*Original Research Article*

Physicochemical and Sensory Properties of Sweet-Type Cassava Flour

ABSTRACT

The aims of research were to determine the effect of harvesting age, varieties and interaction between harvesting age and varieties on physical properties, chemical and sensory of sweet type cassava flour in South Lampung. The factorial experiment was arranged in a Complete Randomized Block Design with two factors and four replications. The first factor was cassava varieties (3 varieties) and the second factor was age of cassava harvest (2 level of harvesting age). The data were tested for their homogeneity and additivity using Bartlett and Tuckey Tests. The data were analyzed by variance and further tested using Duncan 5%. The results showed varieties significantly affected moisture content, flour yield, peel percentage, swelling power and solubility at temperatures of 60°C, 70°C, 80°C, starch content, amylose, amylopectin, and color. The age of cassava harvest significantly influenced moisture content, flour yield, peel percentage, solubility temperature of 60°C, 70°C, 80°C, starch, amylose, amylopectin. There were interaction between varieties and harvesting age on flour yield, solubility at temperature of 80°C, starch and color. Cassava variety of Krembi is most likely to be recommended for flour production.

Keywords: Cassava flour, harvesting age, krembi, manalagi, mentega

**Introduction**

Cassava (*Manihot esculenta* Crantz) is widely grown in tropical areas because of its high drought resistance, disease tolerance, and contains high carbohydrate mainly starch. It can be consume easily by boiling, steaming, frying of the tubers, or processed as intermediate products such as starch and flour. These intermediate products then can also be processed into various snacks, staple food or other value products. Cassava is a plant that contains high carbohydrates (38.06g/100g) and calories (160 kcal/100g) (Bayata, 2019). In addition, cassava is the third staple food in Indonesia after rice and corn. Cassava has the potential to be developed to support food and non-food diversification programs. However, the utilization of cassava is still constrained by several factors. One of the main constraints is that cassava roots have a short shelf life after being harvested. Fresh cassava roots will under go deterioration shortly after harvest which leads to no economic value when they are sold (Rahmawati et al., 2022). Cassava roots will show symptoms of postharvest physiological deterioration (PPD) within only 24 to 72 hours after harvest(Vanderschuren et al., 2014; Zainuddin et al., 2018). This PPD will cause cassava roots to be unable to be further utilized as raw materials for food products. PPD is a complex process related to the enzymatic stress response to wounds that may occur during harvesting, thus involving changes in gene expression, protein synthesis, and accumulation of secondary metabolites and can be influenced by environmental factors. Physically, PPD is characterized by a change in color from blue to black or brown in the vascular parenchymal tissue, which begins to appear within 24-72 hours of harvest (Reilly et al., 2004, Vanderschuren et al., 2014). One alternative to extend the utilization of cassava in food products is to process it into an intermediate product. An intermediate product from cassava that is relatively durable to store, easier to transport is cassava flour. In flour form, cassava is more flexible and has a longer shelf life when used, especially as a raw material for processed food products.

In general, based on HCN content, cassava is classified into two categories, which are sweet-type cassava, and bitter cassava. Cassava roots contain HCN levels <100mg/kg (wb) are called sweet-type cassava, while those contain HCN levels of 100-500 mg/kg (wb) are called bitter cassava (Wahyuni & Noerwijati, 2021). The bitter taste of cassava is caused by the high HCN content (Mota-gutierrez & O'Brien, 2020). In practice, sweet-type cassava is harvested between 7-9 months after planting and utilized for food product purposes, whereas bitter cassava can be harvested up to 12 months after planting and usually used as industrial purposes mainly tapioca production. The processing of sweet type cassava into flour includes several steps such as peeling, washing, size reduction, and drying followed by grinding , while bitter cassava requires a longer process to reduce or even eliminate HCN from cassava, such as soaking, drying, fermentation (Ndubuisi & Chidiebere, 2018).

A common method for producing flour from bitter cassava is through fermentation, the flour resulted is called MOCAF (modified cassava flour). However, mocaf processing is relatively difficult to be applied by small industries and communities independently because it requires starter culture that must be obtained from certain suppliers, on the other hand, processing flour from sweet-type cassava is more simple and affordable by farmer.

