

A STUDY OF PHYSICAL AND CHEMICAL CHARACTERISTICS OF VARIOUS SWEET POTATO CLONES (*Ipomoea batatas* L.)

Mardhiah Hayati¹, Sabaruddin¹, Efendi¹, Ashabul Anhar¹, Rita Hayati¹, Ari Sandi¹

¹Departement of Agrotechnology, Syiah Kuala University,
T. Hasan Krueng Kale street no. 10 Kopelma Darussalam, Banda Aceh, 23111, Indonesia

E-mail : mardhiahislahuddin@gmail.com ; sabaruddin_zakaria@yahoo.com ; efendi123@yahoo.com ; ash.anhar@gmail.com ; ritanabila@yahoo.com ; sandysipayung75@gmail.com

ABSTRACT

Marketable sweet potato production should meet consumer preferences of size, shape, and colour. This study is aimed at investigating physical and chemical characteristics of various clones of sweet potato taken from CIP-SEA Bogor and Aceh local clones. The research was conducted at Plant Physiology Laboratory and Animal Fodder Laboratory of the Faculty of Agriculture, Syiah Kuala University. The study took place from September to October 2014. The clones used in this study were 19 sweet potato clones obtained from Center of International Potato-South East Asia (CIP-SEA) Bogor and 4 local clones from Saree and 1 from Bener Meriah, The Province of Aceh. The study used Completely Randomized Design of non-factorial, where clones were treated with 3 replications. Data were analyzed using F Test and Duncan's Multiple Range Test at a confidential level of 0.05. Observation on sweet potato tubers included physical properties (tuber diameter, length and colour) and chemical properties (dry matter content). Colour was measured by digital camera with intensity levels of red, green and blue light. The results showed that the largest diameter and tuber length were found in CIP-513, CIP-B9, SARI and CIP-W. The highest dry matter content was found in CIP-CER (69.10%). The highest *L* (brightness) values was on CIP-204 and Saree yellow, and the *a* (red) values were found in CIP-1945, CIP-513, CIP-440137, CIP-286, CIP-287, CIP-W, CIP-W104, Saree Cream, while *b* (yellow) values were found on CIP-LSQ and Saree yellow.

Key words: clones, colour, brightness, red, yellow, dry matter

I. INTRODUCTION

Diversification of food can be enriched by utilizing sweet potatoes to reduce dependence on rice. Sweet potatoes are rich in carbohydrates, vitamins and minerals. It is also a storehouse of many important pigments like β -carotene, anthocyanin, which act as antioxidants [1]. Dry matter is an important feature of good sweet potato varieties, as represented by 70% of starch [2]. In Indonesia, 89% of sweet potato production is consumed as food with consumption level of 7.9 kg/capita/year [3]. The rest are used as raw materials of food industry and as animal fodder.

Sweet potatoes are varied in physical properties such as shape, colour of skin and flash, and its texture according to their varieties. The shape and tuber size are among the main quality criteria that influence its price. Oval tuber shape without many bumps will ease the process of peeling and minimize scraps. Tubers at average weight of 200-250 g and uniform takes relatively faster peeling time than small or large tuber [4]. The chemical properties of sweet potato are influenced by its varieties and seasons. In dry season, the same varieties may produce a higher starch properties than in rainy season [5].

The basic economic value of sweet potato products for farmers and industries is the dry matter content which is the chemical potential of the crop and reflects its true biological yield. Since most processed products are sold on dry matter basis, it is important that as much dry matter as possible is recovered from a given quantity of fresh tubers. Dry matter contents are the widely accepted measurements of potato quality, and these may be affected by genotype, season, tuber size, planting density and location [6], [7].

Therefore, information on physical and chemical characteristics in a variety of sweet potato clones need to be studied and used as a baseline of post-harvest development of sweet potatoes, considering sweet potatoes as an alternative source of food commodities. Sweet potatoes that are acceptable by consumers can be developed to facilitate its development and marketability.

This study is aimed at studying physical and chemical characteristics of various sweet potato clones taken from CIP-SEA Bogor and Aceh's local clones.

II. MATERIALS AND METHODS

This study was conducted at Plant Physiology and Animal Fodder Laboratory of Faculty Agriculture, Syiah Kuala University which took place from September to October 2014.

In this study, tools such as analytical scales, ovens, petridish, ruler, slide, plate, spoon, camera, and others were used, 19 clones of sweet potato clones were derived from Center of International Potato - South East Asia (CIP-SEA) in Bogor, 4 Aceh's local clones from Saree and Bener Meriah (Table 1). Those sweet potatoes were cultivated in the District of Bukit, Municipal of Bener Meriah, at the altitude of 1400 meters above sea level, during dry season from April to August 2014.

