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The effect of adding Sacha-Inchi oil on the quality of omega-3-rich mocaf-based nastar for toddlers aged 1–5 years

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Abstract

Nastar is a cookie popular among children and has the potential to serve as a medium for fortifying essential nutrients such as omega-3, which plays a role in supporting brain development, cognitive function, and visual health in toddlers. This study aims to determine the effect of adding sacha inchi oil on the quality of omega-3-rich mocaf flour-based nastar for toddlers aged 1–5 years. Mocaf flour is a gluten-free, high-fiber flour produced through the fermentation of cassava, while sacha inchi oil is a vegetable oil with a high content of omega-3 fatty acids. This study employed an experimental design using a completely randomized design (CRD) with three treatments: F1 (95% mocaf flour, 5% sacha inchi oil), F2 (90% mocaf flour, 10% sacha inchi oil), and F3 (87.5% mocaf flour, 12.5% sacha inchi oil). Data collection was conducted via organoleptic testing (color, aroma, taste, and texture) using a hedonic scale with 30 moderately trained panelists. The data were analyzed using an ANOVA test, which showed that the addition of sacha inchi oil had no significant effect ($p > 0.05$) on color, taste, aroma, and texture. It can therefore be concluded that the best formulation was obtained in treatment F3, which had the highest panelist preference and nutritional content. It is recommended that mocaf nastar with added sacha inchi oil be developed as a healthy, omega-3-rich snack alternative for toddlers, and further research is needed regarding shelf-life testing as well as a more specific analysis of DHA and EPA content.

Keywords: Mocaf flour, Nastar, Omega-3, Sacha inchi oil, Toddlers.

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1. Introduction

The issue of undernutrition among toddlers remains a serious challenge in many countries, including Indonesia. According to the World Health Organization (WHO), one of the main problems currently affecting toddlers in Indonesia is malnutrition. Based on the 2022 Indonesia Nutrition Status Survey (SSGI), the prevalence of underweight (weight-for-age) was 17.1%, stunting (height-for-age) was 21.6%, and wasting (weight-for-height) was 7.7%. The prevalence of underweight and wasting has even increased from the previous year [1]. This situation indicates that toddlers, as a vulnerable age group, require special attention regarding nutritional adequacy, particularly during the golden period (ages 1–5 years) when rapid physical growth and brain development occur. One of the essential nutrients during this period is essential fatty acids such as omega-3. However, data from the Indonesian Ministry of Health [2] indicates that only 2 out of 10 Indonesian children meet their omega-3 intake requirements, while approximately 74.4% of children are deficient. Omega-3 deficiency has negative effects on brain development, concentration, memory, as well as children's motor and physical skills [2]. Toddlers tend to prefer sweet and convenient foods, so snacks can serve as an effective means of meeting their nutritional needs. One popular snack among children is nastar cookies, due to their sweet taste and soft texture. This situation presents a strategic opportunity for food innovation by using nastar as a vehicle for fortifying essential nutrients such as omega-3. This innovation can not only improve the nutritional quality of the snack but also help meet toddlers' nutritional needs for omega-3 fatty acids, particularly docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), which play a crucial role in the growth and development of toddlers. DHA is a primary structural component of the brain and retina, thus playing a crucial role in children's cognitive development and visual function. Research by Mulder, et al. [3] indicates that adequate DHA intake during early childhood growth is positively correlated with improved cognitive abilities and memory. Additionally, omega-3 contributes to the development of the central nervous system, helps form optimal neural connections, and plays a role in mood stability and behavior. Studies by Nyaradi, et al. [4]. It states that children who receive an adequate intake of omega-3 tend to have better motor development and a lower risk of developmental disorders such as ADHD. Additionally, omega-3 is known to possess anti-inflammatory properties that support toddlers' immune systems and help maintain overall health [5]. Thus, ensuring adequate omega-3 intake from an early age is crucial for supporting physical growth, brain development, and children's overall quality of life [6]. To develop a more nutritious nastar, using local food ingredients can be an appropriate choice. Mocaf flour (modified cassava flour) is a cassava- based flour that has been fermented with lactic acid bacteria. This flour is gluten-free, has a smooth texture, and a nutritional profile similar to wheat flour, making it safe for toddlers. Meanwhile, sacha inchi oil (Plukenetia volubilis) is a high-source of plant-based omega-3, containing approximately 48% alpha- linolenic acid (ALA), as well as protein, fiber, and antioxidants. The combination of mocaf flour and sacha inchi oil can serve as an alternative in creating functional snacks that are not only delicious but also rich in benefits for toddlers [7].