Sweet-type cassava varieties such as Manalagi, Mentega and Krembi, although their production amount has never been quantified statistically, are widely cultivated by farmers in Palas District, South Lampung Regency. In addition, these varieties are mainly used as raw materials in the food processing, either on a micro, small or medium scale industries. However, publications regarding the characteristics of the three varieties have not been found. Knowledge of the characteristics of each variety is essential to predict the suitability of its use in various types of cassava-based foods. Therefore, this study identified the physical, chemical and sensory properties of sweet cassava flour of sweet-type cassava grown in Palas District, South Lampung Regency to provide a guideline for its uses in accordance with the desired quality of food products.

RESEARCH METHODS

Materials

The materials used are cassava varieties Manalagi (V1), Mentega (V2) and Krembi (V3) with a harvest age of 7-8 (U1) and 8-9 (U2) months obtained from Palas District, South Lampung Regency, ether, 10% ethanol, 25% HCl, 45% NaOH, 1 N acetic acid, iodine solution, α-amylase enzyme, glucoamylase enzyme, pure amylose and distilled water.

Tools

The tools used were oven, FCTZ300-Ramesia flouring machine, 80 mesh sieve, PLC series centrifuge tube, water bath shaker, water bath, and UV-Vis DR/4000 U spectrophotometer.

Experimental design

The experiment was factorial and arranged in a Complete Randomized Block Design with two factors and four replications. The first factor was cassava varieties and the second factor was age of cassava harvest. The data were tested for their homogeneity and additivity using Bartlett and Tuckey Tests, then subjected for analysis of variance ( ANOVA) and further tested using Duncan 5%.

Experiment stage

Cassava Flour Preparation

Fresh cassava was peeled and washed thoroughly from dirt under running tap water. Then the cleaned cassava was thinly sliced ​​crosswise using a Hobart slicer with a thickness of 1 mm and dried in an oven at 60 ℃ for 20 hours. Then the dried cassava slices were floured using a flour machine (FTCZ 300, Ramsia), sieved using a 80 mesh siever. After that, the flour was cooled to room temperature, which was around 25 ℃, then packed in zip-lock plastic bag, stored in a tightly closed container until used for further analysis.

Moisture Content Analysis

The sample was weighed as much as 2 g in a cup then oven-dried at 105oC for 6 hours. The sample was cooled in a desiccator for 30 minutes and weighed. This stage was repeated until a constant weight was achieved.

Flour Yield

The yield analysis was carried out by dividing the final weight of the product by the weight of the initial material, then 100%.

Peel Weight

The weight of the skin (%) is determined by weighing the outer and inner skin divided by the initial cassava weight multiplied by 100%.

Starch Content

A total of 10 g of sample was suspended in 100 mL of distilled water and heated to reach the gelatinization temperature for about 30 minutes. Then cooled for 15 minutes and 1 mL of α-amylase enzyme was added. Reheat the sample to a temperature of 50°C then 1 mL of glucoamylase enzyme was added and incubated for 15 minutes. The solution obtained was filtered with a filter cloth, the residue left on the filter cloth was tested with a Lugol solution to to assure that the starch was completely hydrolyzed. Then the free-starch residue was dried and then weighed. The weigh different between the sample and the residue divided by the sample weigh multiplied by 100% was determined as % of starch content. This procedure was based on method developed by Okrathok et al. (2022) with slight modification.

Amylose Content

Amylose content was determined according to Tuaño et al.(2021) with modification. Sampel, 100mg of cassava flour, was added with 1mL of 95% ethanol and 1N NaOH. The mixture was then heated in boiling water (95°C) for 10 minutes until a gel was formed. The gel was added with water up to 100mL and shaken. The mixture was taken 5mL and added 1mL of 1N acetic acid, 2mL of 0.01N iodine solution then added water up to 100mL and shaken. Then the sample was heated with a water bath at a temperature of 30°C for 20 minutes, then its absorbance was measured with a UV-Vis spectrophotometer with a wavelength of 620nm. The results obtained were plotted in a standard amylose curve to obtain the amylose concentration of the sample.

Amylopectin Content

The amylopectin content was calculated by subtracting the starch content from the amylose content (by different). Amylopectin content (%) = 100% - amylose content (%)

Solubility and Swelling Power

Solubility and swelling power were analysed using the method of Jiao et al.(2020). Flour suspension (1% w/v) as much as 10mL was heated in a water bath shaker at a temperature of 60°C and 80°C for 30 minutes each. The suspension was then centrifuged at a speed of 3000rpm for 15 minutes, the resulting supernatant was separated from the swollen granules. The swollen granules were used as the result of swelling power while the supernatant was dried at a temperature of 105oC and weighed to obtain the results of solubility.

