cookies had the highest energy, ash, and fat content. This is attributed to the addition of 125g of wheat flour to this formula, which increases the energy content. The highest protein and moisture content were found in Formula 03C cookies, due to the use of 50% Sacha Inchi nuts. Conversely, the highest carbohydrate and crude fibre content were found in Formula 01A cookies, because this formula contains the highest proportion of banana flour compared to the others—100g of banana flour yields 25.8g of

carbohydrates.

b. Analysis of Omega-3, -6, and -9 Content

The omega-3, -6, and -9 content of these Sacha Inchi cookies was analysed by gas chromatography. The levels of omega-3, -6, and -9 were measured in a single replication. The results showed that the Sacha Inchi cookies, whether Formula 01A, 02B, or 03C, contained no detectable omega-3 or omega-6 fatty acids, as indicated by laboratory results at <0.1% (relative). However, testing for omega-9 revealed that Sacha Inchi cookies with Formula 03C had the highest omega-9 content among the formulas at 4.7% (relative). Formula 03C contains a higher proportion of Sacha Inchi (50%) compared to the other cookies, which influences its omega-9 content, making it the highest among the formulations.

c. Analysis of Saturated and Unsaturated Fatty Acid Content

The saturated and unsaturated fatty acid content of these Sacha Inchi cookies was analysed using Chromatography.

The results of the saturated and unsaturated fatty acid analysis indicate that cookies from Formula 03C had the highest saturated fatty acid content compared to the other cookies. Meanwhile, Formula 01A cookies had the highest unsaturated fatty acid content among the cookies.

d. Organoleptic Quality Analysis

The organoleptic quality evaluation of Sacha Inchi cookies containing arrowroot and banana flour was conducted using organoleptic and hedonic testing with 30 panellists. The organoleptic test results were statistically analysed using the SPSS program with the Kruskal-Wallis test. and luteinizing hormone (LH) levels were also low.

1) Texture

The results of the Kruskal-Wallis test for the texture parameter showed a p-value > 0.05, indicating no significant difference among the treatments (01A, 02B, 03C) in cookie texture.

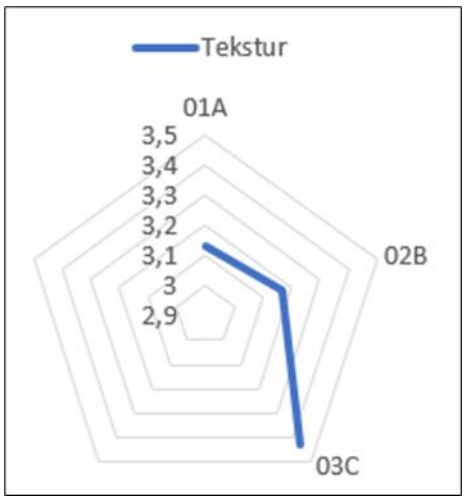

Figure 1. Texture Result Graph

Based on the graph above, it can be concluded that the texture of cookies from formula 03C was the most preferred by the panellists.

2) Color

The results of the Kruskal-Wallis test for the colour parameter showed a p-value > 0.05, indicating no significant difference among the treatments (01A, 02B, 03C) in cookie colour.

3) Aroma

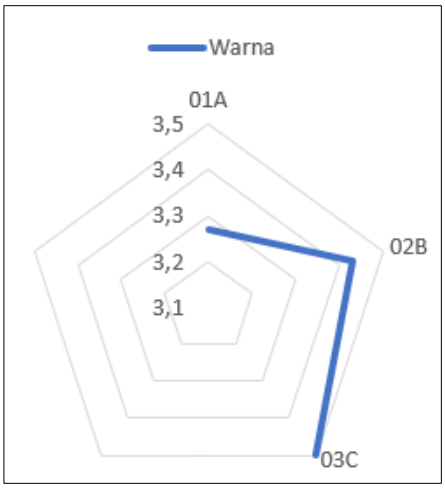

Figure 3. Graph of Aroma Analysis Results

4) Taste

The results of the Kruskal-Wallis test for the taste parameter showed a p-value > 0.05, indicating no significant difference among the treatments (01A, 02B, 03C) in cookie taste.

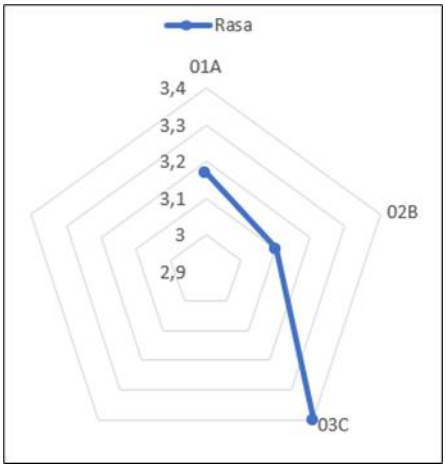

Figure 4. Graph of Taste Analysis Results

Based on the graph above, it can be concluded that the taste of cookies from formula 03C was the most preferred by the panelists.

4. DISCUSSION

The nutritional values analysed in this study included energy, protein, fat, carbohydrates, ash content, moisture content, total sugar, fatty acids, and crude fibre. In this study, the percentage of arrowroot flour was kept the same across all three treatments, while the treatments differed primarily in the percentage of added sacha inchi flour: Formula 01A contained 30% sacha inchi flour, Formula 02B contained 40%, and Formula 03C contained 50%.