The urgency of developing functional, locally-based food innovations for toddlers is growing increasingly important as the need for nutritious and safe food for this vulnerable age group rises. The development of food products such as omega-3-enriched mocaf nastar has the potential to enhance food security, support early childhood health, and optimally utilize Indonesia's local food resources.

However, to date, there have been few innovations or studies combining mocaf flour with natural omega-3 sources such as sacha inchi oil in nastar production. Nastar products available on the market tend to be low in and high in saturated fat, thus failing to fully meet the nutritional needs of toddlers. Based on this phenomenon, the researchers were motivated to conduct a study titled: "The Effect of Adding Sacha Inchi Oil on the Quality of Omega-3-Rich Mocaf Flour-Based Nastar for Toddlers."

2. Research Methodology

This study employed an experimental method using a randomized block design (RBD), with the aim of determining the existence of a causal relationship between the treatments administered and the resulting responses. In this case, the experimental method allows researchers to strictly control variables, thereby enabling them to accurately measure the effects of the treatments administered. The RCT was chosen because it allows for the random assignment of subjects into several groups receiving different treatments, as well as a control group for comparison. With this approach, the internal and validity of the study is enhanced because potential bias can be minimized [8]. This method was implemented by creating three different formulas using the Design Expert application. The three formulas consisted of variations in the composition of mocaf flour and sacha inchi oil. Formula I used 95% mocaf flour and 5% sacha inchi oil. Formula II consisted of 90% mocaf flour and 10% sacha inchi oil. Meanwhile, Formula III uses 87.5% mocaf flour and 12.5% sacha inchi oil. These composition variations are intended to observe the extent to which the addition of sacha affects the characteristics of the resulting product, in terms of quality, texture, taste, and nutritional value.

3. Results and Discussion

3.1. Organoleptic Test

3.1.1. Color

The results of the descriptive organoleptic color test of mocaf flour nastar with added sacha- inchi oil can be seen in the figure below.

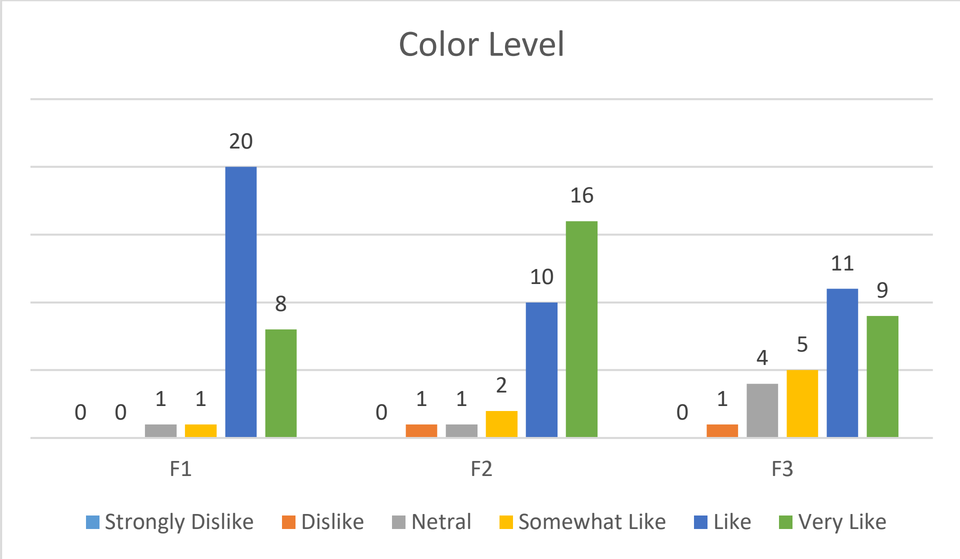

Figure 1.
Results of the Organoleptic Color Test of Nastar Made from Mocaf Flour with Added Sacha-Inchi Oil.

