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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Research Article
Chemical Properties of High-Quality Cassava Flour (HQCF) from Several Varieties of Cassava

[1]Sofyan Samad, [2]Hamidin Rasulu, [3]Hasbullah and [3]Syamsuddin Hasan

[1]Agrotechnology Programme, Faculty of Agriculture, Khairun University, North Maluku, Indonesia
[2]Agriculture Technology Programme, Faculty of Agriculture, Khairun University, North Maluku, Indonesia
[3]Laboratory of Feed Plant and Pasture, Hasanuddin University, South Sulawesi, Indonesia

Abstract

Background and Objective: Cassava (*Manihot essculenta* Cranz) is a carbohydrate source similar to rice that is highly preferred, especially in areas where rice production is scarce such as Halmahera, North Maluku. The aim of this research was to determine the chemical characteristics of high-quality cassava flour (HQCF) from four local varieties, namely: jame-jame cassava, yellow cassava, digol cassava and butter cassava. **Methodology:** This research used experimental methods with a completely random design with four treatments (K_1 = Jame-jame cassava, K_2 = Yellow cassava, K_3 = Digol cassava and K_4 = Butter cassava) and 4 repetitions. The observation parameters were the chemical characteristics of the HQCF samples, including the moisture content, crude protein content, crude fat content, carbohydrate content and starch content. **Results:** The moisture content of HQCF from several local varieties in Halmahera, North Maluku ranged from 10.6-11.6%. The hydrogen cyanide (HCN) content ranged between 24.4-48.5 ppm. The protein content ranged from 1.3-2.0%. The crude fat content was between 0.3-0.5%. The carbohydrate content ranged from 83.2-85.5%. The starch content after treatment had an average value that ranged between 72.5-76.2%. **Conclusion:** This research indicates that differences in cassava varieties affect the chemical characteristics of the HQCF produced. Thus, before making HQCF, the cassava variety that will be used should be considered because of the inconsistency between varieties, which may cause differences in the characteristics of processed products.

Key words: Cassava flour, starch, cyanogenic glycosides, jame-jame cassava, yellow cassava, digol cassava, butter cassava

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Corresponding Author: Sofyan Samad, Agrotechnology Programme, Faculty of Agriculture, Khairun University, North Maluku-Indonesia

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a major root crop and an important staple food for over 500 million people in the developing world[1]. It is one of the local foods preferred in Indonesian society. Specific areas of Indonesia rarely develop rice commercially because of the unpredictable climate and weather, such as in Maluku, Ternate and Papua. In these areas where rice is not a staple food, local food sources eventually develop such as tubers like cassava. North Maluku has reached 2.118 hectares of cassava harvest area with 30.674 tonnes of total production[2].

Cassava (*Manihot essculenta Cranz*) is a source of carbohydrates. Minerals that are very important for the body are also found in cassava, including zinc, magnesium, copper and iron. The amount of potassium in cassava is high enough to satisfy the nutritional needs of humans. Cassava is cultivated mainly for consumption and contains 85% starch and 1-2% protein by weight[3].

Cassava has great potential as a local food that can be developed and processed into various food products that have economic and commercial value. One example that has been developed is the processing of cassava into high-quality cassava flour (HQCF). The production process of HQCF was initially developed at the International Institute for Tropical Agriculture (IITA) in Nigeria as an alternative to imported wheat flour for the food and non-food industry and the technology is now used in other cassava-growing nations[4]. HQCF is defined as an unfermented, white, smooth and odourless cassava flour. In addition to its ability to stay fresh for long periods of time, cassava flour also has high economic value.

The process of making cassava flour can be accomplished in several ways, such as the stripping process, followed by immersion, pressing and then drying to become cassava flour. According to Amin[5], the process of making cassava flour traditionally begins with stripping and washing before milling, drying and sieving. The processing of cassava in the traditional way to make flour is more practical and cost-effective for cassava flour production. The fermentation process followed by the drying process can assist in the reduction or elimination of toxic compounds[6]. Although cassava can be used as food, some varieties of cassava can also cause poisoning because cassava contains potentially toxic compounds, namely, linamarin and lotaustralin, both belonging to the family of cyanogenic glycosides. Cyanogenic glycosides are secondary metabolites in plants in the form of amino acid derivatives. In cassava, the main cyanogenic glycosides is linamarin, while a small amount of lotaustralin (linamarinmethyl) is only found in a small number of cassava varieties[7,8]. Therefore, this study aimed to determine the physical characteristics of HQCF in several high-yield local varieties in Halmahera, North Maluku.