Color

Color assessment of cassava flour using sensory testing with a scoring method with a score range of 3 = White, 2 = Brownish white, 1 = Brown. Sensory testing was conducted by 20 panelists.

**RESULTS AND DISCUSSION**

Moisture Content

The interaction between variety and harvest age of cassava significantly affected the moisture content of cassava flour produced. Duncan's further test at 5% level (Figure 1) showed that the highest moisture content of the flour was found on Manalagi harvested at 7-9 months after planting, while the lowest moisture content was found on Mentega variety harvested at 8-9 months.

Figure 1. The interaction effect of variety and age of harvest on moisture content of cassava flour

Note: V1:variety of Manalagi; V2: Mentega; V3: and Krembi ; U1: harvest age of 7-8; U2 8-9 months

Cassava varieties with different harvest ages showed various moisture content due to the chemical components such as starch and non-starch contained in the roots. Water will interact and bind to each other in the chemical components so that the structure becomes more compact. In addition, the drying factor also greatly affects the moisture content of the flour. According to Eriksson (2013), the recommended moisture content in cassava flour is 8-10%. According to Nurdjanah et al. (2020), water absorption and water requirements for each variety are different. This is influenced by the different genetic characteristics of each cassava plant in water absorption, so it will affect the water content of the roots. In addition, different harvest ages will also produce different physical and chemical properties.

Flour Yield

The flour yield was significantly affected by interaction of variety and harvest age. Figure 2 shows that the highest cassava flour yield was found in the Krembi variety 8-9 months, while the lowest flour yield was shown in the Manalagi variety 7-8 months. The three cassava varieties with a harvest age of 8-9 showed significantly higher yield compared to those of from the three varieties with a harvest age of 7-8.

Figure 2. The interaction effect of variety and age of harvest on yield of cassava flour

Note: V1: variety of Manalagi; V2: Mentega; V3: and Krembi ; U1: harvest age of 7-8; U2 8-9 months

This phenomenon may be caused by genetic differences and harvesting factors that will affect the components in cassava, so that each variety and harvest age has a different flour yield. According to Chisenga (2021), the dominant component of flour is starch, and the rest are water, non-starch polysaccharides , protein, fat, and ash. According to Apea-bah et al. (2011), the increase in flour yield is in line with the increasing age of the plant and reaches a maximum at the optimum harvest age, but after that, the starch components in cassava will decrease whereas the fiber will increase. In addition, various enzymes in the Krembi variety synthesize starch faster than that of in Mentega and Manalagi varieties. Starch biosynthesis in cassava involves several enzymes, namely the ADP-glucosepyrophosphorylase (AGPase) enzyme, starch synthases (SS), branching enzymes, and de-branching enzymes (DBE). The starch synthesis mechanism occurs through glucose-1-phosphate with ATP through the help of the AGPase enzyme to form ADP-Glucose with pyrophospase. Then ADP-Glucose is synthesized into ADP with the help of the starch synthesizing enzyme. At the beginning of growth, amylopectin synthesis is higher than that of amylose, but during further growth, amylose and amylopectin are synthesized simultaneously (Mitsui et al., 2010).

Cassava Peel Weight

The interaction of variety and harvest age had a significant effect on the weight of cassava peel. Duncan's further test at the 5% level (Figure 3) shows that the interaction between variety and harvest age on the percentage of cassava peel of the Mentega 8-9 month variety is significantly different from the Krembi 7-8 month variety.

Figure 3. The interaction effect of variety and age of harvest on peel weight of cassava flour

Note: V1:variety of Manalagi; V2: Mentega; V3: and Krembi ; U1: harvest age of 7-8; U2 8-9 months

The difference in peel weight is thought to be due to genetic factors that will cause the components of the peel and roots to vary, along with the increase in harvest age. Nudjanah et al. (2020), added that the formation of roots that occurs during growth is greatly influenced by the environment, each cassava variety is able to absorb nutrients in the soil for the division and enlargement of root cells. Cassava varieties with different harvest ages will cause the components formed to also be different, this is because cassava with a harvest age that is not yet optimal will affect the weight and yield of roots. According to Carvalho et al. (2018), the components of roots consist of epidermis, phloem, xylem, parenchyma, sclerenchyma and meristem cells, while those included in the peel category are peridem, phloem, parenchyma and sclerenchyma. According to Setiawan et al. (2023), the peel tissue in cassava develops in line with the development of the cassava roots itself so that the harvest age will affect the percentage of peel.

