Physico-chemical exploration of Yam Flour (Dioscorea alata L.) as a raw material for processed cookies

A Yalindua\textsuperscript{1,*}, N Manampiring\textsuperscript{1}, F Waworuntu\textsuperscript{2} and F Y Yalindua\textsuperscript{3}

\textsuperscript{1}Department of Biology, State University of Manado in Tonsaru Tondano, Indonesia
\textsuperscript{2}Department of Chemistry, State University of Manado, Indonesia
\textsuperscript{3}Researchers from LIPI Bitung, North Sulawesi, Indonesia

*aseryalindua60@gmail.com

Abstract. Yam (Dioscorea alata L.) is a vine and twisted stems plant, which are easily wrapped around poles. Yam is a perennial tuber plant grown as an annual plant. Yam contains carbohydrates with low levels of sugar, amylase, minerals, fat, protein and fiber. This research objective was to explore the physico-chemical of white yam and purple yam as raw material for processed cakes. Fourteen accessions of yam, consisting of 7 accessions of white yam and 7 accessions of purple yam are obtained from a previous personal collection from community gardens in 2009 located in Banggai Islands Regency, Central Sulawesi Province. The determination of carbohydrate content was carried out by hydrolysis method, amylase content by iodometry, moisture content was measured by oven drying method, ash content was obtained by using dry ashes method, fat content measured using Soxhlet method and crude fiber content using Gravimetric method. The results show that purple yam physico-chemical exploration was higher on average than white yam, except for the protein in white yam (6.96\%) slightly higher than purple yam (6.57\%). Purple yam contains the highest water content (10.6\%) while white yam has the lowest (7.42\%). The carbohydrate content of purple yam was 79.4\% which was higher than white yam (73.41\%). Furthermore, the level amylase content of purple yam was on average (9.05\%) higher than white yam (6.93\%). The total sugar content of purple yam was 0.75\% higher than white yam (0.57\%). The ash content was relatively the same between purple yam and white yam (2.35\% and 2.25\%, respectively). The fat content of purple yam is slightly higher than white yam (0.28\% and 0.19\%, respectively). In terms of protein content, purple yam was lower than white yam (6.57\% and 6.96\%, respectively). The crude fiber content of purple yam is 1.83\% which is higher than white yam (1.11\%).

1. Introduction

Yam (Dioscorea alata L.) is a vine and its stems are easily wrapped around poles. The yam plant is a perennial tuber plant grown as an annual plant. Yam is one of the most economically important species of Dioscorea, which serves as a staple food for millions of people in tropical and subtropical countries [1]. D. alata is very popular and in agro-ecology in Banggai Islands, Central Sulawesi, and in its home area it is better known as “baku” and in Indonesia it is better known as Uwi. Yam is consumed by boiling, grilling, frying or pounding and eaten with a protein-rich sauce. Yam can also be processed into flour. In general, yam contains less sugar and has a long enough shelf life so that it can become a stock in times of famine.
Yam is very potential as a source of calories and food ingredients because yam contains approximately 25% starch, 0.1 - 0.3% fat and 1.3 - 2.8% protein. The production potential can reach 60-70 tons / ha. The tubers contain approximately 25% dry matter [2]. According to Lebot et al. [3] contains 73.1% carbohydrates with low sugar content of 1.85%, 17.2% starch, minerals 3.3%, 0.3% fat, and 11.95% protein. Apart from being a food ingredient, uwi can be useful in preventing the possibility of breast cancer and cardiovascular disease in postmenopausal women. Yam contains dioscorin in which there is a protein binding enzyme hydrolysates which is useful for controlling hypertension [4]. The advantage of using yam as a source of carbohydrates is its long dormancy period of up to 4 months, so that the quality of starch is guaranteed for a long time.

Yam yield potential is 20-25 tonnes / ha and the number of tubers 1-3 per tree weighing 5-10 kg per tuber [5]. The average tuber yield varies between yam producing areas, and is influenced by species, tubers pieces, and growing environment. Yams production potential depends on location, variety, and cultivation practices [6].

