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Improving The Capacity of Tuber Flour Manufacturer by Enhancing The Production Process and Utilizing Proper Technology

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Abstract. In an effort to increase the value of local food products and reduce wheat imports, it is critical to develop the design of root/tuber drying technology and improve the refining process. This research was conducted by experimental method through developing drying machine and laboratory tests. The object of this research is UMKM Rejeki Berkah (Small Medium Enterprise). The used samples for this research are yam, canna, arrowroot, taro, sweet potato. The analysis used for this research is proximate analysis, which includes analysis of water content, ash content, carbohydrate, protein and crude fat content. Proximate analysis is the method to observe the quality of the flour. The results of this research show that: First, the drying machine is useful to reduce the moisture content so that the tubers don't get rotten too quickly. Second, in order to get the best quality of yam, arrowroot, and sweet potato, it is recommended to steam, cooling, shrink, dry, grind, and sift. It is not recommended to steam canna and sweet potatoes, they only needed to be mixed, blanched, dried, and sifted. Similar to canna flour, taro flour only needs to be mixed, blanched, dried and sifted after it has been soaked in warm water and then later soaked again in normal water for 3 hours. Based on this research, the recommendation action for UD Berkah is to develop the upstream-downstream supply chain to maintain the quality of tubers and processed products.

INTRODUCTION

One of the priorities for 2019 Central Java Development Planning is to empower regional economy based on their surrounding potential with technology and oriented towards people/community economy. One of the potentials of Central Java is the diverse type of tubers, including sweet potato, cassava, canna, and yam. In 2014, Balai Pengkajian Teknologi Pertanian Provinsi Jawa Tengah (Center for Agricultural Technology of Central Java) stockpiled 13 types of specific non-crops genetic resources in Central Java.

In accordance with the Central Java development program, the City of Semarang also actively empower local potential to increase food security and availability. The largest tuber production is located in Gunungpati District. Due to its lack of processing, tuber in Gunungpati doesn't have an added value yet. The production of tubers in Semarang is shown in Figure 1.

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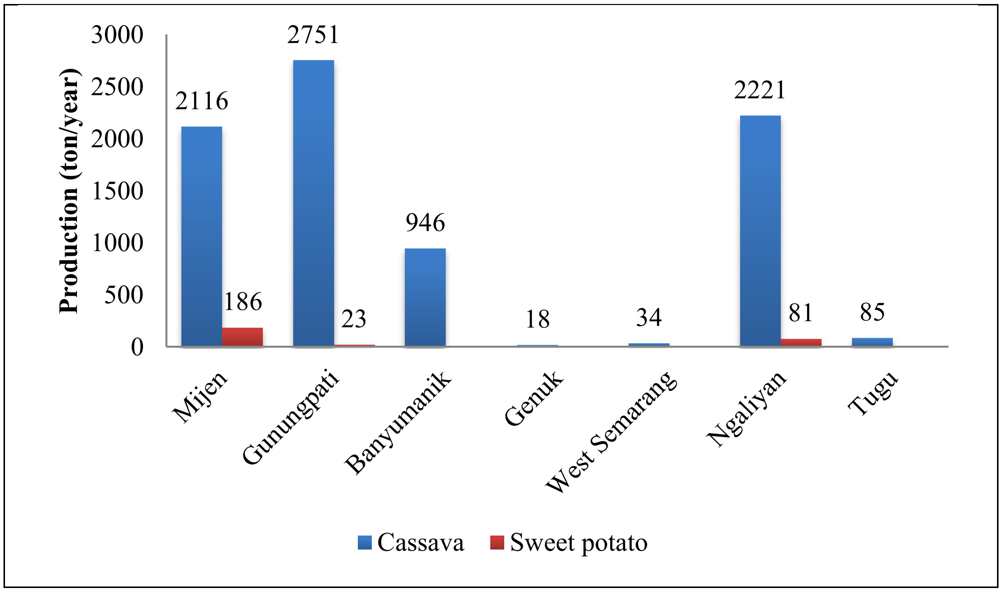


FIGURE 1.

