International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

Development of Analog Rice Made from Cilembu Sweet Potato, Mocaf Flour, and Avocado *(Persea Americana)* Flour as a Plant-Based Alternative Food

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Abstract

Analog rice is a type of rice made from non-paddy plants, such as tubers and cereal, using either granulation or extrusion methods, the former of which generates granular form, while in the latter produces oval-shaped grains resembling regular rice. This research employed Cilembu sweet potato and avocado as the primary ingredients. A proximate analysis, covering five parameters: moisture, ash, crude protein, fat, and carbohydrate, conducted. Moisture, ash, and fat contents were determined using gravimetric methods, protein content was analyzed using the Kjeldahl method, while carbohydrate content was assessed using the difference method. The research employed one-way ANOVA tests to analyze the parameters mentioned. The results showed that the addition of Cilembu sweet potato flour had no significant effect on moisture, ash, and fat contents. However, protein showed variation, with the 50:50 ratio having the highest content (3.780%) and the 80:20 ratio having the lowest one (3.780%). Carbohydrate was significantly affected, with the 50:50 ratio having the highest content (74.939%) and the 80:20 ratio having the lowest one (71.564%). Additionally, the ANOVA analysis yielded a *p*-value of 0.482, indicating a significant effect of the addition of Cilembu sweet potato flour on the carbohydrates contained in analog rice made from mocaf flour and avocado flour.

Keywords: Analog Rice, Avocado Flour, Cilembu Sweet Potato, Mocaf Flour

Full-length article **Corresponding Author*, e-mail: henykusuma_yanti@yahoo.co.id Doi # https://doi.org/10.62877/2-IJCBS-24-26-20-2

1. Introduction

Analog rice is a food produced by combining various non-rice ingredients, such as tubers, flour, and grains, to duplicate the texture and taste of conventional rice. One interesting ingredient for use in developing analog rice is Cilembu sweet potato, known for its high nutritional content, including fiber, vitamins, and minerals. Additionally, the use of mocaf flour as a binding agent and avocado as a source of plant-based fat can provide additional nutrition and rich flavor to analog rice. Mocaf flour, derived from cassava, has properties similar to wheat flour's but it is gluten-free. Avocado contains healthy fats, fiber, and other essential nutrients [1-3]. Although the potential use of Cilembu sweet potato, mocaf flour, and avocado in analog rice development is intriguing, in-depth research on this product is still limited. Therefore, this research aimed to develop and evaluate analog rice made from Cilembu sweet potato, mocaf flour, and avocado as a healthy and nutritious plant-based alternative. Exploring the potential of these ingredients hopefully can bolster the innovation of plant-based food products that are nutritionally rich, environmentally friend, and able to meet the needs of health-conscious and consumers in a sustainable manner [4]. Economically, producing analog rice from Cilembu sweet potato, mocaf flour, and avocado is beneficial as Cilembu sweet potato is a local agricultural commodity.

This production sector can create new opportunities for local farmers and producers to increase their income [5-6]. In the environmental point of view, analog rice development also contributes to environmental sustainability. Conventional rice production often involves the use of harmful chemicals and requires significant water usage. In this context, utilizing Cilembu sweet potato, mocaf flour, and avocado as the primary ingredients in analog rice has advantages in terms of resource efficiency and reducing negative environmental impacts [7-8]. This research aims to fill existing knowledge gaps and provide a deeper understanding of the potential use of Cilembu sweet potato, mocaf flour, and avocado in analog rice development. Through comprehensive research, including nutritional quality analysis, organoleptic evaluation, and product stability testing, it expected that the results of this research would provide a strong scientific foundation for developing Cilembu sweet potato, mocaf flour, and avocado-based analog rice. Moreover, the findings of this research have the

potential to offer new insights into the field of plant-based food product development in general. By combining nutrient-rich non-rice ingredients, such as Cilembu sweet potato, mocaf flour, and avocado, in analog rice development, it may pave the way for other innovative food products that cater to the increasingly diverse needs of consumers [9].