Starch is the main energy source and is a carbohydrate in the form of deposits for plants in the form of granules found in tubers and their roots. Nutritional and biochemical composition of 16 varieties (Dioscorea spp) originating from Ghana, dry matter content ranged from 22.3 to 33.8% of the wet weight with moisture content between 66.2 and 77.7%. Crude protein range from 4.3-8.7%, ash 2.9-4.1%, sugar 3.6-11.0%, starch 60.3-74.4% and total fiber 4.1-11, 0% of dry weight. The mineral range in mg per kg (dry weight) is P 878-1900, Ca 260-410, Mg 390-580, K 10.55-20.10, Na 4.8-22.1, Cu 12.3-15.7 and Zn 10.1-14.1 [7].

The conversion of fresh yam tubers into ready-to-use flour, especially for the production of processed food, besides encouraging the emergence of more diverse products, it can also encourage the development of an industry made from flour or yam starch so as to increase the selling value of the uwi commodity. It is also hoped that the yam starch will avoid losses due to the non-absorption of fresh yam tubers in the market when the harvest is overproduced. The composition of starch in general consists of amylpectin as the largest part and the remaining amylose. The information regarding the composition of yam flour is expected to be supporting data in determining the type of product to be made from starch or yam flour. The research objective was to explore the psycho-chemistry of white yam and purple yam as raw material for processed cakes.

1.1. Determination of levels of carbohydrates, amylose and reducing sugars
The determination of the carbohydrate content was carried out by hydrolyzing yam flour with 80% alcohol in a water bath. Then the precipitate was separated and hydrolyzed again with 9.2 N HClO4 3 times and neutralized with 1N NaOH. Subsequently reduced with Cu and Nelson reagents. Carbohydrate content was measured by a spectrophotometer at a wavelength of 500 nm. Determination of amylose levels is carried out iodometry based on the reaction between amylose and iodine compounds which produce a blue color. Yam flour 100 mg was put into a test tube, then added 1 ml 95% ethanol and 9 ml 1N NaOH. The mixture is heated in boiling water to form a gel. Then all the gel was transferred into a 100 ml volumetric flask. The gel was added to water and shaken, then 100 ml of water was added. A total of 5 ml of solution was put into a 100 ml volumetric flask and added 1 ml of 1N acetic acid and 2 ml of iodine solution. The solution is adjusted to 100 ml, then shaken and left for 20 minutes. The intensity of the blue color was measured by a spectrophotometer at a wavelength of 625 nm. Amylose content is calculated based on the standard amylose curve equation.

1.2. Moisture content was measured using AOAC (Oven Drying Method), 1990
The yam sample which had been sliced thinly was weighed as much as 5 g and then dried in an oven at 105 ° C for 3 hours. The sample has been oven cooled in an excicator and then weighed. This drying is repeated until the sample reaches a constant weight.

\[
\text{% Water content} = \frac{(\text{initial weight} - \text{final weight})}{(\text{initial weight})} \times 100\%
\]
Ash content was measured using Dry Ashes Method [8]. The mashed uwi sample was weighed as much as 5 g, put in porcelain and placed on a bunsen, then heated until no smoke came out. Porcelain and yam materials that have become ash are put into the furnace for 3 hours at 600 ° C until the ash turns white, then weighed.

1.3. Protein levels were measured using the Kjeldhal method, Sudarmadji et al [8]
Each sample of mashed yam was weighed 5 g and put it in the Kjeldahl flask separately. Then 10 g of selen mixture and 30 ml of concentrated H2SO4 were added. Then digested in an acid chamber until the solution becomes clear green. After cooling, each solution was diluted with 250 ml distilled water and transferred to a 500 ml boiling flask and a few boiling stones were added. The solution was added with 120 ml of 30% NaOH and then connected to a distillation distiller. Distill the solution to 200 ml of the distilled liquid. The distillate or distillate product is collected with 0.25 N H2SO4 solution. Titrate excess H2SO4 with 0.5 N NaOH (a ml) using the Mengsel indicator as a pointer. Balnko decoyed above (ml).

