Effect of Drying Temperature on the Proximate Content of Moringa Leaves (*Moringa oleifera*) Powder as Raw Material in Food Industry using Fluidized Bed Dryer

Andi Tenrimega Tjalo[1], *A.* Hasizah[1,2*], *Andi* Dirpan, and *Jumriah* Langkong[1,2]

[1]Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, 90245, Makassar, Indonesia
[2]Center of Excellence in Science and Technology on Food Product Diversification, Hasanuddin University, 90245, Makassar, Indonesia

Abstract. Moringa (Moringa oleifera) leaves can be used as a functional food as well as a source of nutrition for health. Moringa leaves are very rich in carbohydrates, protein, fiber, iron, magnesium, potassium, folate, phosphorus, selenium, zinc, copper, calcium, vitamin A, B vitamins, vitamin C, alkaloids, tannins, terpenoids, flavonoids, and saponins. Moringa leaves processing is very limited in Indonesia, therefore further processing is needed using the best temperature. Because the content contained in Moringa leaves is very easy to damage. This study aims to obtain the best temperature treatment in the drying process of Moringa leaves and determine the effectiveness of drying Moringa leaves with a fluidized bed dryer, and it with the drying method at room temperature (20oC to 25oC) on the degradation of the proximate content of Moringa leaves. The stages of this research the cleaning and separation process from the stems of Moringa leaves, followed by a drying process at temperatures of 35oC, 45oC, 55oC, 65oC, and room temperature (20oC to 25oC). Followed by making Moringa leaves to powder and the process of proximate analysis of Moringa leaves. Results. The results showed that the best treatment proximate analysis results was at a temperature of 45oC with a water content of 8.97%, and ash content of 10.31%. The protein content of 36.04%, fat content of 9.56%, and carbohydrates of 35.11%.

1 Introduction

Because of the numerous health advantages associated with its leaves, fruit, seeds, stems, and flowers, the moringa plant is also known as "The Miracle Tree." The moringa plant, (*Moringa oleifera*), is a naturally occurring food with the potential to be functional due to its various qualities and the minerals it contains. Moringa leaves are one of the food items that are used extensively nowadays. It has been demonstrated that moringa leaves naturally contain highly

* Corresponding author: andihasizah@gmail.com

beneficial elements. Because moringa has a higher protein content than other medical plants, it can also be utilized as a natural medicine [1].

In Indonesia, moringa leaves are still used very sparingly. Moringa leaves are typically only used by people as vegetables, ornamental plants, and animal feed. The community has not processed moringa leaves much beyond growing vegetables because the general populace is unaware of the benefits of using moringa leaves. The proximate analysis test is employed to ensure that the general public is aware of the primary ingredient in moringa leaves. A chemical analysis technique called "proximate analysis" can be used to identify the food material content of an item in a dish. Determining an ingredient's primary constituents quantitatively is the goal of proximate analysis. Water, ash, fat, protein, and carbs are the components of food ingredients that are categorized using approximate analysis based on their chemical makeup and function [2].

To address nutritional issues, substitute moringa leaves for other meal ingredients. Moringa is a well-known herbal medicinal plant with numerous health advantages. Its leaves, branches, flowers, fruits, and even roots are rich in nutrients. Moringa leaves are a rich source of minerals, carbohydrates, and protein. As such, they can be used to cure malnutrition. Fresh moringa leaves are mostly composed of 75% water, 6.7% protein, 1.7% fat, 13.4% carbs, and 92.2% calories. Moringa leaves are ground into a powder to make it easy for people to use as a functional meal [3].

Because moringa leaves are currently essential for maintaining good health, they are highly desirable to customers. Since moringa leaves are highly susceptible to deterioration once they are plucked from the tree, processing is necessary to increase their shelf life. The drying process of moringa leaves that will be ground into powder or moringa leaf powder is one substitute to increase the shelf life of moringa leaves [4].