Starch Content

Starch content was significantly affected by interaction between variety and harvest age. Figure 4 shows that the starch content of cassava flour in variety of Mentega harvested at 8-9 months was significantly different from Manalagi and Krembi 7-8 month varieties.

Figure 4. The interaction effect of variety and age of harvest on starch content of cassava flour

Note: V1:variety of Manalagi; V2: Mentega; V3: and Krembi ; U1: harvest age of 7-8; U2 8-9 months

Each variety has different rate of starch synthesis in line with the harvest age, so that cassava varieties with a longer harvest age will cause the enzyme's ability to synthesize starch to be faster. The enzymes found in roots can also determine the high and low starch levels because the enzymes will synthesize starch. The higher the enzyme, the faster the starch synthesis rate will be. The enzymes that play a role in starch synthesis are ADPG pyrophosphorylase (AGPase), granule bound starch synthase (GBSS), starch synthase (SS), starch branching enzyme (SBE), de-branching enzyme (DBE) and glucan (Tappiban et al., 2019). The harvest age of cassava affects the size, structure, and number of starch granules. Starch granules will enlarge and increase in number along with the level of maturity of the cassava (Oriola & Raji, 2013). However, if the harvest age of cassava is too old, the roots will become harder and woody. Cassava hardens and becomes woody due to the presence of non-starch components such as fiber and lignin, causing the starch content to decrease (Nurdjanah et al., 2007).

Amylose Content

The interaction between variety and harvest age had significant effect on amylose content of the cassava flour. Duncan's further test at 5% (Figure 5) showed that the amylose content of cassava flour of the Mentega 8-9 month variety was different and the highest among other varieties and harvest ages, while the lowest was the Krembi 7-8 month variety.

Figure 5. The interaction effect of variety and age of harvest on amylose content of cassava flour

Note: V1:variety of Manalagi; V2: Mentega; V3: and Krembi ; U1: harvest age of 7-8; U2 8-9 months

The difference in amylose content may be due to the fact that the increasing age of the plant will be followed by an increase enzymes contained in cassava , consequently the starch synthesis results are higher. This is in line with the difference in varieties that will result in differences in starch composition in cassava. Figure 5 indicates that the Mentega 8-9 month variety has higher enzymes than the Manalagi and Krembi varieties with harvest ages of 7-8 months and 8-9 months, while the Krembi 7-8 month variety is thought to have low enzymes. In this study, the enzyme worked optimally at a harvest age of 8-9 months rather than 7-8 months. Eriksson (2013) reported that the amylose content of cassava varieties Afisiafi 9.8%, Bankye Hemmaa 8.2%, and Doku Duade 10.5%. In general, the amylose content in this study was around 7-10%, it is thought that the three cassava varieties are low amylose cassava so that the highest amylose content only reaches 10% in the Mentega variety. The phenomenon of increasing and decreasing amylose content is in line with starch content. The increase in starch content is caused by the length of the cassava harvest, so that if cassava is harvested at the optimal time, the starch and amylose content in cassava will reach the optimum point (Ginting & Noerwijati, 2012).

Amylopectin Content

Duncan's further test at the 5% level (Figure 6) showed that the amylopectin content of cassava flour of the Krembi 7-8 month variety was different and the highest of the Krembi 8-9 month variety, Mentega 7-8 months and 8-9 months and Manalagi 8-9 months, while the lowest amylopectin content was the Mentega 8-9 month variety.

Figure 6. Interaction effect of variety and harvest age on amylopectin content of the cassava flour

Note: V1:variety of Manalagi; V2: Mentega; V3: and Krembi ; U1: harvest age of 7-8; U2 8-9 months

According to Rahmiati et al. (2016), the presence of genetic factors will affect the amylopectin ratio contained in the roots. This difference is thought to be due to the different amylose-amylopectin synthesis of each genotype due to the enzymes contained in each variety and harvest age. Harvesting conditions will be related to the level of starch synthesis contained in the roots, the longer the harvest age, the more starch granules will be formed. These starch granules are synthesized directly with the help of the enzymes Starch Synthase (SS), Branching Enzyme (BE), and Debranching Enzyme (DBE) which play a role in producing amylopectin. In general, amylopectin content is negatively correlated with amylose levels, if the amylose levels in cassava are high, then the amylopectin levels in cassava will be low.