\[
\text{Protein} = x = \frac{((b-a) \times N \times 0.014 \times 5.95)}{\text{(Sample weight)}} \times 100\%
\]

Information :
\(a = \text{ml titar example}\)
\(b = \text{ml titar blank.}\)
N = normality of NaOH

1.4. Fat content was measured using the Soxhlet method, Sudarmadji et al [8]
The yam sample has been mashed, each weighed as much as 5 g, then put in a tube made of filter paper. Then put it in the Soxhlet tool and extract it with petroleum ether solvent for 6 hours. As a container is a fat flask whose weight is known. Then the filter paper cartridge is taken, the petroleum ether solvent is distilled until it runs out, and the fat in the flask is heated in a drying oven at a temperature of 103-105°C for about 1 hour. Cool in an excavator and weigh until constant weight.

\[
\% \text{Fat} \times = \frac{\text{(Weight of final container} - \text{Weight of initial container})}{\text{(Weight of initial sample})} \times 100\%
\]
- Levels of carbohydrates (by difference)
\% Carbohydrates = 100% - A.
A = Protein + Fat + Water Content + Ash Content

1.5. The analysis procedure for determining crude fiber uses the Gravimetric Method
Samples that have been weighed weighing 2 grams, transferred into a 500 ml erlemeyer. Added was 200 ml of 1.25% (0.255N) H2SO4 solution was. Then connected with an upright cooler in the mouth of Erlenmeyer, and heated to boiling for 30 minutes. The suspension is filtered through filter paper and the residue left in the erlemeyer is washed with boiled aquadest. The residue on the filter paper is washed until the washing water is no longer acidic. (Tested with Litmus Paper). The residue was transferred from the filter paper to the erlemeyer again with a spatula and the rest was washed with 200 ml of 1.25% NaOH solution until all the residue entered the erlemeyer, then connected to an upright cooler at the mouth of the erlemeyer and boiled for 30 minutes. The residue is filtered through filter paper with known weight (a) The residue is again washed with 10% K2SO4 then rinsed with sterile aquadest, and then washed with 15 ml of 95% alcohol. The filter paper and its contents are dried at 110°C to constant weight (1 to 2 hours), then lighten and then weighed (y).

The formula for determining crude fiber is as follows:

\[
\text{Crude fiber content} \times = \frac{(y-a)}{(x)} \times 100\%
\]
2. Results and discussion

2.1. Results

Physico-chemical exploration of yam flour was carried out on 14 yam accessions from North Sulawesi introduced from Banggai Island. Each of the seven white yam accessions (Table 1) and seven purple yam accessions (Table 2).

Table 1. Physico-chemical exploration of white yam flour.

| Accession | Local name  | Water content % | Carbohydrates % | Amylose % | Total sugar % | Ash % | Fat % | Protein % | Crude fiber % |
|-----------|-------------|-----------------|-----------------|-----------|---------------|-------|-------|-----------|--------------|
| BDa/01    | Uwi Butun   | 10.48           | 70.2            | 6.36      | 0.22          | 1.80  | 0.17  | 5.77      | 0.80         |
| BDa/05    | Uwi potil   | 11.68           | 79.90           | 5.59      | 0.13          | 1.74  | 0.15  | 8.06      | 2.42         |
| BDa/14    | Uwi Boan    | 6.00            | 53.5            | 5.59      | 0.19          | 2.25  | 0.11  | 7.18      | 1.05         |
| BDa/18    | Uwi Mailu   | 7.57            | 86.41           | 8.31      | 0.43          | 2.38  | 0.12  | 5.69      | 0.88         |
| BDa/20    | Uwi Sombok  | 5.26            | 64.25           | 5.71      | 2.10          | 3.15  | 0.08  | 5.78      | 1.15         |
| BDa/32    | Uwi Pusus   | 5.77            | 78.24           | 8.57      | 0.71          | 2.65  | 0.07  | 8.06      | 0.75         |
| BDa/38    | Uwi Kasiabang | 5.20           | 81.38           | 11.37     | 0.23          | 1.75  | 0.65  | 8.20      | 0.75         |
| Average   |              | 7.42            | 73.41           | 6.93      | 0.57          | 2.25  | 0.19  | 6.96      | 1.11         |
| Maximum   |              | 11.68           | 86.41           | 8.57      | 2.10          | 3.15  | 0.65  | 8.20      | 2.42         |
| Minimum   |              | 5.20            | 53.5            | 5.59      | 0.13          | 1.74  | 0.07  | 5.69      | 0.75         |