Drying is the technique used to turn moringa leaves into powder. Moringa leaves can be dried conventionally (in the sun and at room temperature) or mechanically (with drying machine equipment). Moringa leaves are dried in order to increase their shelf life as a raw ingredient for the food industry. In order to maximize the effectiveness of the drying process, moringa leaves are dried using a fluidized bed dryer, which uses hot air for drying [5]. The nutritional value of moringa leaf powder can be increased by combining it with extracts in common foods like milk, juice, bread, pasta, seasonings, tea, instant soup, and other ingredients [6].

In this study, the drying process of moringa leaves was carried out using a fluidized bed dryer and room temperature drying. Drying using a fluidized bed dryer as an alternative way of drying is used to make moringa leaf powder [4]. Therefore, research was conducted to determine the drying temperature that can minimize damage to the proximate content of moringa leaves.

2 Research Methods

2.1 Tools and Materials

The tools used in this research are aluminum foil, sieve (80 mesh), fluidized bed dryer, grinder machine (Fomac), desiccator, erlenmeyer (Pyrex), ziplock plastic, measuring cup (Pyrex), tissue, crucible cup, kjedhal flask, soxhlet, porcelain cup, volume pipette, tweezers, filter paper (Whattman), test tube, furnace (Furnace), oven (Memmert), analytical balance and glass jar.

The materials used in this study are water, distilled water, Moringa leaves, Chloroform, Potassium sulfate (K_2SO_4), Mercury (II) oxide (HgO), Sulfuric acid (H_2SO_4), Sodium hydroxide (NaOH), Boric acid (H_3BO_3), Hydrochloric acid (HCl), Potassium permanganate ($KMnO_4$ 0.1 N).

2.2 Research Procedure

2.2.1 Drying of Moringa Leaf at Room Temperature

Moringa leaves dried at room temperature. In Makassar, plantation land was utilized to harvest moringa leaves for this study in the morning. The leaves were harvested by trimming the fifth to ninth leaf stems from the top of the moringa leaf tree. At Teaching Industry, drying was done at room temperature. It stays free of insects and rats as it dries. After being cleaned by running water, the moringa leaves were detached from the stem. Subsequently, the moringa leaves' weight was measured until they reached 300 grams. After that, the moringa leaves are uniformly spread out on a baking sheet that will be kept inside at room temperature and allowed to dry for a few days.

2.2.2 Drying of Moringa Leaf

After being cleaned by flowing water, moringa leaves were detached from the stalk. Then, up to 300 grams of moringa leaves were weighed. After that, place it in a fluidized bed drier set to four different treatment temperatures: 35°C, 45°C, 55°C, and 65°C. The water content is sampled every 30 minutes for each drying temperature treatment. Each drying temperature is tested three times to obtain the best proximate analysis results.

2.2.3 Making Powdered Moringa Leaf

After the moisture content of the dried leaves was determined, they were pulverized in a grinder, sieved through an 80 mesh screen, and then placed into glass jars with labels indicating the drying temperatures of 35°C, 45°C, 55°C, and 65°C.

2.3 Observation Parameters

2.3.1 Moisture Content

The porcelain cup was first cooked at 105 °C for 30 minutes. It was then placed in a desiccator for 15 minutes and its constant weight was measured. The sample was then weighed up to two grams and placed inside a porcelain cup. After that, the sample-containing porcelain cup was baked for five hours at 105 °C. After that, the sample-containing porcelain cup was taken out and allowed to cool in a desiccator for fifteen minutes. Repeat the weighing and the 30-minute oven cycle. After cooling, the sample was weighed once more until it attained a stable weight. Should the weight of the sample not remain consistent, it will be baked once again until the sample weight varies by 0.02. The formula for calculating water content:

$$\%Water\ Content=\frac{Initial\ Weight\text{-}Final\ Weight}{Final\ Weight}\ x\ 100\%$$