2. Materials and Methods

2.1. Material

The materials applied in this research were Cilembu sweet potato, mocaf flour, and avocado obtained from CV Amie Herbal, vegetable oil produced by PT Bina Karya Prima, and glycerol monostearate (GMS) produced by Asian Chemical.

2.2. Methods

Cilembu sweet potato, mocaf flour, avocado, glycerol monostearate (GMS), water, and vegetable oil processed first into dough. The mixture was then wrapped in a cloth for 20 minutes and preconditioned at a temperature of 90°C to produce composite flour before being fed into a single-screw extruder.

2.3. Proximate analysis of the nutritional value of flours in analog rice

The analysis of *proximate* using the following equation [10-12]:

2.3.1. Analysis of carbohydrate content in analog rice

The analysis of carbohydrate content done using the following equation:

$\%carbohydrate = 100\% - (\%protein + \%fat + \%ash + \%water)$

2.3.1.1. Analysis of water content in analog rice

Analysis of water content done based on the following equation:

$$\%water = \frac{(wet\ sample\ weight + cup\ weight) - (dry\ sampel\ weight + cup\ weight)}{(wet\ sample\ weight + cup\ ) - (cup\ weight)} \times 100\%$$

2.3.1.2. Ash content

Ash content used method

$$\%ash = \frac{cup\ weight + ashed\ cup\ weigth - empty\ cup\ weight}{sample\ weight + cup\ weigth\ before\ being\ ashed} \times 100\%$$

2.3.1.3. Protein content

Protein content calculated using the following equation

$$\%protein = \frac{(V2 - V1)}{W \times 10} \times N\ NaOH \times 14.008 \times conversion\ factor \times 100\%$$

Note:

Va = mL HCl for sample titration
Vb = mL HCl for blank titration
N HCl = normality of HCl
HCl W = sample weight (grams)
14.007 = nitrogen atomic weight

2.3.1.4. Fat content

Fat content was determined based on the following equation

$$\%fat = \frac{W3 - W2}{W1} \times 100\%$$

Note:

W1 = sample weight (grams)
W2 = weight of empty flask (grams)
W3 = weight of tallow flask + extracted fat (grams)

3. Results and discussion

3.1 Effect of flour composition on the nutritional value of analog rice

3.1.1 Proximate analysis

The analog rice that had produced analyzed to determine the protein, carbohydrate, fat, water, and ash contents (see Table 1).

3.1.1.1 Analysis of water content in analog rice

Water content refers to the amount of water present in a food product. It is a critical parameter for assessing product quality. Analog rice containing a high amount of water can be susceptible to damage and temperature fluctuations. The effect of Cilembu sweet potato flour on the water content in analog rice can be seen in Figure 1. In this research, water content was determined through the oven drying method. The sample was first finely ground and then placed in an oven at a temperature of 105°C for 1 hour. Factors that influence water content in a product include temperature and time. The higher the temperature during the drying process, the more the water evaporated [13-18]. The lowest water content at a 50:50 ratio was 13.000%, and the highest one was 17.000%, indicating that the product water content was still relatively low, making it safe for consumption, as microorganisms were less likely to proliferate therein. The result of the ANOVA analysis yielded a *p*-value of 0.468 > 0.05, suggesting no significant effect of adding Cilembu sweet potato flour to the water content of rice analog made from mocaf flour and avocado. Water content testing does affect the shelf life of a product. Factors influencing water content include drying, temperature, the amount of water added during production, and the water content of the raw materials. The highest water content of 17.000% was found in Sample 6, as Table 1 shows. Such a figure expresses that the product is vulnerable to be easily damaged, as microbes grow well in media with high water content [17].