The results of the analysis of water content of white yam flour were the highest, 11.68% (accession BDa / 05) and the lowest 5.20% (accession BDa / 38) or an average of 7.42%. The highest carbohydrate content was 86.41% (accession BDa / 18) and the lowest was 53.5% (accession BDa / 14) or an average of 73.41%. The highest amylose content was 11.37% (BDa / 38) and the lowest was 5.59% (accessions BDa / 05 and BDa / 14) or an average of 6.93%. The highest total sugar content was 2.10% (BDa / 20) and the lowest was 0.13% (BDa / 05) or an average of 0.57%. The total sugar content is very low. The highest ash white yam content was 3.15% (BDa / 20) and the lowest was 1.74% (BDa / 05) or an average of 2.25%. The highest fat content was 0.65% (BDa / 38) and the lowest was 0.07% (BDa / 32) or an average of 0.19%. The highest protein content was 8.20% (BDa / 38) and the lowest was 5.69% (BDa18) or an average of 6.96%. Meanwhile, the highest crude fiber content of white yam was 2.42% (BDa / 05) and the lowest was 0.75% (BDa / 32 and BDa / 38) or an average of 1.11%.
Table 2. Physico-chemical exploration of purple yam flour.

| Accession | Local name  | Water content % | Carbohydrates % | Amylose % | Total sugar % | Ash % | Fat % | Protein % | Crude fiber % |
|-----------|-------------|-----------------|-----------------|-----------|---------------|-------|-------|-----------|--------------|
| BDa/03    | Uwi Banggai | 10.50           | 73.2            | 11.24     | 0.21          | 2.01  | 0.46  | 4.73      | 2.04         |
| BDa/09    | Uwi Tombos  | 11.43           | 64.1            | 9.94      | 0.48          | 2.01  | 0.32  | 6.71      | 2.04         |
| BDa/11    | Uwi Lembet  | 11.75           | 75.3            | 8.57      | 2.48          | 2.77  | 0.22  | 4.74      | 2.13         |
| BDa/17    | Uwi Doso    | 8.50            | 99.6            | 8.57      | 0.28          | 2.30  | 0.15  | 7.00      | 0.88         |
| BDa/29    | Ndolonut    | 10.22           | 73.5            | 6.52      | 0.37          | 2.25  | 0.32  | 5.78      | 1.70         |
| BDa/30    | Uwi Bunggon | 10.14           | 98.2            | 9.94      | 1.14          | 2.32  | 0.30  | 8.06      | 1.50         |
| BDa/35    | Uwi Salabangga | 11.70          | 75.4            | 8.55      | 0.31          | 2.80  | 0.16  | 8.99      | 2.52         |

Average: 10.60 79.4 9.05 0.75 2.35 0.28 6.57 1.83
Maksimum: 11.75 99.6 11.24 2.48 2.80 0.46 8.99 2.52
Minimum: 8.50 64.1 6.52 0.21 2.01 0.15 4.73 0.88