2.3.2 Ash Content

The porcelain mug is ready. Subsequently, the porcelain cup underwent a 30-minute oven calibration at 105 °C. Subsequently, it was placed in a desiccator for fifteen minutes. Afterwards, five grams of sample were added, and the cup was weighed. The cup was then heated to 600 °C in the furnace for three hours. It was then placed in a desiccator for half an hour. Then the cup is weighed and the ash content is calculated using the formula:

$$Ash\ content = \frac{ash\ weight}{weight\ of\ sample}\ x\ 100\%$$

2.3.3 Fat Content

The soxhlet technique was used in this investigation to test the fat content. After being dried for 30 minutes at 105 °C in the oven, the fat flask is chilled for 15 minutes in a Sunbeam B 100 desiccator before being weighed. The sample was placed inside the extraction equipment after weighing up to five grams and covered in filter paper. Next, the condenser has the extraction tool installed. The solvent made of diethyl ether was then added to the fat flask. Reflux was then continued for a minimum of five hours, or until the solvent that had returned to the fat flask was transparent. After moistening the solvent, the fat flask is baked at 105 °C or until its weight remains constant. After that, the pumpkin and its fat were put into a desiccator and weighed. The fat content is obtained by the formula:

$$\%\ Fat\ content = \frac{weight\ after\ soxhlet\ \text{-}\ weight\ after\ oven}{initial\ weight\ of\ the\ sample}\ x\ 100\%$$

2.3.4 Protein content

After weighing the sample to a maximum of 0.5 grams, 1 gram of the selenium mixture and 25 milliliters of concentrated H_2SO_4 were added to the flask. In a fume hood, destroyed until clear. After letting the substance cool, it is put into a 100 ml measuring flask and rinsed with aquadest. Let cool before adding equivalents up to the mark tera. Erlenmeyer 100 ml test tube containing 10 ml of H_3BO_3 2% is filled with 4 drops of indicator solution. 5 ml of 30% NaOH and 100 ml of equivalents were pipetted, and the mixture was distilled until the reservoir's volume was around 50 ml. the distiller's tip was washed with equivalents before fitting it and its contents.Titrated with a solution of HCl or H_2SO_4 0.02 N, then the protein content is calculated by the formula:

$$\%Protein\ content = \frac{V1\ x\ Normalitas\ x\ 6{,}25\ x\ P}{Weight\ of\ sample}\ x\ 100\%$$

2.3.5 Carbohydrate contant

Carbohydrate by Difference is the term for the rough computation method of analyzing carbohydrates. The term "proximate analysis" refers to a method of calculating the carbohydrate content, or crude fiber, as follows:

$$\%Carbohydrate = 100\% \text{-} (\%\ ash + \%\ water + \%\ fat + \%\ protein)$$

2.4 Research Design

The research focuses on the drying treatment at different temperatures on moringa leaves in stages with physical and chemical properties based on the temperature variations used, namely:
A0: Room Temperature (25 °C)
A1: 35 °C
A2: 45 °C
A3: 55 °C
A4: 65 °C

2.5 Data Analysis

A complete randomized design (CRD) with three repetitions will be utilized to assess the data obtained from the proximal analysis. Analysis of variance (ANOVA) was used to find differences between the examined variables. Software from SPSS and Microsoft Excel were used for data analysis.

3 Results and Discussion

3.1 Moisture Analysis

Based on the results of testing the water content using the fluidized bed dryer method, the water content test results were obtained:

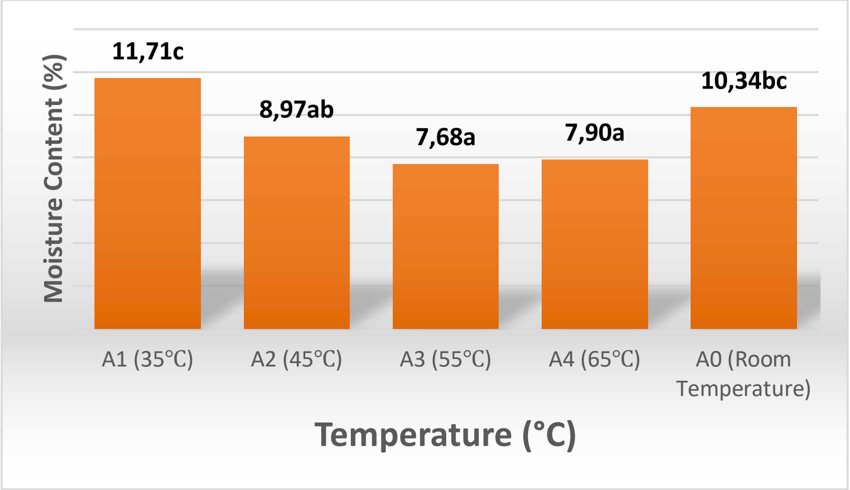

Fig. 1. Result of Moisture Content of Moringa Flour.