3.1.1.2 Ash content

Ash content is one of the essential parameters in proximate analysis to determine organic or mineral components present in analog rice. This test can be performed using the dry ashing method, where combustion occurs in a furnace, causing the organic content in the rice to burn off, leaving behind inorganic residues known as ash [13-14]. In this research, the ash content analysis results showed average values of 2.282% and 2.783% for the 80:20 and 50:50 ratios, respectively. The ANOVA analysis yielded a *p*-value of 0.555 > 0.05, indicating no significant effect of adding Cilembu sweet potato flour on the ash content of analog rice made from mocaf flour and avocado. Table 1 shows that the ash content remained within reasonable limits [18]. However, when ash content becomes higher and suggests increased mineral content, the product is not safe for consumption.

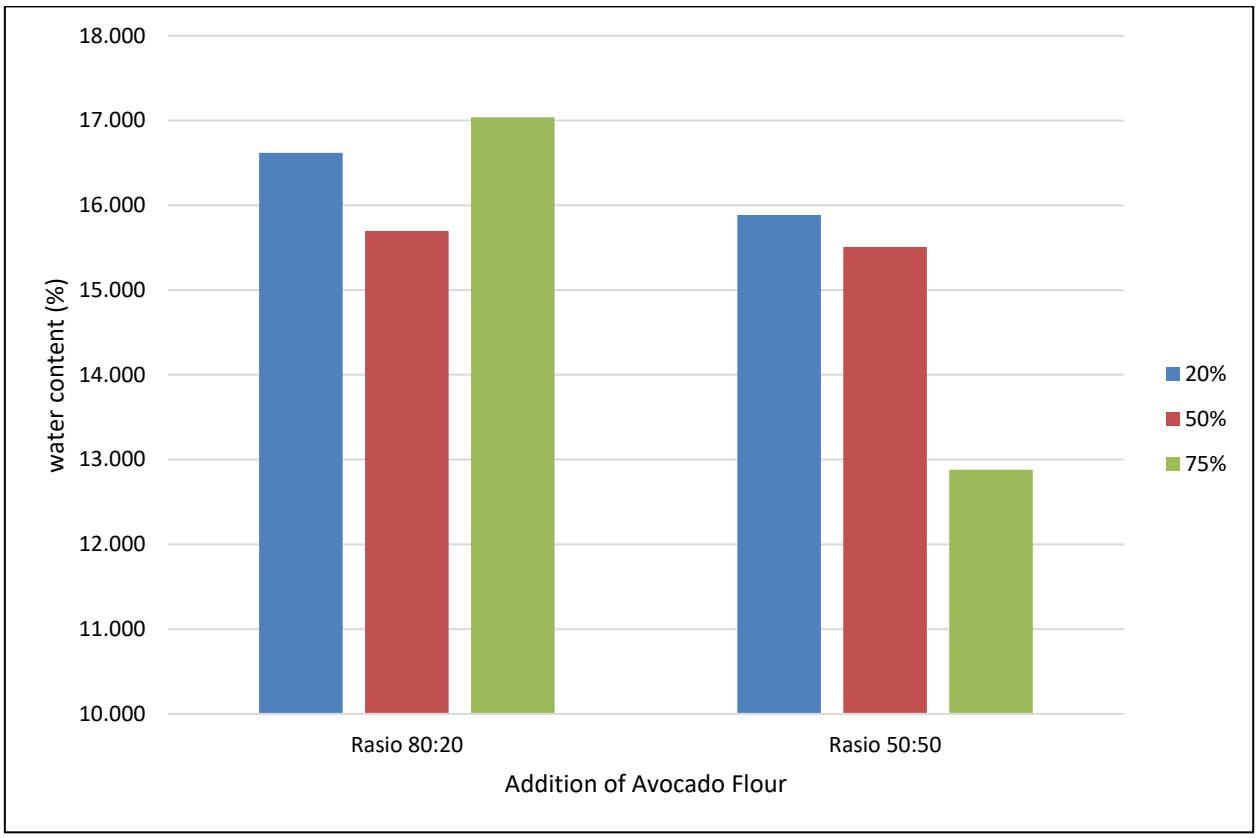

Figure 1. Water content

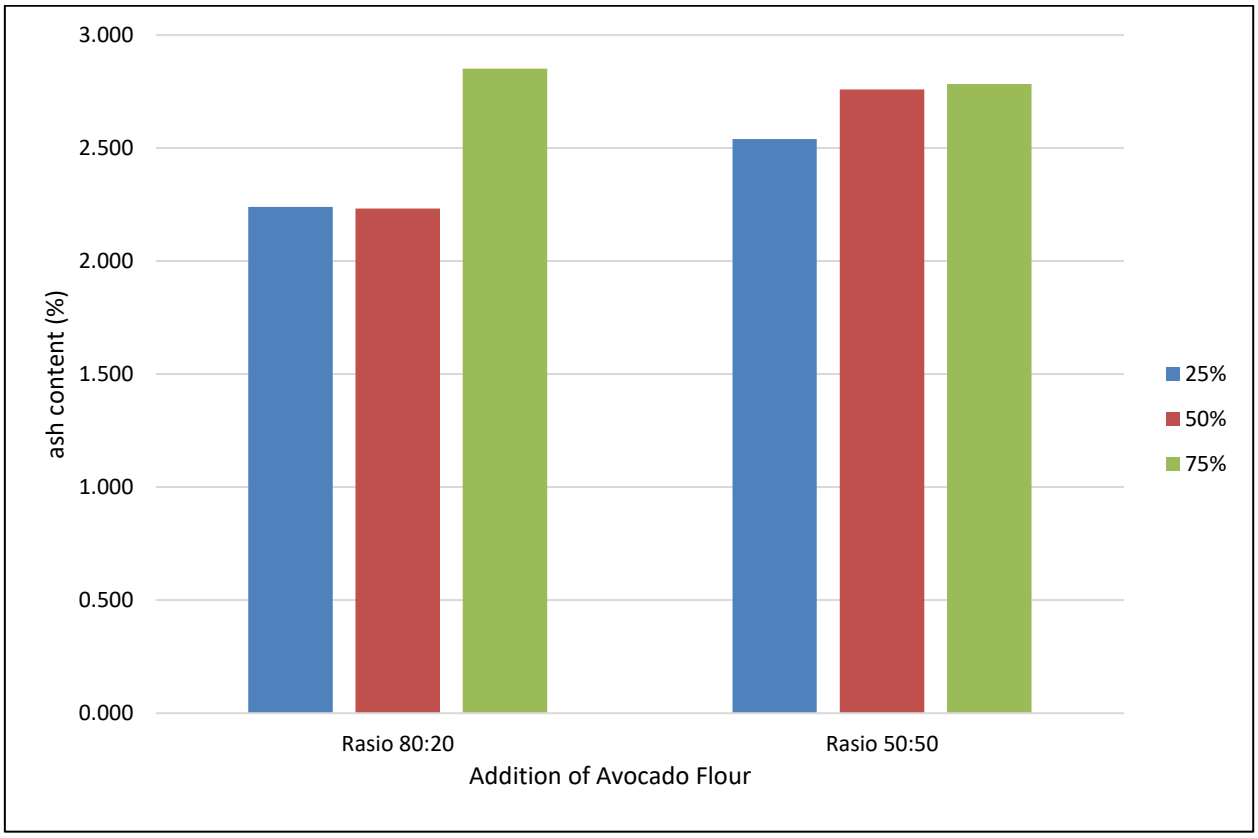

Figure 2. Ash content

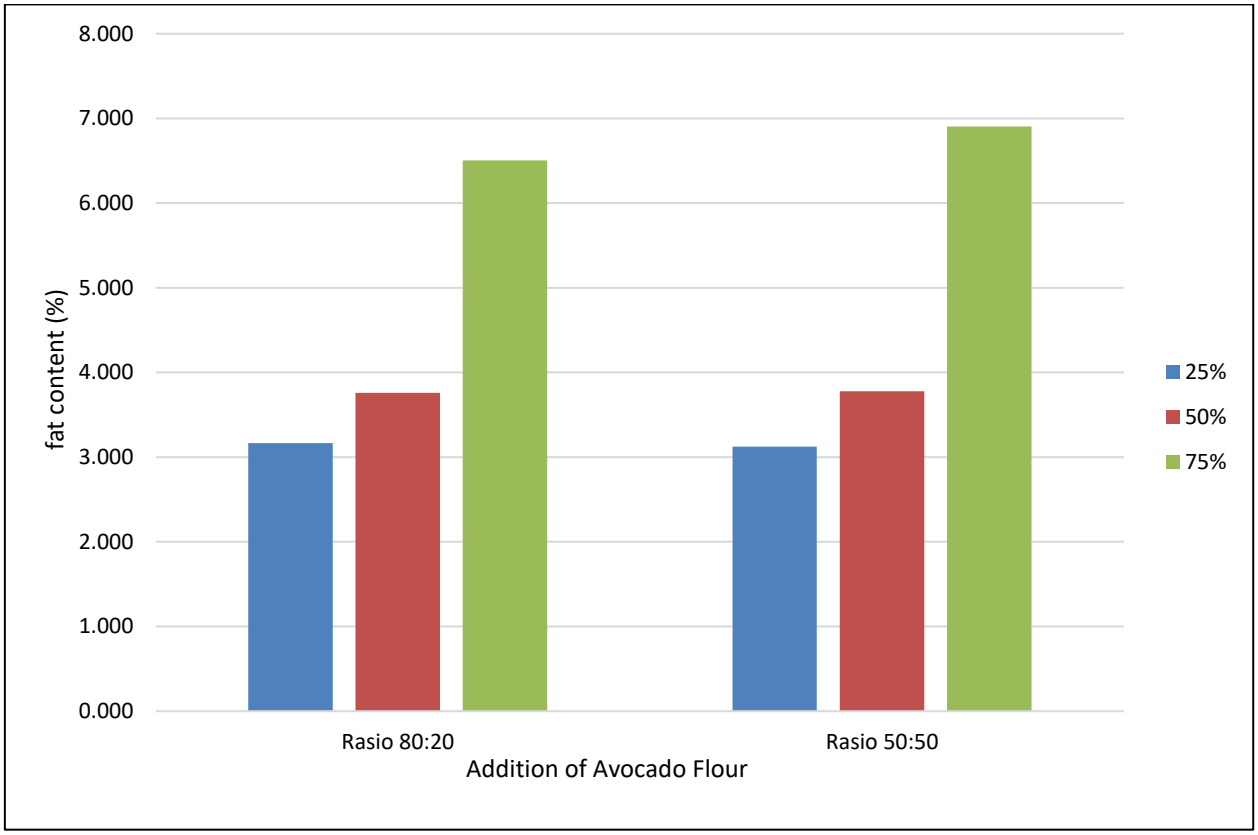

Figure 3. Fat content

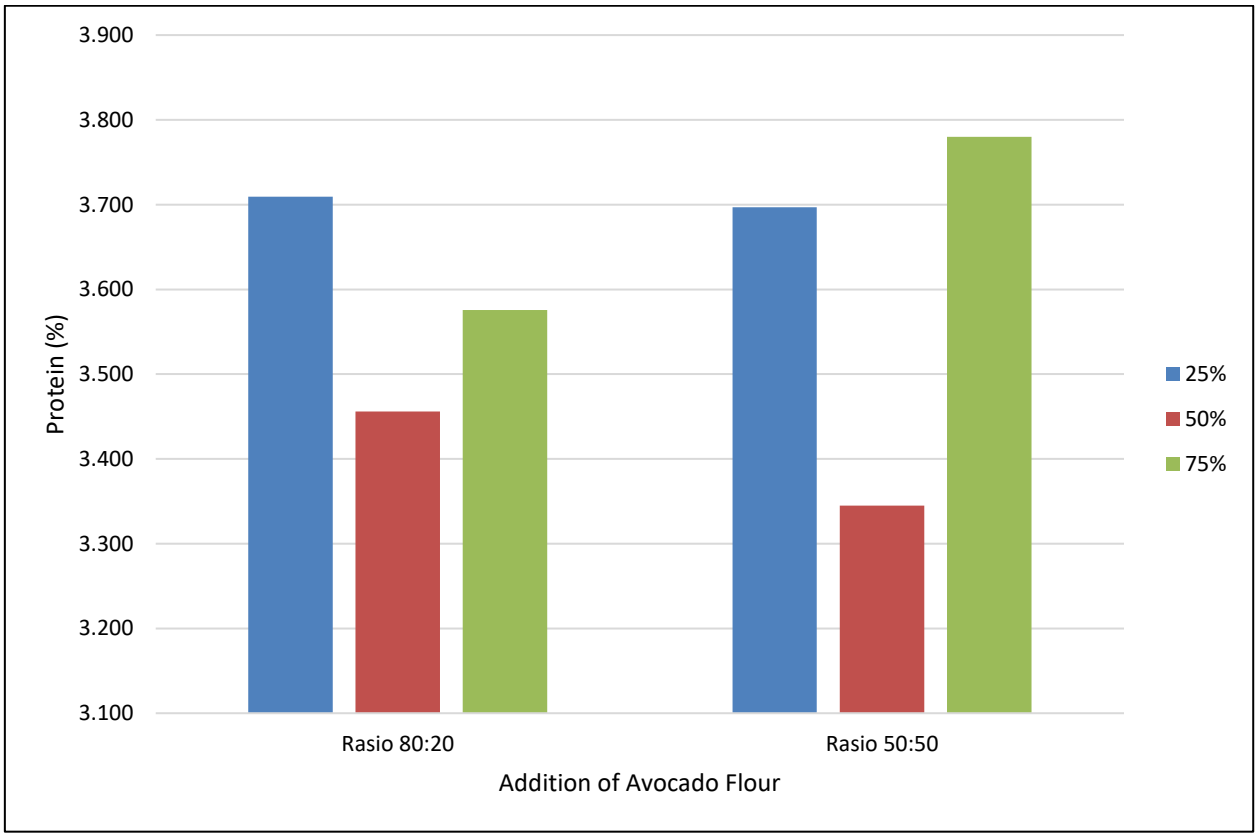

Figure 4. Protein content

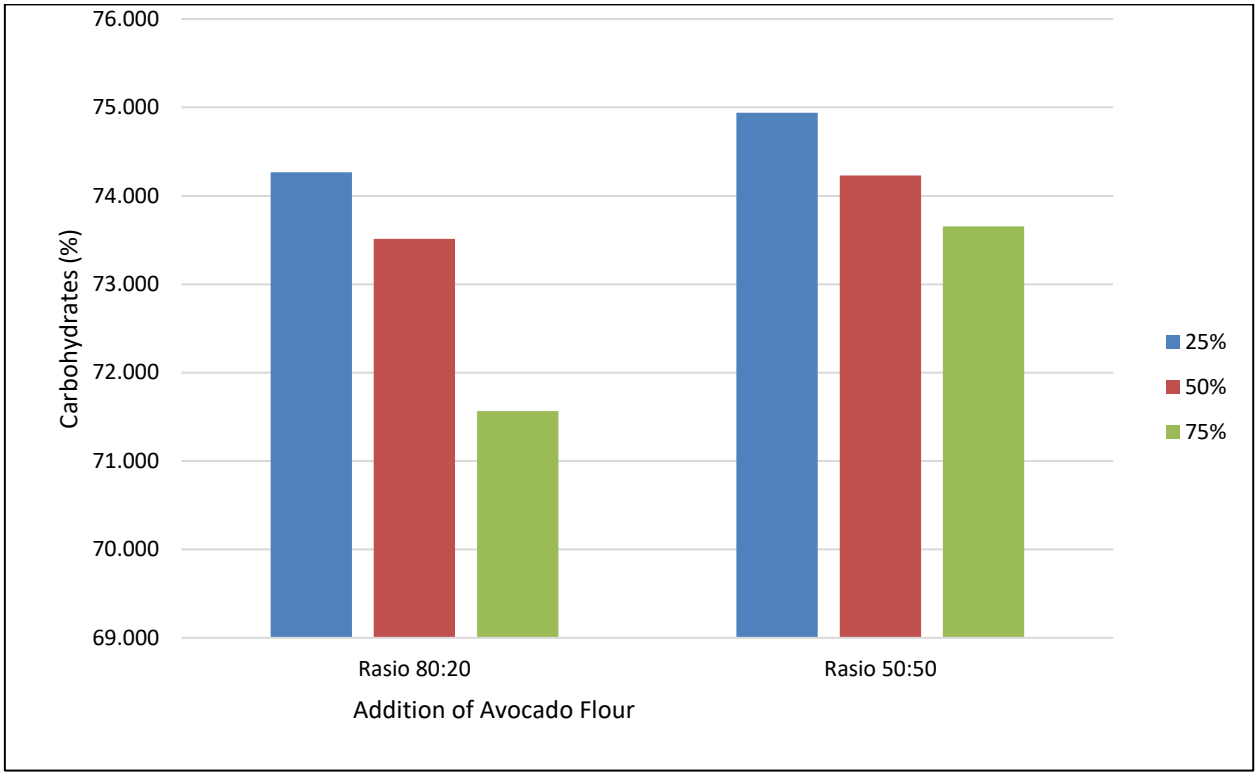