Based on the Figure 1, the most preferred formula in terms of color was formula 1 (95% mocaf flour and 5% sacha-inchi oil), with 20 panelists rating it as “like,” 8 as “very like,” 1 as “somewhat like,” and 1 as “neutral.”

3.1.2. Taste

The results of the descriptive organoleptic test for the color of mocaf flour Nastar with added sacha-inchi oil can be seen in the image below.

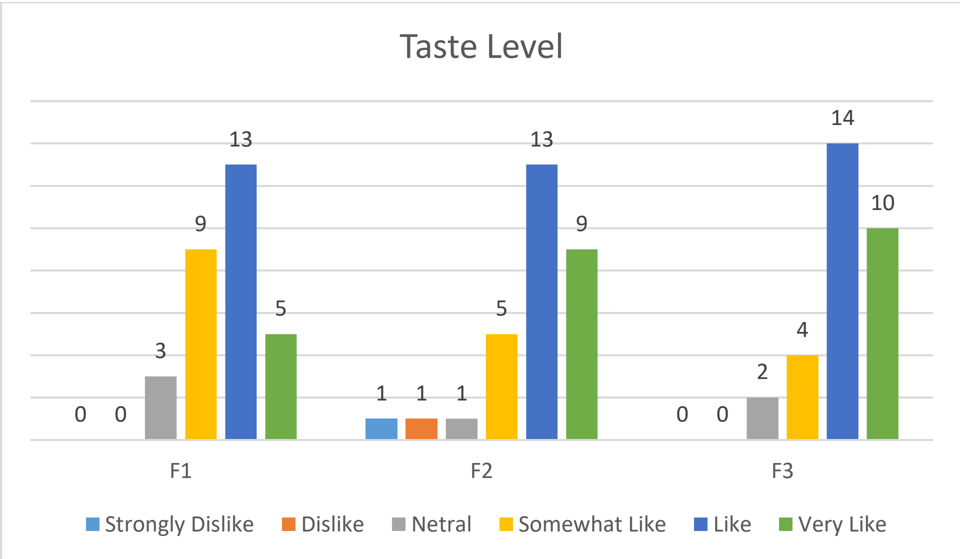

Figure 2.
Results of the Organoleptic Test of the Taste of Mocaf Flour Nastar with Sacha-Inchi Oil.

Based on the Figure 2 The most preferred formula in terms of taste was formula 3 (87.5% mocaf flour and 12.5% sacha inchi oil), with 13 panelists rating it as "like," 10 as "like very much," 2 as "like somewhat," and 4 as "neutral."

3.1.3. Aroma

The results of the organoleptic test of the aroma of mocaf flour nastar with added sacha inchi oil are described in the figure below.