Based on Figure 1. The average moisture content results shown in moringa leaf powder products ranged from 7.68% to 11.71%. The A3 (55 °C) treatment produced the lowest moisture content, while the A1 (35 °C) treatment produced the highest moisture content.

The treatment has a substantial impact on the water content test, according to the findings of the analysis of variance (ANOVA) on powdered moringa leaf. Based on the anova table above, which shows that the resulting significant value is 0.001, which is less than the predefined α value of 5% or 0.05, the therapy is thought to have a significant effect. Thus, it can be argued that the treatment considerably impacts the amount of water content in the

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product at a 95% confidence level. Duncan's test was then used to complete the research and look for differences across all treatment pairs. Three distinct treatment groups have been identified based on the Duncan test results. The first group is A2 (45 °C), A3 (55 °C) and A4 (65 °C). The second group is A2 (45 °C) and A0 (Room temperature). The third group is D (Room temperature) and A1 (35 °C).
The study's findings indicated that low water content results were necessary for powder manufacturing, which may impact the processed powder's durability. The findings show that the water content is less than 10% because as the drying temperature rises, more and more water vapor escapes the material, causing the water content to drop [9]. The powdered moringa leaf has a long shelf life due to its low moisture content. Materials that may release water from their surface will release much more water when the drying temperature rises [7-8]. The nature, kind, or origin of the raw material used to make the powder, the type of packing, and the humidity of the air all significantly impact the amount of water in the powder. The water content of moringa leaves that do not deteriorate rapidly is less than 10%.

3.2 Ash Content

The following ash content test results were produced based on the fluidized bed dryer method results:

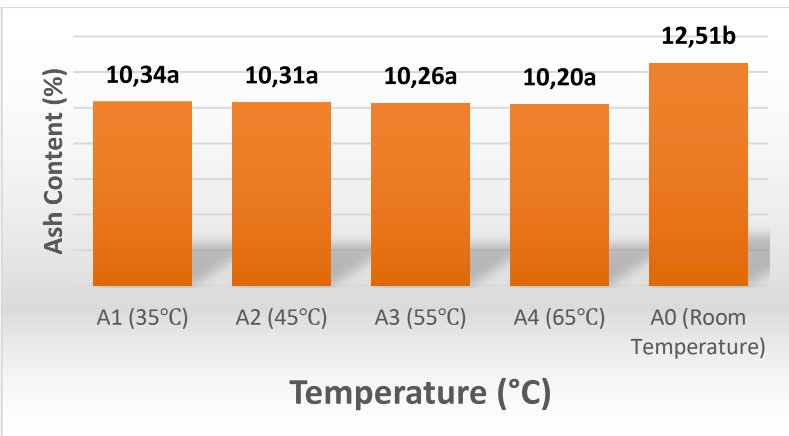

Fig. 2. Result of Ash Content of Moringa Flour.

The average ash content shown in moringa leaf powder products ranged from 10.20% to 12.51%. Treatment A4 (65 °C) produced the lowest ash content, while treatment A0 (Room Temperature) produced the highest ash content.

The analysis of variance (Anova) results for powdered moringa leaf indicated that there was a significant effect ($p<0.05$) for each treatment. Finding that the ash level of goods containing powdered moringa leaf was significantly impacted by the procedures identified. Duncan's test was then used to continue the research and see how each treatment pair differed from the other. Two distinct treatment groups were identified based on the Duncan test findings. A4 (65 °C), A2 (45 °C), A1 (35 °C), and A3 (55 °C) made up the initial group. The A0 group (room temperature) is the second group.