Figure 5. Carbohydrate content

Table 1. Research variables

No.	Sample Code	Water %	Protein %	Fat %	Ash %	Carbohydrate %
1	A1 U1	16.322	3.818	3.110	2.217	74.533
2	A1 U2	16.915	3.601	3.219	2.262	74.003
3	A2 U1	15.930	3.680	3.102	2.523	74.765
4	A2 U2	15.467	3.714	3.149	2.557	75.113
5	A3 U1	17.020	3.680	3.701	2.261	73.338
6	A3 U2	17.058	3.232	3.818	2.205	73.687
7	A4 U1	15.869	3.428	3.696	2.727	74.280
8	A4 U2	15.902	3.262	3.863	2.791	74.182
9	A5 U1	15.424	3.691	6.266	2.973	71.646
10	A5 U2	15.589	3.460	6.740	2.730	71.481
11	A6 U1	12.834	3.691	6.864	2.801	73.810
12	A6 U2	12.925	3.869	6.943	2.765	73.498

3.1.1.3. Fat content

In this research, the fat content was determined using the Soxhlet method. The analog rice sample extracted with n-hexane, a non-polar solvent insoluble in water, allowing the non-polar compounds to more readily dissolve. The drying method then employed using an oven, causing the remaining solvent to evaporate and leaving behind the fat residue in the flask. Fat is a macronutrient composed of carbon C, hydrogen (H), and oxygen (O) atoms, which are sparingly soluble in water. Fat also serves as an essential energy source for maintaining overall health. The fat content obtained for the 80:20 ratio averaged 6.503%, while that for the 50:50 ratio averaged 6.904%. The ANOVA analysis resulted in a *p*-value of 0.270 > 0.05, indicating no significant effect of adding Cilembu sweet potato flour on the fat content of analog rice made from mocaf flour and avocado. The lower fat content in analog rice contributes to reduced rancidity or undesirable flavors, thereby extending the rice shelf life. In this research, the fat content served to improve the texture of analog rice, making it softer and more palatable to consume [18]. It can provide a better taste and is closer to natural rice.