The experimental design used in this study was Completely Randomized Design with non-factorial pattern. Treatment of the study consisted of 24 levels of clonal species, with 3 replications. The arrangement of sweet potato tuber treatment is presented in Table 1. The data were analyzed by F test. If the F test result showed a real effect, then the analysis was continued with Duncan's Multiple Range Test (DMRT) test at confidential level of 5%.

Table 1. Types of sweet potato clones used in the study

Clone Code (Clone Types)	Origin	Flash Colour	Skin Colour
K ₁ (CIP-LSQ)	Local Bogor	Cream	Yellow
K ₂ (CIP-1945)	Breeding CIP ESEAP	A little Orange	Purple
K ₃ (CIP-MAN)	Local Kuningan, North Java	Cream	Cream
K ₄ (CIP-513)	Breeding CIP-Lima, Peru	White	Purple
K ₅ (CIP-CER)	Local Bogor, North Java	Orange	Purple
K ₆ (CIP-BDG)	Local Bandung	Dark Purple	Dark Purple
K ₇ (CIP-WHI-5)	Breeding CIP ESEAP	White	Rather Yellow
K ₈ (CIP-W86P)	Breeding CIP ESEAP	Orange	Purple
K ₉ (CIP-B9)	Local Kuningan	Cream	Rather Yellow
K ₁₀ (CIP-204)	Breeding CIP ESEAP	White	Rather Yellow
K ₁₁ (CIP-440137)	Breeding CIP-Lima, Peru	White	Purple
K ₁₂ (CIP-AC)	Local Kuningan, Jawa Barat	Orange	Purple
K ₁₃ (CIP-B19)	Breeding CIP ESEAP	White	Purple
K ₁₄ (CIP-286)	Breeding CIP-Lima, Peru	Orange	Purple
K ₁₅ (CIP-287)	Breeding CIP-Lima, Peru	A little Yellow	Purple
K ₁₆ (CIP-GA)	Local Bogor	Orange	Purple
K ₁₇ (SARI)	Breeding BALITKABI	A little Yellow	Purple
K ₁₈ (CIP-W)	Breeding CIP ESEAP	Dark Purple	Dark Purple
K ₁₉ (CIPW104)	Breeding CIP ESEAP	Yellow	Purple
K ₂₀ (Saree Cream)	Local Saree	Cream	Purple
K ₂₁ (Saree Orange)	Local Saree	Orange	Yellow
K ₂₂ (Saree Purple)	Local Saree	Purple	Cream
K ₂₃ (Saree Yellow)	Local Saree	Yellow	Rather Orange
K ₂₄ (Bener Meriah Yellow)	Local Bener Meriah	Yellow	Rather Orange

Sweet potatoes harvested when the plants were 5 months old. Harvesting done when the plant leaves have started to yellow and tubers were enlarged.

Research observation on sweet potato tubers consist of physical properties (tuber diameter, length, and colour) and chemical properties (dry matter content). Colour measurement is determined based on digital camera with the intensity of red, green, and blue (RGB) taken with Exilim Casio camera. The RGB values of the sweet potato clones were then converted to the values of L , a , and b , by the equation:

$$X = 0,607R + 0,174G + 0,201B \quad (1)$$

$$Y = 0,299R + 0,587G + 0,114B \quad (2)$$

$$Z = 0,066G + 1,117B \quad (3)$$

The conversion equation used to determine L , a , and b values are as follows:

$$L = 25 \left[\frac{100Y}{Y_0} \right]^{\frac{1}{3}} - 16 \quad (4)$$

$$a = 500 \left[\left(\frac{X}{X_0} \right)^{\frac{1}{3}} - \left(\frac{Y}{Y_0} \right)^{\frac{1}{3}} \right] \quad (5)$$

$$b = 200 \left[\left(\frac{Y}{Y_0} \right)^{\frac{1}{3}} - \left(\frac{Z}{Z_0} \right)^{\frac{1}{3}} \right] \quad (6)$$

where :

$X_0 = 98,071$

$Y_0 = 100$

$Z_0 = 118,225$

In conversion equation, the value of L denotes the brightness [$L = 100$ (white) and $L = 0$ (black)], the value of a denotes red when it was positive, gray when it was 0, and green when it was negative. While the value of b denotes yellow when the value was positive, the gray when it was 0, and blue when it was negative [8].