According to the results, the ash level of powdered moringa leaf ranged from 10.20% to 12.51%. Room temperature yielded the maximum ash content, much higher than drying in a fluidized bed drier. The results of the investigation demonstrated that the ash content of moringa leaves that were dried using a fluidized bed drier at a high temperature was substantially lower than that of leaves that were dried at room temperature (aerated). The outcomes are consistent with the research. [9], demonstrated the ash content of leaves dried at high temperature and leaves dried at room temperature (aerated) was unaffected by the drying temperature utilized in this investigation. The high result at room temperature can be attributed to the fact that, when drying moringa leaves, the container is left uncovered, making it easier for contamination to occur and alter the extracted powder's mineral concentration. As per [10], the high ash content is a result of the high mineral content of the growing environment. A decrease in water content can impact the increase in nutritional value, which includes minerals.

3.3 Protein Content

Because it functions as the body's fuel, protein is a crucial part of meals. Protein makes up the majority of bodily tissues and is thought to be the greatest component in the body after water. It accounts for roughly 50% of the dry weight of cells in tissues. Proteins help the body's immune system mechanically and act as storage, transporters, and catalysts for chemicals like oxygen. As a result, protein in meals serves as the primary component in both development and growth. The Kjedahl method is the test used to determine protein content. The following test results for protein content were obtained based on the fluidized bed dryer technique results:

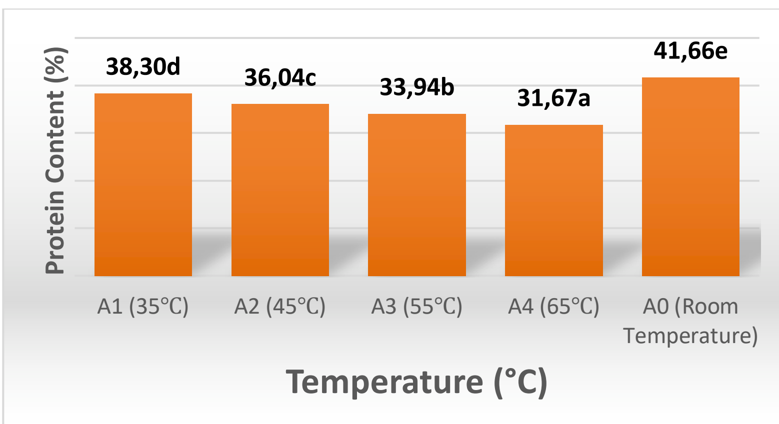

Fig. 3. Result of Protein Content of Moringa Flour.

Products made from powdered moringa leaf vary in average protein content from 31.67 to 41.66. Moringa leaf powder goods generated from treatment A0 (room temperature) have the highest protein content, whereas products created from treatment A4 (65 °C) have the lowest protein content.

The treatment had a significant influence ($p<0.05$) on the protein content of the moringa leaf powder products, according to the analysis of variance (Anova) results for moringa leaf powder. claimed that the treatment chosen has a major impact on the amount of protein found in goods made from powdered moringa leaf. Duncan's test was then used to continue the research and see whether there were differences between any treatment pairs. based on the Duncan test results, which were used to compare the variations across all treatment pairs. Based on the results of the Duncan test, there are five distinct treatment groups. A4 is the first group (65 °C). A3 is the second group (55 °C). A2 is the third group (45 °C). A1 is the fourth group (35 °C). A0 is the fifth group (Room temperature).

The protein content of the powdered moringa leaf ranged from 31.67% to 41.66%, with the room temperature treatment yielding the maximum protein content when compared to the fluidized bed dryer drying method. The drying process significantly impacts the protein content [10]. The results obtained are consistent with study [11], which indicates that as drying temperature goes from 40 °C to 50 °C, 60 °C, and 70 °C, hot air drying provides lesser protein content while shade drying produces the highest protein content. By raising the drying temperature, tumble drying can reduce the protein concentration. The amount of protein in the dried Moringa leaves was significantly influenced by temperature and drying time. Many proteins denature when heated to high drying temperatures. The amino acids included in moringa leaves may become harmed by high heating temperatures [12]. High concentrations of essential amino acids, especially sulfur amino acids akin to those in soybean seeds, are present in moringa leaves. Tannins, alkaloids, and saponins are the components found in moringa leaves [3]. This supports the claim made in [13] that the drying time and temperature significantly impact the protein content of moringa leaves.

