Morphophysiological Characteristics Analysis of Tuber from Multiple Sweet Potato Clones (*Ipomea batatas* Lamb.) with Mulching Application

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Keywords: Clones, Morphophysiological Characteristics, Mulching.

Abstract: The purpose of this research was to determine the morphophysiological characteristics of sweet potato tubers. The design used in this research was a Randomized Group Design consisting of the first factor, namely sweet potato clones with different color of tuber flesh (yellow, purple, orange) and the second factor was types of mulching (without mulch, plastic mulch and straw mulch). The results showed that the highest water content was in orange-fleshed sweet potato clones. Tuber flesh hardness in the three types of sweet potato was not significantly different, but the results of the observation showed that the higher the tuber water content the softer the tuber flesh. The highest betacarotene content was found in sweet potato clones with orange-fleshed tuber (845 mg/100 g) and the lowest was in sweet potato clones with purple-fleshed tuber (566 mg/100 g). The highest anthocyanin content was found in sweet potato clones with purple-fleshed tuber (10.46 mg/100 g) and the lowest was in sweet potato clones with yellow-fleshed tuber (3.73 mg/100 g). Mulching application in this study significantly affected the water content and hardness of sweet potato tuber but did not significantly affect the levels of betacarotene and anthocyanin.

1 INTRODUCTION

Sweet potato *(Ipomoea batatas* Lamb.) is an alternative food crop that can be used to diversify food to reduce dependence on rice and wheat. Sweet potatoes can be planted throughout the year and can grow on various types of soil and drought resistance (Masango, 2014).

Generally, sweet potatoes are cultivated on dry land, gardens and yards, as well as in rainfed lowland fields. Sweet potato is used as a high-fiber, feed, and industrial food ingredient. The storage capacity of the tuber is quite good. Sweet potatoes have value in modern society because they function as natural and healthy foods, this is related to the presence of anthocyanin and beta-carotene compounds they contain (Masango, 2014; Husna et al. 2013; Prabhavat at al. 2008).

Anthocyanins contained in sweet potatoes can block the rate of free radical cell damage due to nicotine, air pollution and other chemicals. Anthocyanin plays a role in preventing aging, deterioration in memory and senility, polyps, gout, people with stomach ulcers (stomach acid), coronary heart disease, cancer and degenerative diseases, such as arteosklerosis. In addition, anthocyanin also has the ability to be antimutagenic and anti-carcinogenic to mutagens and carcinogens found in food and processed ingredients, prevent disruption in liver function, antihypertensive and reduce blood sugar levels (antihypergicemic) (Rumbaoa et al. 2009; Elisabeth et al. 2007; Ameny et al. 1997).

Beta-carotene has a very yellow color and is the most active form of provitamin A, which is found in two interconnected retinol molecules. Carotenoids are present in plant chloroplasts and act as catalysts in photosynthesis carried out by chlorophyll. Beta-carotene (β-carotene) is an organic compound and is classified as a terpenoid. β-carotene is a red-orange pigment that is very abundant in plants and fruits. Beta-carotene is thought to have many functions that other compounds do not have. The amount needed by the body is only the size of milligrams per day. But if it is not fulfilled it can cause a disruption of function (Kusumaningtyas et al., 2009). The benefits of beta carotene for the body are to prevent and reduce the risk of cancer. Eating foods or fruits that contain beta-carotene is expected to support nutritional needs and

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increase immunity. The antioxidant properties found in beta carotene can protect plants and microorganisms from damaging sunlight (Listya, 2010).

In Binjai city, there are three clones commonly planted by farmers, namely yellow, purple and orange flesh clones. But until now research on the content of secondary metabolites from each clone has never been done. Sweet potato production in Binjai city in 2016 was only 771.62 tons with a harvest area of 51 ha. The low production in Binjai city apart from the limited of sweet potato cultivation fields was also caused by several obstacles including, the disturbance of pests and diseases and technical cultural actions that were still not good. Therefore, in this research mulch was used as a method of natural technical culture to control pest disorders that commonly attack sweet potato plants. In addition, the use of mulch is expected to improve the quality of sweet potato tuber characteristics.