III. RESULTS AND DISCUSSION

The result of F test showed that variations in sweet potato clones have a highly significant effects on diameter, length, dry matter, L (brightness), a (red), b (yellow) values of sweet potato tuber. Average diameter and length of sweet potato tubers, and dry matter content are presented in Table 2, while L (brightness), a (red), and b (yellow) values due to clonal type treatment are presented in Table 3.

The largest diameter of sweet potato tubers was found in clone K₁₈ (CIP-W) which is not significantly different from K₁ (CIP-LSQ), K₄ (CIP-513), K₇ (CIP-WHI-5), K₉ (CIP-B9), K₁₄ (CIP-286), K₁₇ (SARI), and K₁₉ (CIP-W104). While the smallest diameter of sweet potato tuber was found in clone K₁₀ (CIP-204) which is not significantly different from K₂ (CIP-1945), K₃ (CIP-MAN), K₅ (CIP-CER), K₈ (CIP-W86P), K₁₁ (CIP-440137), K₁₂ (CIP-AC), K₁₃ (CIP-B19), K₁₅ (CIP-287), K₁₆ (CIP-GA), K₂₀ (Saree Cream), K₂₁ (Saree Orange), K₂₃ (Saree Yellow), and K₂₄ (Bener Meriah Yellow).

Table 2. Average diameter and length of sweet potato tuber (cm) and dry matter content (%) according to clone type treatment

Clones	Tuber Diameter (cm)	Tuber Length (cm)	Dry matter (%)
K ₁ (CIP-LSQ)	7.30 (2.70) e-g	11.60 (3.40) a-c	51.35 l
K ₂ (CIP-1945)	4.83 (2.20) a-d	12.70 (3.56) a-d	28.10 d-f
K ₃ (CIP-MAN)	5.43 (2.32) a-e	12.93 (3.58) a-e	34.80 i
K ₄ (CIP-513)	8.67 (2.91) g	20.33 (4.51) f	26.45 d
K ₅ (CIP-CER)	4.30 (2.07) a-d	10.73 (3.25) ab	69.10 m
K ₆ (CIP-BDG)	5.80 (2.39) b-e	13.60 (3.68) a-e	26.90 de
K ₇ (CIP-WHI5)	8.20 (2.86) fg	9.83 (3.13) a	22.10 bc
K ₈ (CIP-W86P)	4.10 (2.01) ab	16.93 (4.10) c-f	28.00 d-f
K ₉ (CIP-B9)	8.10 (2.84) fg	17.73 (4.21) d-f	28.55 e-g
K ₁₀ (CIP-204)	3.50 (1.87) a	14.07 (3.75) a-e	23.65 c
K ₁₁ (CIP-440137)	4.57 (2.14) a-d	16.97 (4.10) c-f	32.55 h
K ₁₂ (CIP-AC)	5.23 (2.29) a-e	12.77(3.57) a-d	30.20 g
K ₁₃ (CIP-B19)	4.90 (2.21) a-d	15.73 (3.96) b-f	52.60 l
K ₁₄ (CIP-286)	6.27 (2.50) c-g	10.73 (3.24) ab	37.95 j
K ₁₅ (CIP-287)	5.37 (2.28) a-e	15.17 (3.88) b-f	38.65 j
K ₁₆ (CIP-GA)	5.20 (2.28) a-e	21.3 (4.57) f	30.25 g
K ₁₇ (SARI)	8.30 (2.87) g	15.40 (3.89) b-f	21.55 b
K ₁₈ (CIP-W)	8.73 (2.95) g	15.97 (3.99) c-f	30.50 g
K ₁₉ (CIP-W104)	6.50 (2.54) d-g	9.73 (3.11) a	41.65 k
K ₂₀ (Saree Cream)	4.20 (2.04) a-c	17.83 (4.21) d-f	17.00 a
K ₂₁ (Saree Orange)	5.33 (2.30) a-e	18.33 (4.28) d-f	27.50 d-f
K ₂₂ (Saree Purple)	5.87 (2.42) b-f	21.20 (4.60) f	29.15 fg
K ₂₃ (Saree Yellow)	5.03 (2.24) a-e	17.47 (4.18) d-f	18.10 a
K ₂₄ (Bener Meriah Yellow)	4.57 (2.12) a-d	19.00 (4.33) ef	39.80 j

Description: The number followed by the same letter in the same column is not significantly different at 5% confidential level of the DMRT test. The number (...) transformation value \sqrt{x}