Description: 
BDa = Banggai Dioscorea alata
03 - 35 = Accession number

Physico-chemical exploration of purple yam flour had the highest moisture content of 11.75% (BDa / 11) and the lowest was 8.50% (BDa / 11) or an average of 10.60%. The highest carbodirate was 99.6% (BDa / 11) and the lowest was 64.1% (BDa / 09) or an average of 79.4%. The highest amylose content was 11.24% (BDa / 03) and the lowest was 6.52% (BDa / 29) or an average of 9.05%. The highest sugar content of purple yam was 2.48% (BDa / 11) and the lowest was 0.21% (BDa / 03) or an average of 0.75%. The highest ash content from exploration was 2.80% (BDa / 35) and the lowest 2.01% (BDa / 03 and BDa / 09) or an average of 2.35%. Fat content 0.46% (BDa / 03 and BDa / 09) or an average of 0.28%. The highest protein was 8.99% (BDa / 35) and the lowest was 4.73% (BDa / 03) or an average of 6.57%, while for crude fiber the highest was 2.52% (BDa / 35) and the lowest was 0.88% (BDa / 17) or an average of 1.83%.

Table 3. Comparison of the average physico-chemical content of white yam and purple yam.

| Physico-chemical | White yam (%) | White purple (%) |
|------------------|---------------|------------------|
| Water content    | 7.42          | 10.60            |
| Carbohydrate     | 73.41         | 79.4             |
| Amylose          | 6.93          | 9.05             |
| Total sugar      | 0.57          | 0.75             |
| Ash              | 2.25          | 2.35             |
| Fat              | 0.19          | 0.28             |
| Protein          | 6.96          | 6.57             |
| Crude Fiber      | 1.11          | 1.83             |

Based on proximate data in Table 3. It shows that the physico-chemical ingredients which are nutrients in purple yam on average are higher than white yam, except for the protein in white yam is 6.96% while purple yam is 6.57%. The water content of purple yam was higher than white yam, and was 10.60% for purple yam and 7.42% for white yam. The purple yam was 79.4% higher than the white yam, which was 73.41%. Likewise, the level of purple yam amylose was on average 9.05% higher than white yam, 6.93%. The total sugar content of purple yam was 0.75% higher than white yam was 0.57%. The ash content was relatively the same between the purple yam and the white yam, namely 2.35% and 2.25%. The fat content of purple yam is 0.28% and white yam is 0.19%. The protein content of purple yam was 6.57% lower than white yam, 6.96%. The crude fiber of purple yam is 1.83% higher than 1.11%.
2.2. Discussion

The chemical composition of the white yam is presented in Table 1, the purple yam is in Table 2. For a comparison of the chemical composition of the white yam and the purple yam it is presented in Table 3. Almost all of the chemicals analyzed in purple yam are higher than white yam. Unless the protein level of white yam is higher than purple yam. The water content for example purple yam was 10.60% higher than white yam 7.42%, almost the same as the water content of sweet potato 7.63% [9]. Physically, if you peel it, you can see that the purple yam contains more mucus than white yam. Water in food, including yam, acts as a solvent for several components in addition to being a reagent, while the form of water can be found as free water and bound water. Free water can easily be lost if evaporation or drying occurs, while bound water is difficult to release in this way. Water can also be physically bonded, namely bonds according to the capillary system and water is chemically bonded, including crystalline water and water bound in a dispersion system [10]. Tabrani states that water content plays an important role, except for temperature, water activity has its own place in the decomposition process [11]. Fresh uwi contains high water content, therefore at harvest it can last up to 4 months because the water content is stored in the tubers. In this study, the analysis of the moisture content of fresh tuber was not carried out, but rather the moisture content of the yam flour.

This study, it was known that the carbohydrate content in yam was quite high, on average 79.4% of purple yam was higher than white yam, namely 73.41%. Uwi carbohydrate content is still higher than sweet potato 49.77% [12]. Carbohydrates are of two types, namely simple carbohydrates which provide fast energy, and complex carbohydrates which provide long-lasting energy. Complex carbohydrates are also very important for preventing diabetes, because they do not trigger blood sugar spikes.