2 MATERIALS AND METHODS

2.1 Research Area

This research was conducted in Cengkeh Turi Village, Binjai Utara District, Binjai City. and starting from July to November 2018, with an altitude of ± 28 m above sea level. Analysis of anthocyanin and beta-carotene levels was carried out at Tissue Culture Laboratory Faculty of Agriculture Universitas Sumatera Utara. Analysis of water content and tuber texture at Food Technology Laboratory Faculty of Agriculture Universitas Sumatera Utara. The materials used were 3 clones of sweet potato plants from Binjai (yellow flesh-tuber, purple flesh-tuber, orange flesh-tuber), urea fertilizer, SP 36 and KCl. The tools used include hoes, plastic mulch, straw, plastic rope, labels, scales, knives, shoves, penetrometers, stationeries and other supporting tools.

2.2 Research Methodology

The design used in this research was Randomized Block Design with 3 replications, consisted of the first factor, namely Sweet Potato clones, with 3 levels of treatment, yellow flesh-tuber clones (B1), purple flesh-tuber clones (B2) and orange flesh-tuber clones (B3). The second factor was the type of mulch; without mulch (A0), plastic mulch (A1) and straw mulch (A2).

The data were analysed by Analysis of Variance (ANOVA) and the follow-up test on the treatment that was significantly affected was by Duncan's Multiple Range Test (DMRT) at the level of 5%.

2.3 Research Implementation

The research implementation began with the cultivation of land by cleaning the grasses and then treating the soil until it is loose and then left it for 1 week. The loose soil was made into mounds with the bottom width size of 60 cm, the height was 40 cm and the distance between mounds was 40 cm and the length of the mound was 2 m as many as 27 experimental plots.

Mounds that had been prepared for planting was made into 10 cm array deep and with 30 cm spacing between plants, seedlings planted ½ part of shoot cuttings that have been provided then the soil was compacted near the base of the cuttings. Fertilization was done once during planting with a dose: 100 kg Urea/ha, SP36 50 kg/ha, KCl 50 kg/ha. Fertilization was carried out in an array at a distance of 7 cm with plants and a depth of 5 cm. Installation of Black Silver Plastic mulch (PHP) was carried out together with the installation of straw mulch which was about a week before planting. The use of straw with a dose of 5 tons/ha by placing it covered the entire surface of the beds.

Watering was done once every 2 days until 2 months, while the age of the plant after 2 months was watered once a week. Watering was done in the morning. If rainy day was not watered. Weeding was done to clean up weeds in the crop. Weeding was done at the age of 1 month after planting or when it looked a lot overgrown with weeds. Removal of the stem was aimed to avoid the formation of small tubers on the stem segment that propagates. The stem lifting treatment was carried out on plants aged 60 days after planting. Observations were made on plant samples taken from each treatment plot which was carried out after the plants were harvested at the age of 4 months.

3 RESULTS AND DISCUSSIONS

3.1 Tuber Water Content

The tuber water content in the three sweet potato clones can be seen in Table 1. The highest sweet potato water content was found in orange flesh sweet potato clones which were equal to 74.02% followed by purple flesh sweet potato clones of 69.02% and yellow flesh sweet potato clones of 63.17%. According to Antarlina (1997), sweet potatoes have high water content if the value is more than 73.5% and classified as low if the value is less than 65.5%. Based on these criteria, the orange flesh clones included as high water content and yellow flesh sweet potato clones included as low water content. Ginting et al (2015) stated that sweet potatoes which have low water content will have a high level of dry matter.

Sweet potatoes that have high levels of dry matter are suitable for flour raw materials because they will produce high yields (Antarlina, 1997). According to the National Standardization Agency (SNI 01-4493: 1998), the requirements for quality I sweet potato water content (tuber weight> 200 gr) are 60%, thus from the three clones above, it is sufficient to fulfill the requirements to be used as a source of food. Tubers with high water content such as orange flesh clones are good as a source of food consumed directly because they can facilitate digestion. As a food ingredient, tubers with low water content can be increased in water content when processing, namely by boiling or steaming. The difference in water content is mainly due to differences in clones/varieties, because the three clones are planted at the same location and season (Ginting et al, 2015).

Table 1: Water content in three sweet potato clones with the use of mulch.

Clone	Water Content (%)
Yellow flesh-tuber (B1)	63,17 b
Purple flesh-tuber (B2)	69,02 b
Orange flesh-tuber (B3)	74,02 a
Mulch	
Without Mulch (A0)	70,02
Plastic Mulch (A1)	69,81
Straw Mulch (A2)	70,34

Description: Numbers followed by the same notation on the same line showed no significant difference according to Duncan's Multiple Range Test at the level of 5%.