Solubility

The results showed that the harvest age and cassava varieties had a very significant effect on the flour solubility at all temperature (60°C, 70°C, 80°C), while the interaction between the two had no significant effect. Duncan's further test at the 5% level (Figure 7) showed that the solubility of cassava flour at temperatures 60°C, 70°C and 80°C increased, the magnitude of the increase that occurred was due to the influence of the heating temperature.

Figure 7. The effect of temperature on solubility of cassava flour at various variety and harvest age

According to Ulfa et al. (2020), starch solubility will increase with increasing temperature. At high temperatures, there is an increase in the solubility value which indicates an increase in the solubility of amylose in starch. In this study, a temperature of 60°C had the lowest solubility value compared to the solubility value at a temperature of 80°C. High temperatures have a higher solubility level than low temperatures. High solubility in starch is due to degradation of starch due to heating at high temperatures (Senanayake et al., 2013). The 7-8 month krembi variety has the highest solubility value, while the 8-9 month manalagi variety. The high solubility value is thought to be due to the higher absorption of starch to water in the 7-8 month krembi variety compared to other varieties, so that more amylose comes out of the starch granules.

 Swelling Power

The results showed that the variety had a very significant effect (temperature 60°C, 70°C and 80°C), but the harvest age and the interaction between the two did not have a significant effect (temperature 60°C, 70°C and 80°C) on the swelling power of cassava flour.

Figure 8. The effect of temperature on swelling power of cassava flour at various variety and harvest age

Figure 8 showed that the swelling power of cassava flour at temperatures of 60ºC, 70ºC and 80º C increased with increasing temperature. The highest swelling power value was in the Krembi 8-9 variety, while the lowest swelling power value was in the Manalagi 7-8 variety. The high swelling power value in the three varieties with a harvest age of 7-8 months and 8-9 months is thought to occur due to differences in the amylose amylopectin ratio, this is because the Manalagi, Butter and Krembi varieties have low amylose levels and have high amylopectin levels, so that it will affect the high swelling power value in the three varieties. According to Kumoro et al. (2019), the swelling power value indicates the degree of crystallinity of starch granules. Starch granules with low crystallinity have high water absorption and swelling capabilities. Roots that have high swelling power indicate high amylopectin levels.

Color

Duncan's further test at 5% level (Figure 9) showed that the color score of cassava flour of Krembi variety 7-8 months was different and higher than Mentega and Manalagi varieties with harvest age of 7-8 months and 8-9 months (4.95) (tending to white). While the lowest color was Mentega variety 8-9 months with a score of 3.20 (tending to brownish white).

Figure 9. Interaction effect of variety and harvest age on color of the cassava flour

This difference is thought to be due to enzyme activity and chemical components contained in the roots. This is because enzyme activity decreases as the cassava harvest age gets older. However, in this study, Mentega variety flour tends to be brownish white in color. This is because Mentega variety cassava is included in the yellow cassava cultivar which contains carotenoid components that provide a yellow pigment that tends to be brownish in color to the resulting flour. Udoh et al. (2022), reported the total carotenoid content in yellow cassava cultivars of 12.95–14.8 μg/g. According to Akonor et al. (2023), yellow cassava cultivars contain carotenoid compounds that can function as good provitamin A when consumed.

CONCLUSION

The varieties (Manalagi, Mentega and Krembi) and harvest age of cassava grown in Palas District, South Lampung had a significant effect on the qualities of cassava flour produced. The highest value of cassava flour in moisture content was found in Manalagi cassava flour aged 7-8 months (6.85%), starch yield in Krembi cassava flour aged 8-9 months (23.46%), peel percentage in Mentega cassava aged 8-9 months (18.81%), starch content in Mentega cassava aged 8-9 months (69.11%), amylose content in Mentega cassava aged 8-9 months (10.35%), starch content in Krembi cassava aged 7-8 months (92.78), solubility in Krembi cassava aged 7-8 months, swelling power in Krembi cassava aged 8-9 months, and color in Krembi cassava aged 7-8 months (4.9 = white). It can be recommended that Krembi variety could be the best choice for flour production purposes because it had the highest starch content when harvested at 7-8 months after planting.