The ash content of yam was 2.25% white yam and 2.35% purple yam was greater than the ash content of sweet potato 1.998%. Ash is an inorganic substance left over from the combustion of an organic material. The ash content and composition depend on the type of material and the method of ashing used. The ash content of a material indicates the mineral content in the material. Total ash is useful for determining whether or not a processing process is good, knowing the type of material used, and being used as a parameter of the nutritional value of food [13]. The fat content of 0.19% white yam and 0.28% purple yam was smaller than the fat content of 1.745% sweet potato. The fat values of all the yam accessions explored were very low and comparable to the values found in other root crops such as potatoes [14] and cassava [15]. There is only very little fat in both the white and purple yam. Fat in plants is found mostly in plant seeds while in tubers is very little.

The protein content of white yam was 6.96% and 6.57% purple yam were higher than sweet potato protein 0.257%. Yam accession had the highest protein content of 6.96% for white yam, and 6.57% for purple yam. Meanwhile E.A. Udensi et al., [16] found that yam protein was 8.31%. Thus, the relatively high crude protein content of various yam accessions does not need to be considered protein-poor. Protein is very important in the body. Protein in the body, functions as a source of energy, forms various enzymes and hormones, supports the immune system. In this study, it was found that the sugar content of white yam was 0.57% and purple yam was 0.75% lower than the sugar level of sweet potato 0.118% [9]. The total sugar content contained in the yam plant is classified as very low compared to the sugar content contained in rice or rice 31.76% and corn rice has a glucose level of 42.28% [17]. Food with low sugar content is very good as food for diabetics.

The fiber content of white yam was 1.11% and yam was 1.83% lower than the crude fiber content of sweet potato 4.59% [12]. Fibrous foods are needed for the health of the body, especially in the digestive process to facilitate the performance of the digestive tract. Automatically, a healthy digestive tract will help the body's resistance to disease. Therefore, eating fibrous foods is highly recommended. Fiber is needed to facilitate the digestive process, especially peristalsis in the intestine, which can be controlled with a fibrous food solution. Peristalsis is a wave of consecutive contractions in the digestive tract that push food waste toward the anus.

The amylose content of the uwi tested in this experiment varied. The range of amylose levels averaged 6.93% in white yam and 9.05% in purple yam. Amylose is the main parameter that determines the quality of the cook and the taste quality of food, especially rice. Therefore, amylose is one of the
quality components analyzed in the release of rice varieties. Rice is classified as glutinous or very low amylose rice (<10%), low amylose rice (10-20%), medium amylose rice (20-24%), high amylose rice (>25%). Based on the results of the analysis of amylose levels showed conformity to the above criteria, namely the varieties of accession yam which were analyzed both white yam and purple yam contained amylose 6.93% for white yam and 9.05% for purple yam with very low category. According to Prima Luna et al. [18] and Yusof et al. [19] amylose is the main parameter that determines the quality of cooking and the taste quality of food ingredients, especially rice. Therefore, amylose is one of the quality components analyzed in the release of rice varieties. Therefore, by consuming complex carbohydrate foods like yam can delay hunger and lose weight. If you often consume carbohydrates in the form of fibrous food, including yam, it can nourish the digestive system of food. In addition, consuming carbohydrates from fibrous foods, our bodies can avoid colon diseases, for example diverticulitis. This data shown in this study provides information that the yam tuber can be recommended as a non-rice carbohydrate staple food.

3. Conclusion
The results of physico-chemical exploration in purple yam flour were higher on average than white yam, except for the protein in white yam, 6.96% while purple yam was 6.57%. The water content of purple yam was higher than white yam, and was 10.60% for purple yam and 7.42% for white yam. The purple yam 79.4% higher than the white yam, which was 73.41%. Likewise, the level of purple yam amylose was on average 9.05% higher than white yam, 6.93%. The total sugar content of purple yam was 0.75% higher than white yam was 0.57%. The ash content was relatively the same between the purple yam and the white yam, namely 2.35% and 2.25% yam. The fat content of purple yam is 0.28% and white yam is 0.19%. The protein content of purple yam was 6.57% lower than white yam, 6.96%. The crude fiber of purple yam is 1.83% higher than purple yam, which is 1.11%. Whether this has something to do with the anthocyanin dye in purple yam, this is interesting to study further in relation to the proximate value of tuber flour.

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