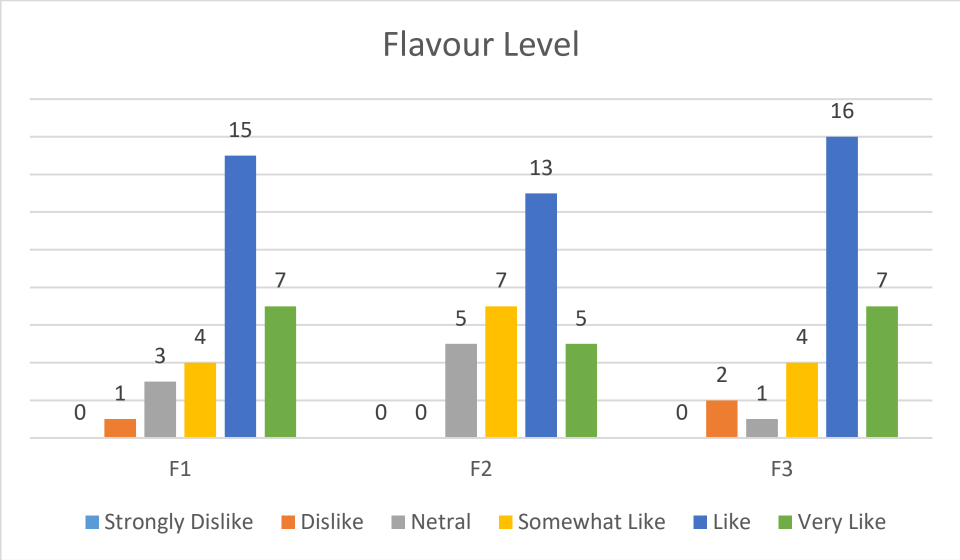

Figure 3.
Results of the Organoleptic Test of the Aroma of Mocaf Flour Nastar with the Addition of Sacha-Inchi Oil.

Based on Figure 3, the most preferred formula in terms of aroma was Formula 1 (95% mocaf flour and 5% sacha inchi oil), with 15 panelists rating it “like,” 4 rating it “really liked by 7 panelists, somewhat liked by 4 panelists, neutral by 3 panelists, and somewhat disliked by 1 panelist.

3.1.4. Texture

The results of the descriptive organoleptic test of the texture of mocaf flour nastar with added sacha inchi oil can be seen in the figure below.

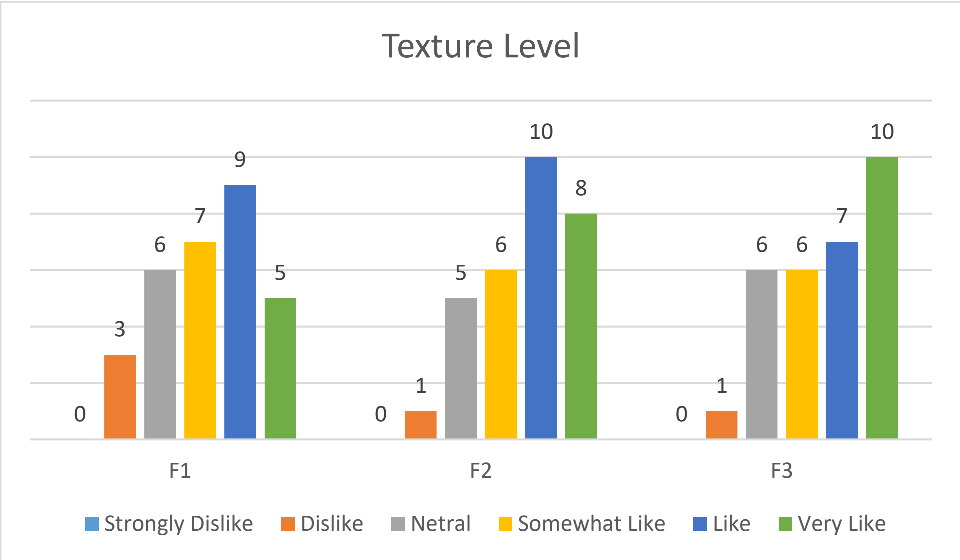

Figure 4.
Results of the Organoleptic Test on the Texture of Nastar Made with Mocaf Flour and Added Sacha Inchi Oil.

Based on Figure 4, the most preferred formula in terms of aroma was formula 2 (90% mocaf flour and 10% sacha inchi oil), with 10 panelists rating it “like,” 8 rating it “like very much,” 5 rating it “like somewhat,” 2 rating it “neutral,” 4 rating it “dislike somewhat,” and 1 rating it “dislike.”

3.2. Laboratory Test

3.2.1. Carbohydrate Test

In this study, carbohydrate content testing was conducted using the by-difference method. The by- difference method is an indirect approach to determining carbohydrate content in a sample, calculated as the difference from 100% minus the known percentages of other major components, such as moisture content, ash content, protein content, and fat content.

In other words, the carbohydrate content is obtained by subtracting the total of 100% after summing the percentages of these four components. This method is commonly used in the proximate analysis of foodstuffs because it is considered efficient and sufficiently accurate in describing carbohydrate content. The results of the laboratory tests on the carbohydrate content of the samples in this study are presented descriptively in the figure below.