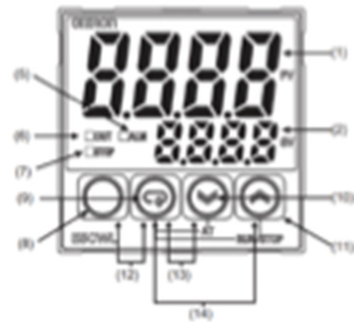
As one of the national fulcrum for food security, the potential of tubers in Semarang has to be developed, both in the amount of production and added economic value. An alternative to increase the value of tubers is to diversify their processed products through the use of flour technology. Tuber flour could work an alternative for wheat flour. To produce one ton of wheat flour, it needs import of seven million tons of wheat. The most considerable consumer of wheat flour is the noodle producer, which reaches 55 percent, while bread producers account for 22 percent and biscuits with 18 percent. The majority of wheat imports come from Australia, Canada, America, Russia, Ukraine, Kazakhstan, India, Pakistan, Brazil and Argentina. Badan Pusat Statistik (Center of Statistics Agency) announced that the value of wheat imports in January 2016 was 443.4 million US dollars, a sharp increase of 86.35 percent [1].

One of the results shows that a mixture of 50% sweet potato and 50% wheat flour is recommended for cakes due to the preferred taste, color, and moderate sweetness [2]. Based on the results of these studies, increasing the utilization of tuber products into various types of processed foods should be a priority. Flour is a form of material processing carried out by minimizing the size of the material using the grinding method [3]. Before the milling process is carried out, the flour raw material has to be dry to reduce the water content in so it will last longer. The drying process can be done conventionally (sunlight) and mechanically (drying machine). At this stage, Small Medium Enterprises often encounter numerous obstacles because the drying process still uses conventional techniques that depend on weather and climate conditions. Even though the drying process is a major aspect at making flour and guarantees the quality of products [4]. Based on the tantalizing problems for these small industries, research is needed to develop the design of tuber/root drying technology as well as flour technology. The goal is to increase the added economic value of local food products and reduce wheat imports altogether.

METHOD

The study used an experimental approach by developing dryer equipment and laboratory tests. The tuber/root dryer is developed by integrating the blower system, temperature, and controlling the fire from the stove. The operating system of the dryer, is when the maximum temperature is determined as the maximum threshold, the fire from the gas stove is automatically large-sized and the blower is active until it reaches the desired temperature. When the temperature has exceeded the maximum threshold, the fire from the stove and blower will automatically go out to adjust the maximum temperature. The dryer also uses a time system as both a pointer to the duration of drying process and safety system, because when the drying time limit has passed automatically the drying machine will shutdown. The capacity building that has been done for UMKM "Rejeki Berkah" in Sabrangan Village, Plalangan Subdistrict, Gunungpati District, Semarang, has succeeded in producing tubers. In accordance with the target of the capacity building, a tuber dryer was made from 180 cm x 70 cm x 50 cm iron frame, made from stainless steel, consisting of 12 racks with 15 cm distance, capacity of 50 kg chips, 150 watts of blower system, gas stove as heating system, digital thermometer, automatic temperature control systems.

(a) Tuber/Root Dryer



(b) Display temperature setting (1) Alarm indicator, (2) Electric output indicator, (3) Complete indicator, (4) Thermocontroller setting button, (5) Thermocontroller option button, (6) Increase temperature button, (7) Decrease temperature button

FIGURE 2.

The research used samples of yam, canna, arrowroot, taro, sweet potato. To see the quality of flour, proximate analysis which included analysis of water content, ash content, carbohydrate content, protein content and crude fat content was conducted.

RESEARCH RESULTS & DISCUSSION

Yam (Dioscorea esculenta) is an ascending shrub, and could reach 3-5 m in height. The biggest component of yam is carbohydrate (27-33%). Yam produces edible tubers that taste slightly sweet like potatoes and has a chewy texture. To avoid air contact, the peeled yam should always be soaked to remove dirt. The peeled yams are then sliced using a stainless knife. There should be minimum air contact during the slicing process. The soaking will extract mucus due to an increase in water pressure against the membrane cell. Judging by the chemical content and community acceptance, yam has great potential to be developed in the future. Through various studies, it has been known that yams can be processed into flour, starch, and ethanol or alcoholic beverages. The final products can be applied in the fields of food, pharmaceuticals, cosmetics, and other industries.