MATERIALS AND METHODS

The cassava varieties that were used in this research were local cassava varieties in North Maluku including jame-jame cassava, yellow cassava, digol cassava and butter cassava.

The stages of making HQCF: The preliminary study began with the selection of cassava that were good and did not have any flaws. The cassava was peeled and washed with clean water to remove dirt. Furthermore, the cassava was soaked in clean water for 15 min, which was intended to reduce the mucus on the surface of cassava. Soaked cassava was then sliced to a thickness of 2-3 mm. Cassava slices were dried using an oven (Memmert, Universal Oven UNB 400) at 70°C. Cassava slices that had dried were then blended into flour. The flour was sifted using an 80-mesh sifter. The resulting flour was then used for analysis of HCN content, moisture content, protein, fat, carbohydrate and starches.

Determination of chemical composition: The moisture content, crude protein, crude fat content, carbohydrate and starch content of the samples were determined using the AOAC[8] method.

Statistical data analysis: This research used an experimental design with four treatments and four replicates. The moisture content, crude protein, crude fat, carbohydrate, HCN and starch content were subjected to a general linear model (GLM) based on the following statistical model:

$$Y_i = \mu+\alpha_i+\epsilon_{ij}$$

Where

- Y_i = The general response of a factor under investigation (moisture, crude protein, crude fat, carbohydrate, HCN or starch)
- μ = The general mean specific to each observation
- α_i = The cassava variety's effect on the observed parameter (i_1 =Jame-jame cassava, i_2= Yellow Cassava, i_3 = Digol Cassava, i_4 = Butter Cassava)
- ϵ_{ij} = The random error term

Significant differences between treatments were further tested using Duncan's multiple range test (DMRT) with the statistical software package SPSS version 21 from the IBM corporation[9]. Differences of $p<0.05$ were considered statistically significant.

RESULTS AND DISCUSSION

Analysis of moisture content: Moisture content is the amount of water contained in the material and is expressed in percent. Moisture content is also a very important characteristic of food because water can affect the appearance and texture, as well as determine the freshness and the lasting power of foodstuffs. The lower the initial moisture content of a product to be stored is, the better the storage stability of the product and the higher the efficiency of the drying method will be because a considerable amount of moisture contained in the fresh sample or product has been removed[10]. High moisture content causes easy bacteria, mould or yeast proliferation, which causes changes in food. Insect infestation is also favoured by higher moisture in flour[11]. The decrease in moisture content of cassava flour is necessary, considering that the moisture content can affect the process of flour storage[5]. The average moisture contents of HQCF from several local varieties in Halmahera, North Maluku are presented in Fig. 1.

Moisture content of the HQCF from several local varieties in Halmahera, North Maluku ranged between 10.6-11.6%. The lowest moisture content was observed in the jame-jame HQCF (10.6%), then followed by yellow HQCF (10.8%). The highest moisture content was in digol HQCF (11.6%). The moisture content of HQCF from all varieties observed was in accordance with the moisture content that is required for cassava flour by the National Standard of Indonesia 01-2997-1996[12]. Based on NSI 01-2997-1996[12] regarding cassava flour, the moisture content of cassava flour has a maximum of 12%. All samples in this research had a moisture content lower than that of Ukpabi and Ndimele[13] (13-16%). They also reported that cassava with a moisture content of <16% but > 13% could be stored for 2-7 months without mould growth. The result of the current study showed that the differences in cassava varieties significantly affected the moisture content of HQCF ($p<0.05$) due to the different abilities of the cassava matrices from several types of varieties to bind water. This was supported by Sriroth *et al*[14], who reported that different varieties, growth environments (soil, climate), age of harvest and post-harvest handling can affect the quality of cassava. Real difference test results showed that the moisture content of jame-jame HQCF, yellow HQCF and butter HQCF had no significant differences ($p>0.05$). However, the moisture content of digol HQCF was significantly higher than those of the yellow HQCF, jame-jame HQCF and butter HQCF ($p>0.05$).