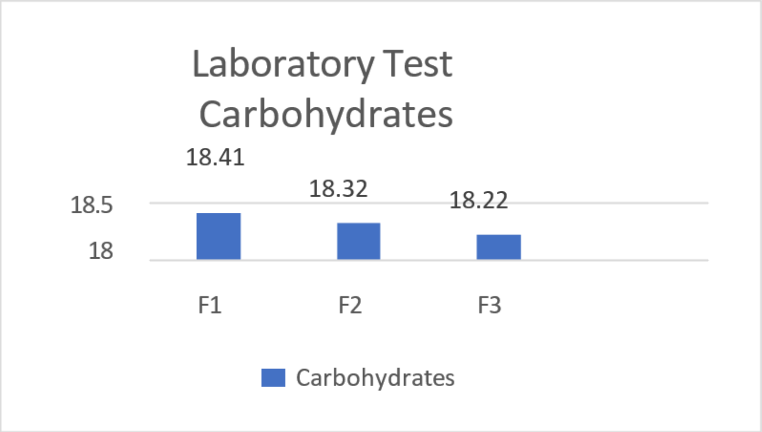

Figure 5.
Laboratory Test Results for Carbohydrate Content.

Based on Figure 5, the laboratory test results for carbohydrate content show that the highest carbohydrate content is found in formula 1 (95% mocaf flour and 5% sacha inchi oil), which is 18.41% or equivalent to 18.41 g, while the lowest carbohydrate content is found in formula 3 (87.5% mocaf flour and 12.5% sacha inchi oil), which is 18.22% / equivalent to 18.22 g.

3.2.2. Protein Test

In this study, the protein content test was using the Kjeldahl method. The principle of the protein content test is that the sample is digested with concentrated sulfuric acid using potassium sulfate and mercury oxide as catalysts. The organic nitrogen present in the sample is converted into ammonium ions and then the ammonium is distilled with the addition of sodium hydroxide. The nitrogen content in the sample is determined by titration using an acid standard. The results of the descriptive laboratory protein content.

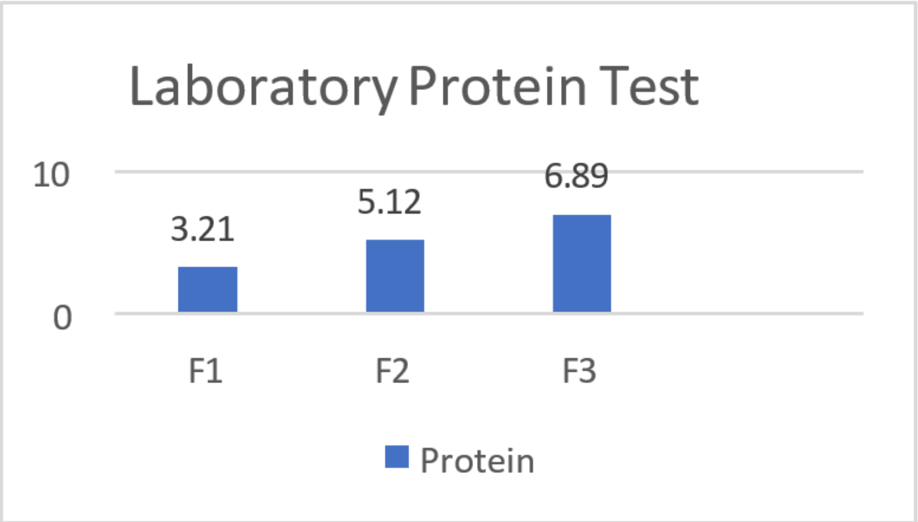

Figure 6.
Results of Laboratory Protein Content Tests.

Based on Figure 6, the results of the protein content laboratory test show that the highest protein content is found in formula 3 (87.5% *mocaf* flour and 12.5% sacha inchi oil), which is 6.89% or equivalent to 6.89 g, while the lowest protein content was found in formula 1 (95% *mocaf* flour and 5% sacha inchi oil), which was 3.21% or equivalent to 3.21 g.