3.4 Fat Content

Lipid compounds, such as fat, are difficult to dissolve in water. Fat has a part in keeping the human body healthy. meals fat serves two purposes for the body: it gives meals a wonderful flavor and texture, and it also serves as an energy source [14]. Fat is an essential substance for the body since it can be used as a repository of stored energy. The Soxhlet extraction method is used for assessing fat content. based on the findings of the fluidized bed dryer method fat content test, the results of testing fat content were obtained:

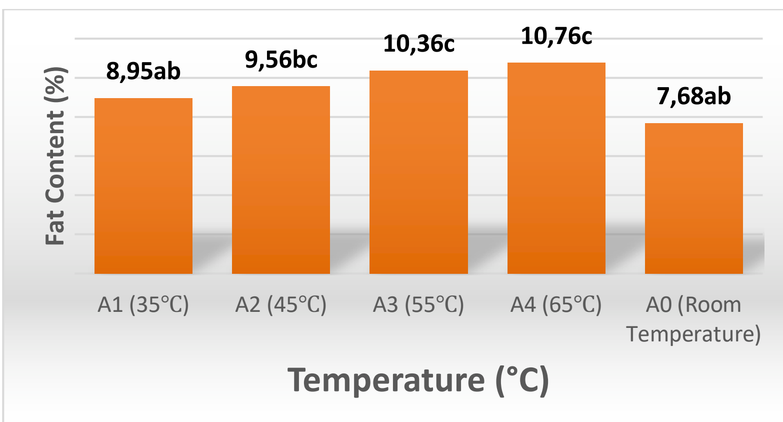

Fig. 4. Result of Fat Content of Moringa Flour.

Products made with powdered moringa leaf ranged in average fat content from 7.68% to 10.76%. Products made from moringa leaf powder treatment A0 (room temperature) have the least amount of fat, whereas products made from treatment A4 (65 °C) have the most fat.

The treatment had a significant impact ($p<0.05$) on the fat content of moringa leaf powder products, according to the analysis of variance (Anova) results for moringa leaf powder. claimed that the treatment chosen has a major impact on the amount of fat found in products made with powdered moringa leaf. The Duncan test was then used to assess the differences between each treatment pair as part of the ongoing research. Based on the Duncan test findings, three distinct treatment groups were identified. A0 (room temperature) and A1 (35 °C) make up the first category. A2 (45 °C) and A1 (35 °C) make up the second group. A2 (45 °C), A3 (55 °C), and A4 (65 °C) make up the third group.

The fat percentage in the powdered moringa leaf ranged from 7.68% to 10.76%, with room temperature yielding the lowest level when compared to drying temperatures with a fluidized bed dryer. Although there is little difference in fat content at drying temperatures, shade drying results in significantly less fat content. The findings of this investigation support the findings of [15], which found that samples dried at room temperature had the lowest fat content; however, this difference was not statistically significant when compared to those dried in an oven or the sun. Because of the oxidation process brought on by oxygen, drying moringa leaves at high temperatures takes less time, which results in an increase in fat content. Fatty acids found in moringa leaves help quicken the body's metabolism. This supports the claim made in [16] that eating moringa leaves can boost energy because they speed up the body's metabolism and improve blood circulation by burning calories.