The longest sweet potato tuber was found in clone K₂₂ (Saree Purple) which is not significantly different from clones K₄ (CIP-513), K₈ (CIP-W86P), K₉ (CIP-B9), K₁₁ (CIP-440137), K₁₃ (CIP-B21), K₁₅ (CIP-287), K₁₆ (CIP-GA), K₁₇ (SARI), K₁₈ (CIP-W), K₂₀ (Saree Cream), K₂₁ (Saree Orange), K₂₃ (Saree Yellow), and K₂₄ (Bener Meriah Yellow). While the shortest sweet potato tuber was found in clones K₁₉ (CIP-W104) which is not significantly different from

clones K₁ (CIP-LSQ), K₂ (CIP-1945), K₃ (CIP-MAN), K₅ (CIP-CER), K₆ (CIP-BDG), K₇ (CIP-WHI-5), K₁₀ (CIP-204), K₁₂ (CIP-AC), and K₁₄ (CIP-286). The largest and longest tubers were K₄ (CIP-513), K₉ (CIP-B9) and K₁₇ (SARI) clusters with average diameter of 83.6 mm and tuber length of 178.2 mm. According to United States Department of Agricultural (USDA), this clone similar to U.S. No 1 grade and considered as an excellent class, with its desirable size for processing. The average diameter and length of tubers of these clones were also higher than the results obtained in previous study [9] presented measurements of agricultural products and reported bulk density of 1.12 g cm⁻³ for potato the graded potato between 57 and 69 mm. While the shortest and smallest tubers were K₂ (CIP-1945), K₃ (CIP-MAN) and K₅ (CIP-CER) with average diameter of 48.5 mm and length of 121.2 mm.

The diameter, length, and thickness of the tubers are among important physical characters of sweet potato. This is a very important parameter in the agronomy production in terms of grading, handling, processing and packaging systems, in addition to the size and weight of the production volume [10], [11]. The variation among the cultivars can be attributed to variation in size, shape, difference in agro - climatic conditions and difference in rate of absorption of nutrients that affects the growth of tubers [12]-[14]. These variations could be due to genotype and environmental conditions during growth period [12], [15]. Varietal difference is one of the most important factor that affects the physical parameters of tubers. In addition, there were also significant effects of land preparation methods on tuber length, with the longest tuber length recorded for sweet potato vines grown on plots with ploughing, harrowing and ridging [16].

The highest dry matters of tubers was obtained in K₅ (CIP CER) of 69.10% and significantly different from K₁ (CIP LSQ) and K₁₃ (CIP B19), each of 51.35% and 52.60%. This results are higher than the highest dry matter content under the studies of Kyukei No: 63 (51.1%) and Istanköy (44.2%) in Turkey [17]. Dry matter contents obtained in this study were also considerably higher than that reported by Caliscan [18]. It is reported that high dry matter content is an important characteristic of a good sweet potato variety [19] and [2]. Dry matter content above 25% is important for farmers in adopting a new variety of sweet potato. For industrial use of sweet potato varieties with a dry matter content that is above 30% of fresh root weight is required [20].

High dry matter content is also the main characteristic preferred by consumers and processors of sweet potato. The development of a new variety of sweet potato with high dry matter content requires efficient methods of crossing, selection of clones from recombined parents and evaluation of the effects of genetic by environment interactions [20]. However, [21] reported that smaller tubers may produce higher dry matter and starch than the larger ones. More dry matter and starch were accumulated during the dry season than the wet season. The production of sweet potato tubers with high dry matter and starch content for industrial processing could be achieved with the use of irrigation facilities during the dry season. The higher dry matters contents of this study may be influenced by cultivation in the dry season.

Table 3. Average L (brightness), a (red), b (yellow) values in sweet potato tubers according to type of clones