3.2.3. Fat test

In this study, the fat content test was performed using the Soxhlet method with a Weibull modification. The principle of the fat content test is that the sample is hydrolyzed with hydrochloric acid to release bound fat. The fat is then extracted with diethyl ether in a Soxhlet extraction apparatus. The diethyl ether is evaporated, and the fat residue in the Soxhlet flask is weighed. The results of the laboratory fat content test can be viewed at image below.

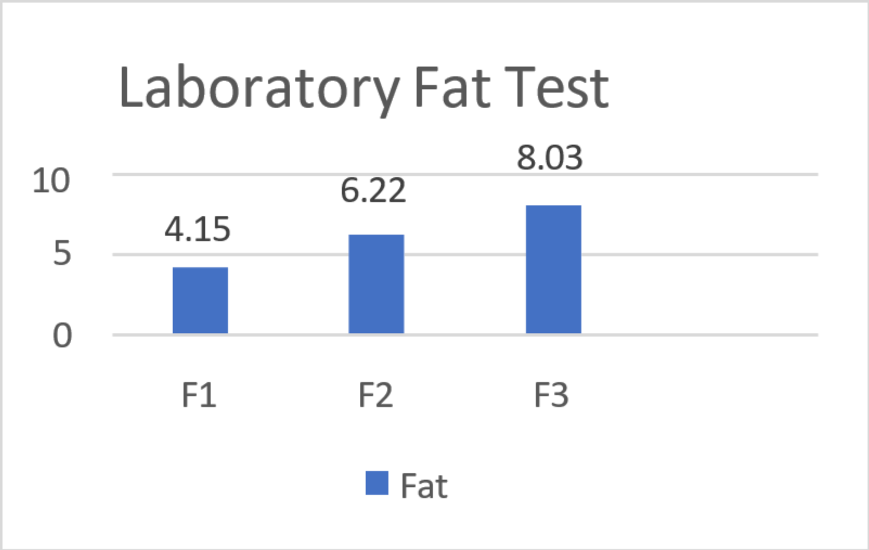

Figure 7.
Laboratory Test Results for Fat Content.

Based on Figure 7, the laboratory test results for fat content show that the highest fat content is found in formula 3 (87.5% *mocaf* flour and 12.5% sacha inchi oil), which is 8.03% or equivalent to 8.03 g, while for the lowest fat content is found in formula 1 (95% *mocaf* flour and 5% sacha inchi oil), which is 4.15% or equivalent to 4.15 g.

3.2.4. Omega-3 Test

The analytical method used in this study aims to convert fatty acids into their derivatives, namely methyl esters, so that they can be detected by a chromatographic instrument. The operating principle of the Gas Chromatography (GC) instrument is based on the separation of compounds based on differences in affinity between the mobile phase (gas) and the stationary phase (a thin layer of liquid), in accordance with the characteristics of each compound [9]. Before injection into the GC instrument, fats are first extracted from the sample material. Next, a methylation process is performed to convert free fatty acids into methyl esters. The analysis results are recorded in the form of a chromatogram. The chromatogram shows several peaks at specific retention times, representing the type and concentration of each fatty acid that is contained in sample. The results of the laboratory analysis of the fat content obtained from this process are presented descriptively in the figure below.

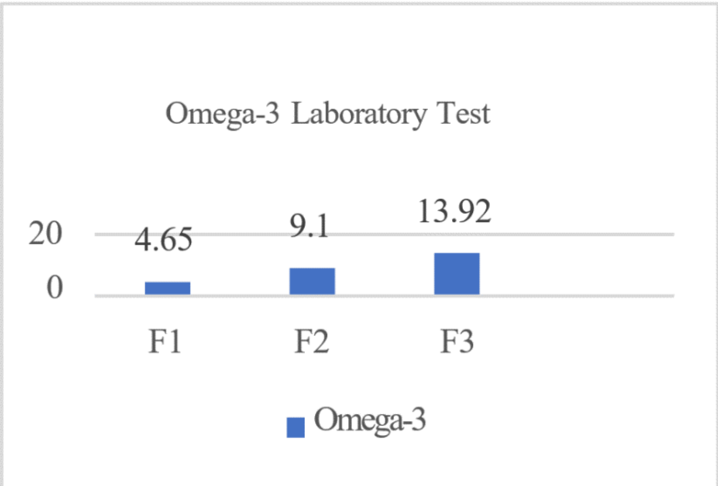

Figure 8.
Laboratory Test Results for Omega-3 Content.