**REFERENCES**

Akonor, P. T., Tutu, C. O., Affrifah, N. S., Budu, A. S., & Saalia, F. K. (2023). Kinetics of β -carotene breakdown and moisture sorption behavior of yellow cassava flour during storage. *Journal of Food Processing and Preservation*, *2023*(2155029), 1–9. https://doi.org/10.1155/2023/2155029

Apea-bah, F. B., Oduro, I. N., Ellis, W. O., & Safo-Kantanka, O. (2011). Factor analysis and age at harvest effect on the quality of flour from four cassava varieties Factor Analysis and Age at Harvest Effect on the Quality of Flour from Four Cassava Varieties. *World Journal of Dairy & Food Sciences*, *6*(1), 43–54.

Bayata, A. (2019). *Review on nutritional value of cassava for use as a staple food*. *7*(4), 83–91. https://doi.org/10.11648/j.sjac.20190704.12

Carvalho, L. J., Filho, J. F., Anderson, J. V., Figueiredo, P. G., & Chen, S. (2018). Storage Root of Cassava: Morphological Types, Anatomy, Formation, Growth, Development and Harvest Time. In *Cassava*. IntechOpen Limited. https://doi.org/10.5772/intechopen.71347

Chisenga, S. M. (2021). Primary Quality Control Parameters of Cassava Raw Materials. In *Cassava - Biology, Production, and Use*. IntechOpen Limited. https://doi.org/10.5772/intechopen.97879

Eriksson, E. (2013). Flour from three local varieties of Cassava (*Manihot esculenta* Crantz) - physico-chemical properties, bread making quality and sensory evaluation. https://stud.epsilon.slu.se/5268/1/eriksson\_e\_130211.pdf

Ginting, E., & Noerwijati, K. (2012). SIFAT KIMIA DAN SENSORIS DELAPAN KLON PLASMA NUTFAH UBIKAYU PADA UMUR PANEN YANG BERBEDA. *Prosiding Seminar Hasil Penelitian Tanaman Aneka Kacang Dan Umbi*, 570–579.

Jiao, A., Yang, Y., Li, Y., Chen, Y., Xu, X., & Jin, Z. (2020). Structural properties of rice flour as affected by the addition of pea starch and its effects on textural properties of extruded rice noodles. *International Journal of Food Properties*, 23(1), 809–819. https://doi.org/10.1080/10942912.2020.1761830

Kumoro, A. C., Retnowati, D. S., Ratnawati, R., & M Widiyanti. (2019). Effect of Temperature and Reaction Time on the Swelling Power and Solubility of Gadung ( Dioscorea hispida Dennst ) Tuber Starch during Heat Moisture Treatment Process. *The 3rd International Conference of Chemical and Materials Engineering*, 1–7. https://doi.org/10.1088/1742-6596/1295/1/012062

Mitsui, T., Itoh, K., Hori, H., & Ito, H. (2010). Biosynthesis and Degradation of Starch. *Bull. Facul. Agric. Niigata Univ*, *62*(2), 49–73.

Mota-gutierrez, J., & O’Brien, G. M. (2020). *Review Article Cassava consumption and the occurrence of cyanide in cassava in Vietnam , Indonesia and Philippines*. *23*(13), 2410–2423. https://doi.org/10.1017/S136898001900524X

Ndubuisi, N. D., & Chidiebere, A. C. U. (2018). Cyanide in Cassava : A Review. *International Journal of Genomics and Data Mining*, *02*(01), 118. https://doi.org/10.29011/2577-0616.000118

Nurdjanah, S; Susilawati, S; Hasanudin, U; Anitasari, A. (2020). Karakteristik Morfologi dan Kimiawi Beberapa Varietas Ubi Kayu. *Jurnal Agroteknologi*, *14*(02), 126–136.

Nurdjanah, S., Susilawati, & Sabatini, M. R. (2007). Prediksi Kadar Pati Ubi Kayu (Manihot Esculenta) Pada Berbagai Umur Panen Menggunakan Penetrometer. *Jurnal Teknologi & Industri Hasil Pertanian*, *12*(2), 65–73.