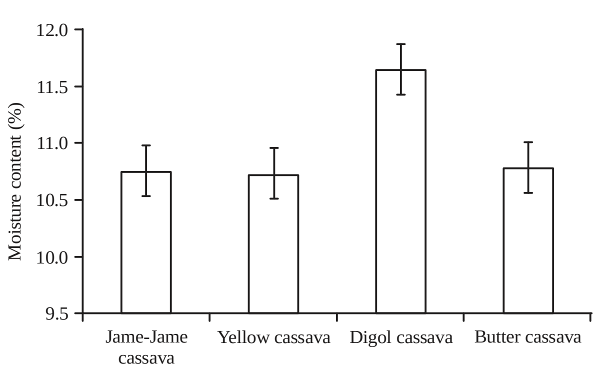

Fig. 1: Graph of the moisture content of HQCF from several local varieties

Analysis of HCN content: Cassava, grown primarily in the tropics, contains potentially toxic compounds called cyanogenic glycosides, linamarin and taxiphillin that break down upon disruption of the plant cells to form hydrogen cyanide. The toxicity of cyanogenic glycosides can be reduced by appropriate preparation of the plant material prior to consumption as food. For cassava, peeling and slicing disrupts the cell structure of the plant, with subsequent liberation of hydrogen cyanide. Hydrogen cyanide can be removed by further processing such as cooking (baking, boiling, or roasting) or fermentation[15].

The processing of cassava into HQCF in this research included several stages such as peeling, washing, cutting and drying and going through these several stages of processing can reduce the HCN content before it is consumed. The average value of HCN of HQCF from several local varieties of cassava in Halmahera, North Maluku is presented in Fig. 2.

The results of the present study showed that the cassava variety was a highly significant factor ($p<0.05$) in the HCN content of HQCF. Real difference test results showed that there was a significant difference in HCN content between each treatment ($p<0.05$).

Figure 2 shows that the HCN content of HQCF from several local varieties in Halmahera was between 24.4-48.5 ppm. The lowest HCN content was 24.4 ppm found in jame-jame HQCF, followed by yellow HQCF (28.7 ppm) and digol HQCF (39.5 ppm). These three types of HQCF are suitable for consumption in terms of the content of HCN. The NSI of SNI 01-2997-1996[12] about cassava flour requires that the maximum limit of HCN content contained in cassava flour be 40 ppm. The highest HCN content of butter HQCF (48.5 ppm) was found in this research. This means that butter HQCF processed in this research still needs additional processing to reduce the HCN content that it has. One of the methods used to reduce HCN content in cassava flour is the fermentation method. This is in accordance with the report from FSAZN[15] which stated that the fermentation process can reduce HCN content in cassava flour.

Analysis of protein content: Low contents of minor components (ash, fat, protein) in cassava flour are preferred because their presence can interfere with their pasting characteristics[16].

Proteins are macro-molecules consisting of long chains of amino acids, which are bound each other in peptide bond; they are a part of all living cells and are the largest part of the human body after water[17]. The average level of crude protein of HQCF from several local varieties is presented in Fig. 3.

The analysis results of HQCF protein from several local varieties ranged from approximately 1.3-2.0%. The highest protein content obtained was from butter HQCF (2.0%), followed by jame-jame HQCF (1.3%) and yellow HQCF and the lowest protein content was found in digol HQCF. The protein content of butter HQCF was higher than that reported by Balagopalan *et al.*[18], who stated that the protein content of HQCF was 1.60%. Our results were also supported by Charles *et al.*[19], who found that cassava contains approximately 1-2% protein, which makes it a predominantly starchy food. The results showed that the differences between the varieties of cassava were highly significant (p<0.01) with respect to the protein content of the HQCF. Real difference test results showed that the protein content of jame-jame HQCF, yellow HQCF and digol HQCF were not significantly different from each other (p>0.05). However, the protein content of butter HQCF was significantly higher than those of the protein content of *jame-jame* HQCF, yellow and digol HQCF.