Based on Figure 8, the laboratory test results for omega-3 content show that the highest omega-3 content is found in formula 3 (87.5% mocaf flour and 12.5% sacha inchi oil), which is 13.92% or equivalent to 13.92 g, while the lowest omega-3 content is found in formula 1 (95% mocaf flour and 5% sacha inchi oil), which is 4.65% or equivalent to 4.65 g.

3.2.5. Moisture Content Test

The moisture content test in this study was conducted using the gravimetric method. The principle of measuring moisture content involves incinerating the sample until it is free of carbon, and the residue from the incineration is the ash of the sample. The descriptive results of the laboratory moisture content test can be seen in the figure below.

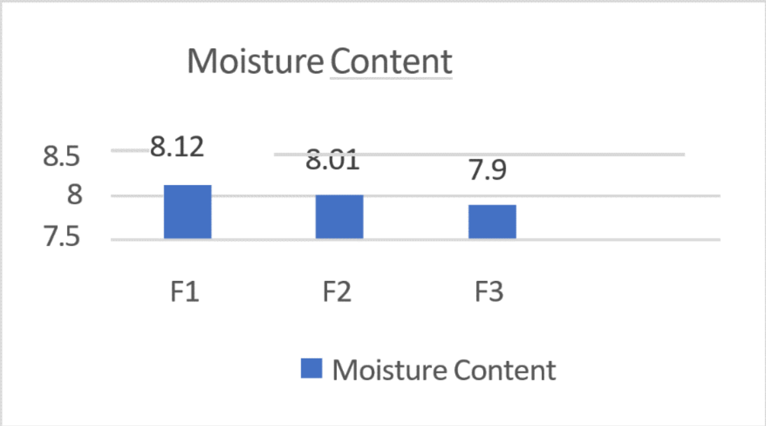

Figure 9.
Laboratory Test Results for Moisture Content.

Based on Figure 9, the laboratory test results for moisture content show that the highest moisture content was found in formula 1 (95% *mocaf* flour and 5% sacha inchi oil), which was 8.12% or equivalent to 8.12 g, while the lowest moisture content was found in formula 3 (87.5% *mocaf* flour and 12.5% sacha inchi oil), which was 7.9% or equivalent to 7.9 g.

4. Conclusion

a. Formula 3 is considered the best the best because it contains a formula of 87.5% mocaf flour and 12.5% Sacha Inchi oil. This produces nastar cookies with a good texture, balanced flavor, and optimal nutritional value, without making the cookies too oily or soggy. Compared to Formulas 1 and 2, Formula 3 yields the most ideal results in terms of quality and nutritional content.
b. Organoleptic test results show that Formula 3, with the addition of 87.5% *mocaf* flour and 12.5% Sacha Inchi oil, is the best formula and the most preferred by panelists in terms of color 5.73 (like), taste 6.00 (like), aroma 5.4 (like), and texture 5.13 (liked).
c. The mocaf flour nastar with the selected sacha-inchi oil addition (F3) had the highest nutritional value, namely a carbohydrate content of 18.22%, a protein content of 6.89%, a fat content of 8.03%, an omega-3 content of 13.92%, and a moisture content of 7.9%.
d. The addition of sacha-inchi oil in the production of *mocaf* flour nastar cookies did not have a significant effect on color, taste, aroma, and texture (F1=95%:5%, F2=90%:10% and F3=87.5%:12.5%).

5. Recommendations

1. The development of sacha inchi mocaf nastar products should be continued to improve compliance with SNI standards and shelf-life testing, as well as to conduct more specific analyses of DHA and EPA content.
2. It is recommended to conduct industrial-scale testing so that the product can be further developed into a healthy and nutritious commercial snack for children.
3. Further research is needed on the direct acceptance of this nastar product by toddler consumers.
4. Educational institutions and researchers can use these results as a reference for the development of functional local foods that support national.

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