The data in Table 1 showed the use of mulch both plastic mulch and straw mulch, not having a significant effect on sweet potato water content. However, from the water content data obtained, the use of straw mulch, yielded quite high levels of sweet potato water content, equal to 70.34% followed by without mulch at 70.02% and the use of plastic mulch at 69.81%. The high levels of sweet potato water content on the use of straw mulch are thought to be related to the availability of soil moisture content. Application of organic mulch like straw in this crop was proven to be able to maintain soil moisture. According to Gillespie et al (1992), organic mulch is plant residues that are spread on the surface of the soil. Mulch is useful for protecting the soil surface from exposure to rain, erosion, maintaining moisture, structure, and soil fertility. Research conducted by Afandi (2013) which used organic mulch in the form of cassava peel, explained that soil water content by cassava mulch application can relatively control the loss of water from the soil compared to soil without mulch. The use of mulch is a matter that needs attention, because it can control the loss of water from the soil. In the treatment of plastic mulch, tuber moisture content was lower than in the use of straw and without mulch, because the soil water content in the treatment of plastic mulch was also low. This was because, at the time of planting, it was carried out on rainfed land hence the source of water was from rainwater. In the treatment with plastic mulch, found dry beds with inadequate rainwater supply, because most of the beds surface were covered with plastic mulch.

3.2 Tuber-fleshed Hardness

Tuber-flesh hardness was measured by a penetrometer. Measurements were made at the base, middle and end of the sweet potato, each with 1 time stabbing. The penetrometer rod was held and the penetrometer needle was inserted vertically and carefully over the sweet potato surface by pressing the needle into the sweet potato for a few seconds. The scale value can be read on the measurement results indicated by the penetrometer scale, added together then averaged. The larger the scale value shown, the softer the texture. According to Suwanto et al. (2012), the softer the sample, the penetrometer suppressor will sink deeper and show an increasingly large number.

Hardness or tuber texture is influenced by tuber moisture content. The higher the water content, the texture of the material will be softer (Purnomo, 1995). In Table 2 it can be seen that the hardness of tuber-flesh from the three clones was not significantly different. The orange flesh clones with the highest water content showed a high hardness scale (3.96 gr/mm2), which showed that this sweet potato clone was softer compared to yellow and purple flesh sweet potato clones. On the other hand, yellow flesh sweet potato clones with the lowest water content showed the lowest hardness scale (3.84 gr/mm2) which means that this sweet potato clone was the hardest compared to the other two clones. This indicated that the tuber moisture content was related to the hardness of tuber-flesh. Ginting et al (2008) research also showed the same results, namely sweet potato clones which have a small hardness value (hard texture) is having a small water content. This was presumably due to differences in other chemical compositions which can affect the hardness of tubers such as starch, especially the components of amylose, amylopectin and fiber.

Table 2: Tuber-flesh hardness in three sweet potato clones using mulch.

Clone	Tuber-flesh Hardness (kg/mm^2)
Yellow flesh-tuber (B1)	3,84
Purple flesh-tuber (B2)	3,87
Orange flesh-tuber (B3)	3,96
Mulch	
Without Mulch (A0)	4,31
Plastic Mulch (A1)	3,79
Straw Mulch (A2)	3,57

The use of mulch had no significant effect on texture or tuber hardness, but it can be seen from table 2 that the use of straw mulch showed the smallest hardness number (3.57 gr/mm2) which means it was the hardest tuber compared to the treatment of without mulch which showed the highest hardness of 4, 31 gr/mm2 which means it was the softest tuber. This was thought due to straw application increased the chemical content in the tubers, for example; starch which can cause the tuber to become harder. Because the application of organic matters such as straw can increase nitrogen in the soil, thus high nitrogen content certainly increases the rate of photosynthesis hence the results of photosynthesis is in the form of more starch produced which are stored in the tubers. This was in accordance with the statement of Djunaedi (2009) which stated that adding organic matter (bokashi) to the soil can increase the content of organic matter and soil nutrients. This was because the more bokashi fertilizer doses are given, the N contained in bokashi fertilizer is also received more by the soil. N element is a very important nutrient because it is the most needed element for plant growth. The use of plastic mulch showed a softer tuber hardness level than the use of straw mulch but harder than without mulch, this was due to the low water content in the tuber.