The results of the research by [5] show that yam flour can be used as composites with other flour, although some of its physicochemical properties still need to be improved. One of the disadvantages of yam flour is the color of flour which is rather dark due to the browning reaction during the processing. This reaction is seen when the tuber is cut, not long after the browning process occurs on the tuber surface. The yield is the product percentage obtained from the final weight of the material divided by its initial weight. Based on the results of calculations, it shows the highest yield in Yam flour through process 1, as shown in Table 1.

TABLE 1. Yield Calculation Results of Yam Flour

No	Code	Initial weight (g)	Final weight (g)	Yield (%)
1	Yam I	2000	260	13
2	Yam II	2000	255	12.8
3	Yam III	2000	255	12.8

Notes :

Yam I : peeled, washed, braised with ± 1-2 mm thickness, steamed for 10 minutes, soaked in 15% salt solvent overnight, washed thoroughly, dried, milled, sifted, packed

Yam II : peeled, washed, steamed, cooled, preserved, dried, milled, sifted, packed

Yam III : peeled, washed, preserved, dried, milled, sifted, packed

According to [7], Yam has the highest yield of starch and starch flour compared to other tubers. Thus, in terms of yields, Yam has the potential to be developed into flour or starch. The proximate analysis showed that Yam flour using method 2 was the best quality flour as shown in table 2.

TABLE 2. Proximate Analysis of Yam Flour (%)

No	Code	Water	Ash	Crude Fat	Protein	Carbohydrate
1	Yam I	9.616	2.753	0.699	4.701	82.331
2	Yam II	7.852	2.718	0.440	5.934	83.056
3	Yam III	8.647	3.950	0.525	6.357	80.520

The proximate result of Yam is not much different from the research conducted by Richana, which has a water content of 8.39%, 0.72% ash, 0.15% fat, 3.92% protein and 86.84% carbohydrate. These results indicate that Yam has the potential to be developed as an ingredient to make flour as a substitute for wheat.The highest protein content of yam flour, 6.357%, is obtained by using method 3. According to [6], a decrease in protein content is due to stages of purification, in every purification process there is a reduction in contaminants present in the solvent, these contaminants can be other unsought proteins or other metabolites. Protein has structures that contain N, in addition to C, H, O (as well as carbohydrate and fat), S and sometimes P, Fe and Cu (as a complex compound alongside protein). Like other polymeric compounds (cellulose, starch) or compounds that are condensed by several units of molecules (triglycerides), protein can also be hydrolyzed or decomposed into components of their own unit by water molecules.

Hydrolysis of proteins will release the constituent amino acids [8]. Whereas according to [9], protein is a food substance that is very important for the body, because this substance is useful as a fuel in the body and also functions as a builder and regulator substance. Protein is a source of amino acids that contain elements C, H, O and N which fat or carbohydrates do not have. Protein molecules also contain phosphorus, sulfur and there are types of proteins that contain metal elements such as iron and copper. In addition, the steaming process is also suspected to cause a decrease in the levels of Yam flour protein using method 1 and 2, because of the loss of water-soluble proteins, as suggested by [10]. The decreasing level of protein with the longer duration of soaking is caused by the release of protein structure bonds so that protein components can be dissolved in water.

While Canna (Canna edulis Ker), is a straight plant that reaches up to 3 m. The root can grow up to 60 cm in length, surrounded by scales and thick fibrous roots. The shape and composition of the tubers are varied. In Indonesia, there are two cultivated Canna varieties, Red Canna and White Canna. Flour is easy to digest, excellent for feeding infants and sick people. Canna is a carbohydrate source of 22.6% [11].