3.5 Carbohydrate Content

Given that they constitute both animals' and humans' primary energy source, carbohydrates are significant to nature. Compounds made of carbon, hydrogen, and oxygen molecules make up carbohydrates. Carbohydrates are mostly used by the body to produce energy. Since one gram of generated carbs provides four kilocalories, carbohydrates are the primary source of energy. The test for carbohydrate content is based on the difference between the findings of 100% reduction in water, ash, fat, and protein content. Carbohydrates are crucial in defining the properties of food items, including taste, texture, and color. While carbohydrates in the body function to prevent the onset of ketosis, mineral loss and can help metabolize fat and protein. So the carbohydrate content depends on the reduction factor [17]. Based on the results of testing carbohydrate content using the fluidized bed dryer method, the results of testing carbohydrate content were obtained:

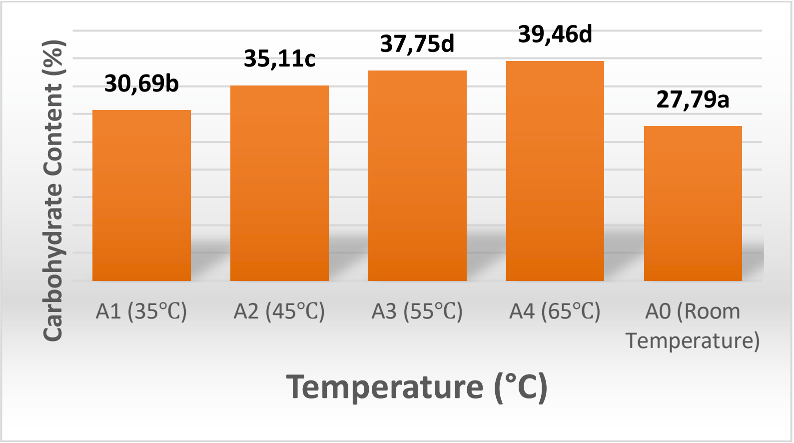

Fig. 5. Result of Carbohydrate Content of Moringa Flour.

Products made from powdered moringa leaf vary in average carbohydrate content from 27.79 to 39.46. The least amount of carbs are found in moringa leaf powder goods made from treatment A0 (room temperature), whereas the most carbohydrates are found in products made from treatment A4 (65 °C).

The analysis of variance (Anova) results for powdered moringa leaf indicated a significant effect of the treatment ($p<0.05$). The given treatment significantly impacted the amount of carbohydrates present in goods made from powdered moringa leaf. The Duncan test was then used to assess the differences between each treatment pair as part of the ongoing research. Based on the results of the Duncan test, four distinct treatment groups have been identified. The A0 group (room temperature) is the first one. A1 is the second group (35 °C). A2 is the third group (45 °C). The A3 (55 °C) and A4 (65 °C) groups make up the fourth.

According to the test results, the carbohydrate content of moringa leaf powder ranged from 27.79% of the ambient temperature sample to 39.46% of the 65 °C temperature sample. The findings demonstrated that, in comparison to the drying sample at a high temperature, the drying sample at room temperature had poorer results. The temperatures of 55 °C and 65 °C resulted in a significant carbohydrate content. The higher processing temperature and longer drying time were the causes of the increased carbohydrate content [18]. The results obtained are consistent with studies [18], which found that the results of high temperature drying show a considerable rise in carbohydrate content as the drying temperature increases, with the room temperature results showing a significantly lower carbohydrate content. The amazing qualities and high carbohydrate content of moringa leaf powder can help meet the body's energy requirements. The body requires a maximum of 50% of its daily calories to come from carbohydrates since they play a significant role [19]. This is consistent with the claim made in [8], according to which a rise in drying temperature is what causes a substantial increase in carbohydrate content. The amount of nutrients, such as carbohydrates, present will rise with increasing temperature and drying time. High levels of amylopectin are found in moringa leaves, which allows starch—the primary carbohydrate component—to hydrolyze at high temperatures. The rate at which starch hydrolyzes will accelerate with rising temperatures. It can break down into simpler substances like glucose, maltose, and dextrin at high temperatures.

4 Conclusion

The best temperature treatment on moringa leaf powder based on the results of the analysis of water content and protein content that has been in accordance with the 45 °C drying temperature treatment with the results of 8.97% water content, 10.31% ash content, 36.04% protein content, 9.56% fat content and 35.1% carbohydrates. The best results obtained have content with little degradation and the durability of moringa leaf powder products to be made as a more nutritious product with many benefits when consumed.

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