Clones	Physical Characteristics Analysis (Colour)		
	L Value (Brightness))	Value of a (Red)	Value of b (Yellow)
K ₁ (CIP-LSQ)	94.70 (9.73) j	10,75 (3,27) b	40,10 (6,33) n
K ₂ (CIP-1945)	76.69 (8.76) b	27,50 (5,24) gh	14,80 (3,85) h
K ₃ (CIP-MAN)	89.26 (9.45)gh	11,25 (3,35) bc	21,00 (4,59) j
K ₄ (CIP-513)	84.66(9.20)d-f	28,75 (5,36) gh	12,60 (3,55) g
K ₅ (CIP-CER)	77.00 (8.78) b	16,25 (4,03) de	10,80 (3,28) e-g
K ₆ (CIP-BDG)	73,48 (8,57) a	16,00 (4,00) de	9,60 (3,10) d-f
K ₇ (CIP-WHI5)	90,75 (9,53) hi	7,00 (2,65) a	31,50 (5,61) l
K ₈ (CIP-W86P)	84,55(9,20)d-f	14,25 (3,77) b-d	24,70 (4,97) k
K ₉ (CIP-B9)	81,21 (9,01) c	10,75 (3,28) b	21,00 (4,58) j
K ₁₀ (CIP-204)	100,29 (10,02)k	6,00 (2,45) a	30,20 (5,50) l
K ₁₁ (CIP-440137)	81,60 (9,04) c	28,25 (5,32) gh	9,10 (3,02) de
K ₁₂ (CIP-AC)	77,89 (8,83) b	20,50 (4,53) ef	19,90 (4,46) ij
K ₁₃ (CIP-B19)	88,36 (9,40)gh	15,50 (3,93) c-e	1,30 (1,14) a
K ₁₄ (CIP-286)	95,39 (9,77) j	25,00 (5,00) f-h	2,40 (1,55) b
K ₁₅ (CIP-287)	83,04 (9,11)cd	29,50 (5,44) gh	18,20 (4,27) i
K ₁₆ (CIP-GA)	86,58(9,31)e-g	23,00 (4,80) fg	8,70 (2,95) d
K ₁₇ (SARI)	88,79 (9,43)gh	23,00 (4,80) fg	7,90 (2,81) d
K ₁₈ (CIP-W)	83,73(9,15)c-e	24,75 (4,98) f-h	5,00 (2,24) c
K ₁₉ (CIP-W104)	76,33 (8,74) b	28,25 (5,32) gh	11,40 (3,38) fg
K ₂₀ (Saree Cream)	82,45 (9,08)cd	30,50 (5,52) h	15,10 (3,88) h
K ₂₁ (Saree Orange)	94,70 (9,73) j	14,25 (3,78) b-d	34,90 (5,91) m
K ₂₂ (Saree Purple)	93,34 (9,66) ij	10,50 (3,24) b	35,80 (5,98) m
K ₂₃ (Saree Yellow)	102,81 (10,14)k	5,75 (2,25) a	36,90 (6,08) mn
K ₂₄ (BM Yellow)	87,13 (9,34) fg	16,25 (4,02)de	29,20 (5,41) l

Description: The number followed by the same letter in the same column is not significantly different at the 0.05% level of the DMRT test. The number (...) transformation value \sqrt{x}

Table 3 shows that the highest *L* value (brightness) was found in K₂₃ (Saree Yellow) with yellow tuber flesh that was not significantly different from clone K₁₀ (CIP-204), while the least bright is found in K₆ (CIP -BDG) with dark purple tuber. The value of *a* that denotes the red green chromatic colour. The highest *a* (red) value of sweet potato tubers was found in K₂₀ (Saree Cream) with creamy flesh colour that is not significantly different from K₂ (CIP-1945), K₄ (CIP-513), K₁₁ (CIP-440137), K₁₄ (CIP-286), K₁₅ (CIP-287), K₁₈ (CIP-W), and K₁₉ (CIP-W104). While the lowest *a* (red) value was found in K₂₃ (Saree Yellow) which is not significantly different from K₇ (CIP-WHI-5) and K₁₀ (CIP-204) with white flesh colour in average.

The value of *b* shows the blue yellow chromatic colour. The highest value of *b* (yellow) was found in K₁ (CIP-LSQ) which is not significantly different from K₂₃ (Saree Yellow), while the lowest is in K₁₃ (CIP-B19).

The colour of sweet potato tubers as well as the colour of the skin differ among clones, this is due to the genetic differences. Colour of sweet potato skin varies and is not always the same with the colour of its tuber flash. Tuber skin may be white, yellow, purple, orange, and red, while the flesh colour may be white, yellow, orange, and purple [22].

Orange and yellow fleshed cultivars recorded higher total carotenoids, β -carotene, and β -carotene-5,6-monoepoxide contents than cream- and white-fleshed cultivars [23]. It has been reported that beta-carotene, a major precursor of vitamin A, serves as an important nutritional component in foods, as [24] and that it has anti-cancer, anti-aging, and anti-ulcer properties, Due to their antioxidative activity [25]. When a food or product has an appealing colour it may cause a person's appetite to try the product because colour is one of the visual profiles that becomes the consumer's first impression of a product [26].

IV. CONCLUSION

Sweet potato tubers that have the largest diameter and tuber length are found in CIP-513, CIP-B9, SARI, and CIP-W clones. The highest *L* (brightness) values are in the CIP-204 and Saree yellow clones. The *a* (red) values were in CIP-1945, CIP-513, CIP-440137, CIP-286, CIP-287, CIP-W, CIP-W104, Cream saree, and *b* (yellow) value were in CIP-LSQ and Saree yellow clones. The highest dry matter content was found in CIP-CER (69.10%).

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