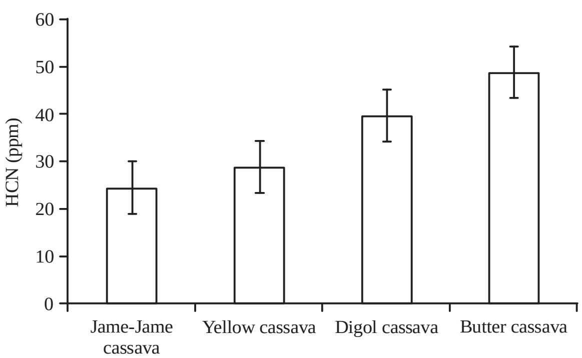

Fig. 2: Graph of the HCN content of organic based HQCF from several local varieties

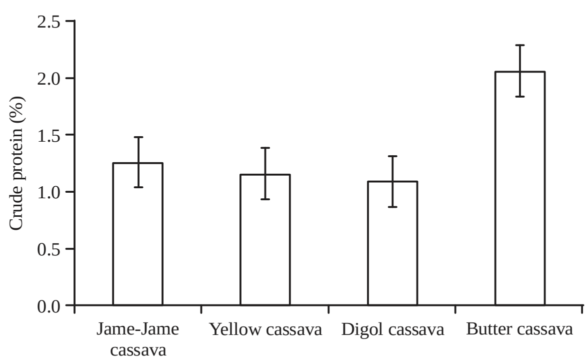

Fig. 3: Graph of the protein content of organic based HQCF from several local varieties

Analysis of fat content: Fat and oil are essential nutrients for maintaining the health of the human body. Fat and oil are found in nearly all foods in different amounts. The average of crude fat content of HQCF from several local varieties in Halmahera, North Maluku is presented in Fig. 4.

The crude fat content of HQCF from several local varieties in Halmahera, North Maluku was between 0.3-0.5%. This result is in accordance with the argument of Hartadi *et al.*[20], who stated that the fat content in cassava was between 0.1 to 0.3%; thus, cassava is a non-fat food. The fat content found in this research was lower than that found in the study of Emmanuel *et al.*[21] (0.74-1.49%). The highest crude fat content of HQCF was 0.5%, contained in butter HQCF, followed by jame-jame HQCF (0.4%). The lowest crude fat content was obtained from yellow HQCF and digol HQCF (0.3%). The result showed that cassava varieties had no effect on crude fat content of HQCF (p>0.05).

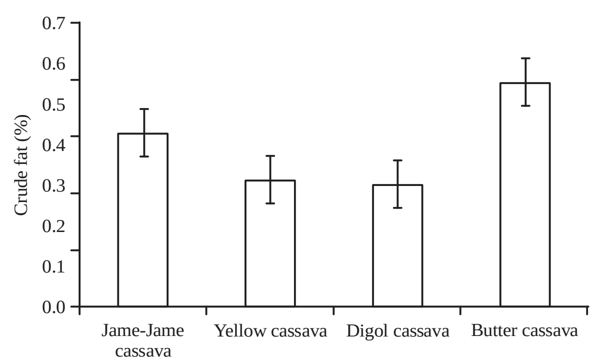

Fig. 4: Graph of the crude fat content of HQCF from several local varieties in Halmahera, North Maluku

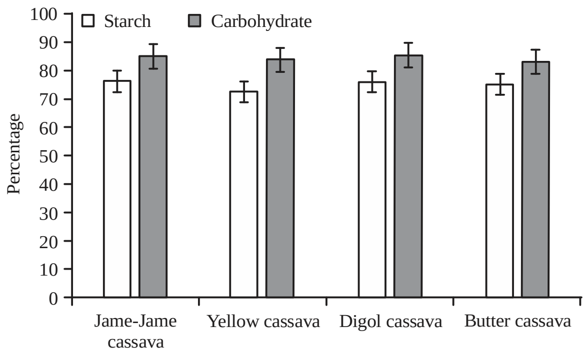

Fig. 5: The carbohydrate and starch content of HQCF from several local varieties in Halmahera, North Maluku

Analysis of carbohydrate and starch content: Carbohydrates are the main source of cheap calories. In addition, some classes of carbohydrates produce dietary fibre, which is useful for digestion. Carbohydrates also have an important role in determining the characteristics of foodstuffs, such as colours, flavours and texture. Raw cassava root has more carbohydrate than potatoes and fewer carbohydrates than wheat, rice, yellow corn and sorghum per 100 g[22]. The average of carbohydrates in HQCF from several local varieties in Halmahera, North Maluku is presented in Fig. 5.