This difference in the percentage of sacha inchi flour mixture influenced the nutritional value of the resulting cookies. In Formula 01A, the cookies contained higher levels of carbohydrates and crude fibre. Carbohydrates are one of the main components in food, providing essential energy for the body and serving as a primary energy source. Carbohydrates are nutrients composed of sugars, fibre, and starches.

Fibre is a type of healthy complex carbohydrate that cannot be digested by the body. However, fibre is crucial for healthy digestion. It can be found in foods such as oatmeal, legumes, and vegetables. In addition to aiding digestion, fibre also has several other functions: regulating blood sugar, lowering cholesterol, and helping to maintain a feeling of fullness for longer.

In Formula 02B, the cookies had higher levels of energy, fat, and ash. The body requires energy to power all activities. Energy is obtained from daily food intake, primarily carbohydrates and fats.

Fat is an organic substance insoluble in water and is one of the important macronutrients for the body. Fat has many functions, including generating energy, aiding in the absorption of vitamins A, D, E, and K, building body structures, protecting vital organs, regulating body temperature, promoting healthy skin and hair, and aiding in recovery from inflammation or injury. Fats can be found in various foods, such as olive oil, avocados, meat, nuts, and dairy products.

Ash content is a parameter that indicates the amount of minerals or inorganic components contained in food materials. Ash content is measured by burning a food sample at high temperatures and measuring the remaining ash. Ash content is part of proximate analysis used to determine the nutritional value of a food material.

Meanwhile, Formula 03C contained higher levels of moisture and protein. Moisture content refers to the amount of water contained in a substance, such as soil, agricultural materials, and food. Moisture content is an important parameter for determining the quality and shelf life of food materials. In the food industry, moisture content is a crucial chemical laboratory testing method. Accurate determination of moisture content during food processing and distribution is essential to avoid spoilage that could endanger health. Moisture content also affects the shape, texture, and taste of a food product.

Protein is one of the essential nutrients for body health. Protein has several functions, including aiding in cell growth, serving as an energy source, maintaining body fitness, providing a longer-lasting feeling of fullness, and supporting eye health. Protein deficiency can lead to adverse effects on the body, such as loss of muscle mass, bone disorders, and impaired

growth and development in children, including stunting.

Based on the average hedonic test for panellists' acceptance of the texture of cookies with a 50% substitution of sacha inchi flour, the highest score was given to cookies with this substitution. This is because the texture of cookies with a 50% sacha inchi flour substitution is softer than that of cookies with 30% or 40% substitutions. The difference in cookie texture is due to the lower moisture content in cookies with 30% and 40% substitution of sacha inchi flour, which makes them slightly harder. Water is a crucial component in food materials because it can influence appearance, texture, and taste. The moisture content in cookies affects consumer acceptance, particularly regarding the texture attribute. Cookies with higher moisture content tend to be less hard, making their texture more preferred.

Colour is the visual aspect of a product that is noticed first, compared to other variables. Colour directly influences panellists' perceptions. Visually, the colour factor is often the first thing people notice and can determine a product's value. Regarding the colour parameter, panellists' assessments indicated no significant difference among all treatments, meaning that 30% (01A), 40% (02B), and 50% (03C) produced cookies with nearly the same colour: brown. The colour of the cookies is also influenced by flour substitution; the higher the concentration of banana and sacha inchi flours added, the browner the resulting cookies, indicating a darker colour due to the Maillard reaction. This reaction has significantly impacted the food industry, as it influences aroma, taste, and colour, according to Avianty and Ayustaningwarno (2013).

Based on panellists' assessments, the most preferred taste was Formula 03C, with an average score of 3.4, while the least preferred was Formula 02B, with an average score of 3.1. The taste of cookies arises from the ingredients used, such as flour, margarine, and eggs. In this study, the ingredients for making cookies were the same except for the type of flour used. The distinct taste of the experimental cookies was due to the use of banana flour made from sacha inchi. The more sacha inchi flour used in the cookie substitution, the more pronounced the sacha inchi flavour, as sacha inchi flour has a higher crude fibre content than wheat flour (Hanifa, R. H., 2013).

The aroma of food is the scent emitted by food, which has an appealing quality that stimulates the sense of smell and can stimulate appetite. The food industry considers aroma testing highly important as it can quickly provide results regarding consumer preference for a product. Panellists' evaluations of aroma showed that the most preferred aroma was at a 50% concentration (03C), while the least preferred aromas were at 30% (01A) and 40% (02B). The aroma of cookies with varying levels of sacha inchi flour substitution is influenced by the distinct nutty aroma of sacha inchi flour. According to Sitohang et al. (2015)

5. CONCLUSION

a. The nutritional analysis results show that cookies from Formula 03C contain the highest levels of protein, omega-9 fatty acids, and saturated fatty acids among the other cookies.
b. Hedonic test results indicate that panellists favoured cookies from Formula 03C in terms of taste, colour, texture, and aroma.
c. Based on the results of nutritional analysis (energy, fat, protein, carbohydrates, saturated fatty acids, unsaturated fatty acids, omega-3, -6, 9) and organoleptic quality, sacha inchi nuts have the potential to be used in cookie formulation at a 50% concentration.
d. The Sacha Inchi cookie product, combining arrowroot flour and banana flour in Formula 03C, serves as an alternative development of a protein source product with high nutritional value and omega-9 content, offering potential health benefits.

6. ACKNOWLEDGMENTS

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