The average yield of Canna flour is 12.3% (Table 3). The low number of yield of flour is due to its rough fiber and difficult to be mashed up. Thus, Canna is quite difficult to be processed into flour due to its rough fiber.

TABLE 3. Yield Calculation Results of Canna Flour

No	Code	Initial weight (g)	Final weight (g)	Yield (%)
1	Canna I	2000	230	11.5
2	Canna II	2000	255	12.8
3	Canna III	2000	255	12.8

Notes :

Canna I : peeled, washed, preserved, dried, milled, sifted, packed.

Canna II : peeled, preserved, washed, dried, milled, sifted, packed.

Canna III : peeled, washed, preserved, soaked for 2 hours, dried, milled, sifted, packed

The finest color of Canna flour is obtained by using method I. This is because there is a heating/steaming process so that the browning process in flour can be inhibited. Browning is a common occurrence in food materials that are not given initial treatment. Natural foods usually experience unwanted enzymatic browning. One method to prevent browning in the material is by giving initial treatment such as blanching which aims to reduce the activity of the enzyme polyphenol oxidase. So that in method 1, Canna could be treated by the blanching process.

The analysis results show that the best Canna flour is obtained by using method 1. This can be seen from its water content of 7.722%, ash content of 2.807%, crude fat content of 0.443%, and protein and carbohydrate content, respectively at 3.975% and 85.052% as shown in Table 4.

TABLE 4. Proximate Analysis of Canna Flour (%)

No	Code	Water	Ash	Crude Fat	Protein	Carbohydrate
1	Canna I	7.722	2.807	0.443	3.975	85.052
2	Canna II	10.714	3.798	0.689	2.858	81.941
3	Canna III	11.537	4.607	0.732	3.208	79.916

Arrowroot has never been a primary food material, but it is often planted in the yard as a food reserve. Arrowroot is mainly planted to produce high-quality, fine-sized and expensive starch/flour. It can also be used as an alternative carbohydrate source to replace wheat flour. Another benefit is for consumption by people who are recovering from illness, because it is easily digested by people with digestive or intestinal problems. It is also used as a viscous ingredient for various kinds of dishes. Based on the calculation results, it shows the highest yield using method II & III, which is equal to 13%.

TABLE 5. Yield Calculation Results of Arrowroot Flour

No	Code	Initial weight (g)	Final weight (g)	Yield (%)
1	Arrowroot I	2000	255	12.8
2	Arrowroot II	2000	260	13
3	Arrowroot III	2000	260	13

Notes :

Arrowroot I : peeled, washed, steamed, blended, dried, ground, sifted, packed

Arrowroot II : peeled, washed, steamed 1/2 cooked, cooled, brewed, dried, milled, sifted, packed.

Arrowroot III : cleaned cuticle skin, washed, brawled, dried, milled, sifted, packed

The finest color of Arrowroot flour is obtained using method I and II. Based on the analysis results, method II has the best quality as described Table 6.

TABLE 6. Proximate Analysis of Arrowroot Flour (%)

No	Code	Water	Ash	Crude Fat	Protein	Carbohydrate
1	Arrowroot I	8.087	5.487	0.970	6.771	78.685
2	Arrowroot II	6.296	6.080	1.091	8.662	77.870
3	Arrowroot III	6.257	5.484	1.316	8.953	77.990

This is in line with the research of [12], who said that Arrowroot flour has water content of 2.40%, ash content of 3.17%, crude fat content of 13.70%, protein content of 10.79%, carbohydrate levels of 72.19%, with energy content of 444.61 kcal. Therefore, Arrowroot flour has the potential to replace wheat flour as a basic ingredient in processed products such as biscuits. Besides being a cake ingredient, it is also used as additional viscous material of various kinds of dishes. The highest protein content in arrowroot flour using method III is 8.953%.

Taro is also a food material that is quite popular in Indonesia. Generally, Taro is only processed by boiling, sowing, fried, and made chips. Taro contains oxalic acid which affects the absorption of calcium in the digestive system, by forming calcium-insoluble bonds. Calcium oxalate is in the form of a crystal that resembles a needle. Besides, Taro calcium oxalate also contains oxalic acid which can form complexes with calcium. The presence of oxalic acid is thought to interfere with calcium absorption. Oxalic acid is soluble in water, while calcium oxalate is insoluble in water but soluble in strong acids. Oxalate is not spread evenly in Taro.