The carbohydrate content of HQCF from several local varieties in Halmahera, North Maluku was between 83.2-85.5%, similar to the Emmanuel *et al.*[21] study (83.42-87.35). The average value of the highest carbohydrate content was obtained in digol HQCF (85.5%), followed by jame-jame HQCF (85.2%) and yellow HQCF (84.2%). The lowest carbohydrate content was obtained from butter HQCF (83.2%).

The result of the present study showed that different varieties of cassava had a significant influence on the carbohydrate content of HQCF ($p<0.05$). The real difference test results showed that the differences between the carbohydrate contents of butter HQCF and yellow HQCF, yellow HQCF and jame-jame HQCF and jame-jame HQCF and digol HQCF were not significant ($p<0.05$). There was a significant difference in the carbohydrate contents of butter HQCF and jame-jame HQCF ($p<0.05$), the butter HQCF was lower than those of jame-jame HQCF, digol HQCF and yellow HQCF in carbohydrate content.

According to Balagopalan *et al.*[18], starch content is the most important quality criteria of flour, either as food or non-food. Carbohydrates, especially starches, are the main source of calories for almost the entire population of the world, especially in developing countries. Carbohydrates, especially starches, have an important role in determining the characteristics of foodstuffs, such as flavour, colour and texture. Cereals and tubers are the main source of carbohydrates for humans that are present in foodstuff are. The starch content in cassava was 34.6%[23].

The average value of starch in cassava from several local varieties in Halmahera, North Maluku are presented in Fig. 5. Based on Fig. 5, the average value of starch content of HQCF from several local varieties in Halmahera, North Maluku was between 72.5-76.2%. The highest starch contents were obtained from jame-jame HQCF and digol (76.2%), followed by butter HQCF (75.2%). The lowest starch content was obtained from yellow HQCF (72.5%). The starch contents of jame-jame, digol and butter HQCF met the National Standard of Indonesia[12] regarding cassava flour, as the starch contents of these HQCFs were at least 75%. The low levels of starch content in yellow HQCF could have been caused by improper harvesting time. This result agrees with the findings of Balagopalan *et al.*[18], who reported that one cause of the high starch content in HQCF is the harvesting time of cassava. The longer the harvesting time of cassava is, the higher the starch content of the produced cassava. When harvesting for up to 10 months, there is still a rise in the level of starch.

The results showed that four varieties of cassava used in this study (jame-jame, yellow, digol and butter) had a significant difference in level of starch content of HQCF produced. Real difference test results showed that there was no significant difference between butter HQCF and digol HQCF, butter HQCF and jame-jame HQCF or butter HQCF and digol HQCF ($p>0.05$). The starch content of yellow cassava was significantly lower than those of jame-jame, digol and butter HQCF ($p<0.05$). The differences between the starch content could have been caused by the different cassava. This is supported by Santisopasri *et al.*[24], who reported that besides harvesting age, there are still some factors that can affect the levels of starch, such as cassava varieties and growing condition.

Different varieties of raw materials that are used in HQCF show different properties. Thus, production of HQCF on an industrial scale should consider the use of the same source of raw materials. This research was limited only to the functional chemical nature of cassava flour, so further research is required to look at the physical-chemical properties of starches. The application of cassava flour in dough-making is highly dependent on the physical-chemical properties of starch.

CONCLUSION

Based on the research results, it can be concluded that the different varieties of cassava influence the chemical characteristics of the HQCF produced. Thus, before making HQCF, the cassava variety that will be used should be considered carefully because the inconsistency of varieties may cause differences in the characteristics of the processed products.

SIGNIFICANCE STATEMENT

This research discovered the chemical properties of high-quality cassava flour from several varieties of cassava that can be beneficial for the production of processed food based on cassava. This study will help researchers uncover critical research areas of cassava flour that many researchers have not been able to explore. This research can add knowledge about the chemical nature of cassava processed from several varieties that may not be found in other areas.

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