Okrathok, S., Thumanu,K., Pukkung, C., Molee, W., & Khempaka, S. (2022) . Extraction of dietary fibers from cassava pulp and cassava distiller’s dried grains and assessment of their components using Fourier transform infrared spectroscopy to determine their further use as a functional feed in animal diets. Anim Biosci. 35,1048–1058

Oriola, K., & Raji, A. (2013). Effects of Tuber Age and Variety on Physical Properties of Cassava [ Manihot Esculenta ( Crantz )] Roots. *Innovative Systems Design and Engineering*. 4(9), 1–11, Special Issue - 2nd International Conference on Engineering and Technology Research*.*

Rahmawati, R. S. R. I., Khumaida, N., Ardie, S. W., & Sukma, D. (2022). Effects of harvest period , storage , and genotype on postharvest physiological deterioration responses in cassava. *Biodiversitas Journal of Biological Diversity23*(1), 100–109. https://doi.org/10.13057/biodiv/d230113

Rahmiati, T. M., Purwanto, Y. A., Budijanto, S., & Khumaida, N. (2016). Sifat Fisikokimia Tepung dari 10 Genotipe Ubi Kayu ( *Manihot esculenta* Crantz ) Hasil Pemuliaan. *Agritech*, *36*(4), 459–466.

Senanayake, S., Gunaratne, A., Ranaweera, K., & Bamunuarachchi, A. (2013). Effect of Heat Moisture Treatment Conditions on Swelling Power and Water Soluble Index of Different Cultivars of Sweet Potato ( Ipomea batatas ( L ). Lam ) Starch. *ISRN Agronomy*, *2013*(502457), 1–4. https://doi.org/10.1155/2013/502457

Setiawan, K., Timotiwu, P. B., Agustiansyah, Hadi, M. S., Kamal, M., Ardian, & Setiawan, W. A. (2023). Root Yield and Starch Synthase Type IV Gene Activity under Different Micro Nutrient Fertilizer and Harvest Ages on Cassava ( *Manihot esculenta*). *Chiang Mai University Journal of Natural Sciences*, *22*(1), 1–16.

Tappiban, P., Smith, D. R., Triwitayakorn, K., & Bao, J. (2019). Recent understanding of starch biosynthesis in cassava for quality improvement: A review. *Trends in Food Science & Technology*, *83*, 167–180. https://doi.org/10.1016/j.tifs.2018.11.019

Tuaño, A.P.P., Castrillo, G.A., & Viola, G.A.V. (2021). Analysis of apparent amylose content of market milled rice via digital image photometry using a smartphone camera. *Curr Res Food Sci*. 25(4), 852-861. doi: 10.1016/j.crfs.2021.11.011. PMID: 34917945; PMCID: PMC8645420.

Udoh, L. I., Agogbua, J. U., Keyagha, E. R., & Nkanga, I. I. (2022). Carotenoids in Cassava (Manihot esculenta Crantz). In *Carotenoids - New Perspectives and Application*. IntechOpen Limited. https://doi.org/10.5772/intechopen.105210

Ulfa, G. M., Putri, W. D. R., Fibrianto, K., Prihatiningtyas, R., & Widjanarko, S. B. (2020). The influence of temperature in swelling power , solubility , and water binding capacity of pregelatinised sweet potato starch The influence of temperature in swelling power , solubility , and water binding capacity of pregelatinised sweet potato starch. *International Conference on Green Agro-Industry and Bioeconomy*, 1–7. https://doi.org/10.1088/1755-1315/475/1/012036

Vanderschuren, H., Nyaboga, E., Poon, J.S., Baerenfaller, K., Grossmann, J., Hirsch-Hoffmann, M., Kirchgessner, N., Nanni,P., & Gruissema, W. (2014). Large-scale proteomics of the cassava storage root and identification of a target gene to reduce postharvest deterioration. *The Plant Cell*, 26, 1913–1924

Wahyuni, T. S., & Noerwijati, K. (2021). Tuber yield , morphology , and chemical properties variability of sweet cassava germplasm*. Ilmu Pertanian ( Agricultural Science )*. *6*(2018), 77–87.

Zainuddin, I.M., Fathoni, A., Sudarmonowati, E. , Beeching, J.R. , Gruissema, W., & Vanderschuren, H. (2018). Cassava post-harvest physiological deterioration: From triggers to symptoms. *Postharvest Biology and Technology*, 142,115–123

Reilly, K., Góomez-Váasquez, R., Buschmann, H., Tohme, J., & Beeching, J.R. (2004). Oxidative stress responses during cassava post-harvest physiological deterioration. *Plant Mol Biol*. 56, 625–641. https://doi.org/10.1007/s11103-005-2271-6