3.3 Tuber-flesh Beta Carotene Content

Beta Carotene is a major component of provitamin A in foods containing carotenoid compounds (van Jaarsveld et al., 2005). Beta Carotene is an ingredient that forms vitamin A in the body, which plays an important role in maintaining a healthy sense of sight (Hasyim and Yusuf, 2008). According to van Jaarsveld et al., (2005) pro-vitamin A sources are in yellow and orange fruits and vegetables and dark green leaf vegetables. The orange tuber-flesh sweet potato is one source of beta-carotene (Eluagu and Oniwamo, 2010).

Table 3: Beta-carotene content in three sweet potato clones using mulch.

Clone	Beta Carotene (mg/100 g)
Yellow flesh-tuber (B1)	6,72 ab
Purple flesh-tuber (B2)	5,66 b
Orange flesh-tuber (B3)	8,45 a
Mulch	
Without Mulch (A0)	7,55
Plastic Mulch (A1)	7,48
Straw Mulch (A2)	5,80

Description: Numbers followed by the same notation on the same line showed no significant difference according to Duncan's Multiple Range Test at the level of 5%.

The highest beta-carotene content was found in orange-fleshed sweet potato clones of 845 mg/100 g and the lowest was in purple-flesh sweet potato clones of 566 mg/100 g (Table 2). Sebuliba et al. (2001) stated that the beta-carotene content contained in orange tuber-flesh cultivars was higher than yellow and white.

The use of mulch also had no significant effect on beta-carotene content in the tubers. Sweet potatoes cultivated without using mulch had the highest tuber beta-carotene content compared to sweet potatoes which are cultivated using mulch. This was allegedly because the content of beta carotene in tubers is influenced by environmental factors, especially the availability of water. Treatment without the use of mulch tends to cause lower groundwater content compared to the use of mulch. Masango (2014) research also showed that watered sweet potato plants every day tended to have lower beta carotene content than sweet potatoes which were not watered.

3.4 Tuber-flesh Anthocyanin Content

Sweet potato anthocyanin levels vary, depending on the intensity of purple color on the tuber-flesh. The darker the purple color of the tuber, the higher the level of anthocyanin (Ginting and Utomo, 2011). The data in Table 4 showed that the highest anthocyanin content was found in purple flesh sweet potato clones which were 10.46 mg/100 g and the lowest was in yellow flesh sweet potato clones of 3.73 mg/100 g. Friedman and Levin (2009), stated that the color of sweet potato flesh is influenced by the content of beta-carotene and anthocyanin. Orange-flesh sweet potato is rich in beta carotene sources, while purple-flesh sweet potato is rich in anthocyanins and phenolic compounds. The difference in anthocyanin contents can also be caused by the season and growing environment of the plant (Damanhuri 2005) which affects the intensity of tuber color. Anthocyanin accumulation is driven by environmental factors such as light, temperature, nitrogen sources, pathogen attacks and some growth regulating substances such as cytokinin, gibberellic acid (GA) and ethylene (Kim and Kim, 2010).

Table 4: Anthocyanin contents in three sweet potato clones with the use of mulch.

Clone	Anthocyanin (mg/100 g)
Yellow flesh-tuber (B1)	3,73
Purple flesh-tuber (B2)	10,46
Orange flesh-tuber (B3)	5,86
Mulch	
Without Mulch (A0)	7,72
Plastic Mulch (A1)	6,55
Straw Mulch (A2)	5,79

The data in Table 4 also showed that the use of mulch did not affect the anthocyanin contents in the tuber. Anthocyanin content in tubers is influenced by the type of clones and environmental factors, especially the soil water content. Sweet potato plants that were not given mulch produce tubers with the highest anthocyanin content compared to other treatments. Research results from Oktavidiati et. al (2013) also showed that anthocyanin content in Red Meniran leaves (*Phyllanthus urinaria* L.) with drought stress treatment to 25% field capacity higher than 100% groundwater content and 75% field capacity. This was thought to be related to the function of anthocyanin as an antioxidant whose activity increases when plants experience environmental stress.

4 CONCLUSIONS

The results showed that 3 sweet potato clones which were commonly planted in Binjai City had various levels of water and various content of beta-carotene and anthocyanins. The use of mulch in sweet potato planting systems in this research significantly affected the water content and hardness of sweet potato tuber but did not significantly affect the levels of beta carotene and anthocyanin in the tuber.

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