Taro has a high starch content that has the potential to be used as a raw material for flour. For safe consumption, oxalic acid in taro must be removed. The boiling process can be done to reduce the amount of dissolved oxalate if the boiled water is removed, because this compound dissolves into boiling. In addition, soaking in warm water, germination, and fermentation can also be done to reduce dissolved oxalate levels [13]. The highest yield in Taro flour was obtained using method I and III, which amounted to 16.7 and 17%.

Table 7. Yield Calculation Results of Taro Flour

No	Code	Initial weight (g)	Final weight (g)	Yield (%)
1	Taro I	1500	250	16.7
2	Taro II	1500	160	10.7
3	Taro III	1500	255	17

Notes :

Taro I : Peeled, Washed, Brushed, Soaked in warm water, Soaked in plain water for 3 hours, Dried, Milled, Sifted, Packed

Taro II : Peeled, Washed, Laughing, Dried, Milled, Sifted, Packed

Taro III : Peeled, Washed, Brushed, Blended, Drained, Milled, Sifted, Packed

Bright color in Taro flour is obtained using method I and III due to heating/blanching process so that the browning process in flour can be inhibited.

The moisture content of taro flour ranges from 8.251-9.389. The greater the water content, the bigger the possibility of these food materials easily damaged. Taro flour with the lowest water content is obtained through method I. According to [14], the low water content in flour is caused by changes in granular shape due to irreversible swelling due to heating. This swelling affects the nature of absorption and binding of granules to water. Granules that have swollen tend to have a larger cavity between cells so that during the drying process, the contained water can be easily released.

The level of ash in taro flour ranges from 3.97-4.258%. Ash content shows the mineral content of a material. The higher the ash content of a material, the higher the mineral content of the material. The ash content depends on the type of material, the method of ignition, the time and temperature used when drying. The crude fat ranges from 0.97 to 1.316%. The lowest fat content in Taro flour is obtained through method III. Crude fat content in flour can interfere with the gelatinization process because fat is able to form a compound with amylose which inhibits the release of amylose from starch granules. In addition, most of the fat will be absorbed by the surface of the granule so that it forms a layer of fat that is hydrophobic around the granule. The fat layer will inhibit the binding of water by starch granules. This results in reduced viscosity and bonds of starch due to the reduced amount of water for the development of starch granules.

The highest protein in Taro flour is obtained through method 3, which is 4.949%. The protein content is inversely proportional to crude fat content, the higher the protein content, the lower the fat content produced in Taro flour will be. A decrease in the amount of protein in the drying process is caused by denaturation of the protein content. Heat-induced denaturation is caused by the formation or alteration of the functional properties of protein [15]. This is supported by [9], that protein denaturation can be done in various ways, namely heat, pH, chemicals, mechanics and so on.

TABLE 8. Proximate Analysis of Taro Flour (%)

No	Code	Water	Ash	Crude Fat	Protein	Carbohydrate
1	Taro I	8.251	3.975	1.064	4.217	82.493
2	Taro II	8.748	4.258	0.922	3.316	82.755
3	Taro III	9.389	4.034	0.760	4.949	80.869

Method I results in Taro flour with a yield of 16.7%, water content of 8.251%, ash content of 3.975%, crude fat content of 1.064%, and protein and carbohydrate content respectively at 4.217% and 82.493%. Sweet potato flour has variations according to the color of the meat, allowing consumers to have the type of sweet potato flour according to the desired color. According to [16], processing purple sweet potatoes into flour is one way to store and preserve the flour. The yield of purple sweet potato flour using all manufacturing methods is 20.8%. Whereas the yield of yellow sweet potato flour averaged at 20.4%.