3.1.1.4. Protein content

Protein is a compound needed by the body to form new tissues and maintain existing ones. It is also a source of amino acids, consisting of several elements: C, H, O, and N. Another function of protein is to regulate the body's metabolic processes. The Kjeldahl method commonly used to

test protein levels in analog rice. This method involves three stages: destruction, distillation, and titration, with liquid separation based on boiling points. One factor affecting protein content is temperature; proteins denature at high temperatures. In this research, the highest protein content found in the 50:50 ratio, with an addition of 75%. The lowest protein content was in the 50:50 ratio with a 50% addition of avocado flour, measuring 3.780%. The analysis of variance (ANOVA) yielded a significance level (sig) of 0.760 < 0.05, indicating that there was no significant effect of adding cilembu sweet potato flour on the protein content in analog rice made from mocaf flour and avocado flour. The protein content functions to provide nutrition to analog rice, which is beneficial for growth, maintenance, and repair of body tissue. Table 1 shows that the protein content levels obtained remained within reasonable limits.

3.1.1.5. Analysis of carbohydrate content in analog rice

Carbohydrates are the primary source of nutrition found in rice, providing energy for the body. Carbohydrates consist of macromolecules containing elements such as C, H, and O. High starch content in a substance indicates a high carbohydrate content, as determined through various calculation methods [15]. The highest calculated carbohydrate content in analog rice was found in the 50:50 ratio with a 25% addition of Cilembu sweet potato flour, measuring 74.939%. The lowest carbohydrate content was in the 80:20 ratio with a 75% addition of Cilembu sweet potato flour, measuring 71.564%. The analysis of variance (ANOVA) yielded a significance level (sig) of 0.482 > 0.05, indicating that there was a significant effect of adding Cilembu sweet potato flour on the carbohydrate content of analog rice made from mocaf flour and avocado flour. Analog rice sample 4 das the highest carbohydrate content, as shown in Table 1. It influenced by the carbohydrate content of each raw material. Based on research, analog rice from tubers has low glycemic index levels [16], thus suitable for being taken as a daily staple food.

4. Conclusion

Analog rice can be produced through two processes: granulation and extrusion. The difference between these two processes lies in the gelatinization and shaping stages. In the granulation process, analog rice is obtained in granular form, while the extrusion method results in round, elongated grains resembling regular rice. For this research, Cilembu sweet potato and avocado were used as the main ingredients. The research employed a one-way ANOVA method, including tests for water content, ash content, protein content, fat content, and carbohydrate content. The ANOVA results indicated that the addition of Cilembu sweet potato flour did not have a significant effect. Specifically, the water content analysis yielded a sig value of 0.468 > 0.05, indicating no significant impact of Cilembu sweet potato flour on the water content of analog rice made from mocaf flour and avocado. Moisture content affects product shelf life and is influenced by factors such as drying, temperature, and the amount of water added during production. Regarding ash content, the 80:20 ratio had an average value of 2.282%, while the 50:50 ratio had an average of 2.783%. The ANOVA result was 0.555 > 0.05, indicating no significant effect of Cilembu sweet potato flour on ash content in analog rice made from mocaf flour and avocado.

As for fat content, the 80:20 ratio had an average of 6.503%, and the 50:50 ratio had an average of 6.904%. The ANOVA result was 0.270 > 0.05, suggesting no significant impact of Cilembu sweet potato flour on fat content in analog rice made from mocaf flour and avocado. Low fat content in analog rice contributes to longer storage life and reduced rancidity or undesirable flavors. The highest protein content found in the 50:50 ratio (3.780%) with a 75% addition of avocado flower, while the lowest protein content occurred in the 50:50 ratio with a 50% addition (3.780%). The ANOVA result was 0.760 < 0.05, indicating no significant effect of cilembu sweet potato flour on protein content in analog rice made from mocaf flour and avocado. Finally, the highest carbohydrate content in analog rice was in the 50:50 sample with a 25% addition of cilembu sweet potato flour (74.939%), while the lowest carbohydrate content was in the 80:20 ratio with a 75% addition of cilembu sweet potato flour (71.564%). The ANOVA result was 0.482 > 0.05, suggesting a significant impact of Cilembu sweet potato flour on carbohydrate content in analog rice made from mocaf flour and avocado.

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