TABLE 9. Yield Calculation Results of Sweet Potatoes Flour

No	Code	Initial weight (g)	Final weight (g)	Yield (%)
1	Yellow I	1250	255	20.4
2	Yellow II	1250	255	20.4
3	Yellow III	1250	255	20.4
4	Purple I	1250	260	20.8
5	Purple II	1250	260	20.8
6	Purple III	1250	260	20.8

Notes :
Yellow I : Peeled, Washed, Brushed, Blended, Drained, Milled, Sifted, Packed
Yellow II : Peeled, Washed, Steamed Half-cooked, Cooled, Laughing, Dried, Milled, Sifted, Packed
Yellow III : Peeled, Struck, Dried, Milled, Sifted, Packed
Purple I : Peeled, Washed, Brushed, Blended, Drained, Milled, Sifted, Packed
Purple II : Peeled, Washed, Steamed Half-cooked, Cooled, Struck, Dried, Milled, Sifted, Packed
Purple III : Peeled, Washed, Struck, Drained, Milled, Sifted, Packed

The bright color of purple flour is obtained using method II. In making purple flour, the main problem the enzymatic browning reaction. The color of purple flour will become dull caused by the phenolase enzyme. To inhibit the enzymatic browning reaction, it needs to be steamed to mangle the structure of the phenolase enzyme. The enzymatic browning reaction in purple can be inhibited [7]. While the bright color of yellow flour is obtained using method II. Water content of sweet potato tuber ranges from 6.438-7.651%. Yellow flour has the lowest moisture content in method III. While the water content of purple flour ranges from 7.103-8.309%.

The ash level of yellow tuber ranged from 1.947 to 2.758%. While the ash content of purple tuber ranged from 2.362 to 4.069%. The results of crude fat in yellow tuber ranges from 0.714 to 1.028%. The lowest crude fat content in yellow tuber uses method I. While the crude fat content in purple tuber showed a range of 1,483 - 2,810%. The lowest crude fat content in purple tuber uses method II. The highest protein content in the purple tuber, which is 2.901%, also uses method II. While the yellow tuber uses methods I and III, respectively 1.302 and 1.789%. The carbohydrate content in yellow and purple tuber ranges from 83.616 – 88.971%. Both yellow and purple tubers classified as tubers with a high carbohydrate content compared to other tubers.

Table 10. Proximate Analysis of Purple and Yellow Tuber (%)

No	Code	Water	Ash	Crude Fat	Protein	Carbohydrate
1	Yellow I	7.230	2.145	0.714	1.302	88.608
2	Yellow II	7.651	2.758	1.028	1.636	86.927
3	Yellow III	6.438	1.947	0.855	1.789	88.971
4	Purple I	7.788	4.069	1.896	2.631	83.616
5	Purple II	8.309	3.314	1.483	2.901	83.993
6	Purple III	7.103	2.362	2.810	2.627	85.098

Based on the results of the analysis, the yellow flour that uses method I is the flour that has the best result. This can be seen from the yield of at 20.4%, the color of flour is good, the water content is 7.23%, ash content is at 2.145%, crude fat content is at 0.714%, and the protein and carbohydrate content are at 1.302% and 88.608%. While the best flour uses method II. This can be seen from the yield of 20.8%, the color of flour including both bright purple, water content of 8.309%, ash content of 3.314%, crude fat content of 1.483%, and protein and carbohydrate content respectively at 2.901% and 83.993%.

CONCLUSIONS AND RECOMMENDATIONS

From the results of the study, it was concluded that: first, to maintain the quality of flour to make it durable, a tuber drying machine is made by integrating the blower system, temperature, and the amount of fire from the stove; second, the best quality of Yam, Arrowroot and purple sweet potato flour is obtained by using the method of steaming, cooling, shrinking, drying, grinding, sifting. While Canna and yellow sweet potato flour do not need to be steamed, only mixes, plants, dries, grinds, and sifts. Similar to Canna, Taro flour needs to be soaked in warm water, then plain water for 3 hours, and later dried, grind, sifted. For the recommended action, UD Rejeki Berkah needs to develop the supply chain from upstream to downstream, so the quality of both tubers and final products can be maintained.

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