Chemical and sensory analysis of several sweet potatoes (Ipomoea batatas L.) clones

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Abstract. This study aims to find out suitable chemical composition and sensory test of 24 sweet potato clones to select clones that meet consumer preferences. This study was conducted at the Laboratory of Animal Food, Faculty of Agriculture, Universitas Syiah Kuala in September to October, 2015. The clones used in this study were nineteen sweet potato clones passed by CIP-SEA Bogor, Indonesia, and five Local clones. The study used Completely Randomized Design of non-factorial where clones were treated. The highest moisture content and ash were found in Cream Saree, local clones (83%; 4.77%). The highest protein content was found in CIP-BDG and CIP-WHI5 clones (4.89%; 4.58%), and the highest carbohydrate content (56.10%) was found in CIP-CER. The sensory results were that the preferred round tuber shape was found on CIP-513 clone, the preferred texture of tuber skin and soft tuber flesh were found on CIP-MAN, CIP-BDG, CIP-WHI5, CIP-204, CIP-B19, CIP-287, CIP-GA, SARI, local Cream Saree, local Orange Saree, the preferred skin color and purple tuber flesh were found in CIP-1945 clones, CIP-BDG, and CIP-W, the preferred sweet tuber taste was found in CIP-B9 clones, and the overall reception criteria was found on the CIP-GA clone.

1. Introduction
Sweet potato (Ipomoea batatas L.) plays an important role as food, industrial raw materials and animal feed. This plant is the main carbohydrate source after rice, wheat, corn and sweet potatoes [1]. Sweet potato is the most efficient food source as a source of carbohydrates per unit time. Judging from its chemical composition, sweet potatoes in addition to being a source of carbohydrates also contain protein, several vitamins, and minerals. Different sweet potato varieties have different levels of carbohydrates, fiber content, ash content and beta-carotene [2][3].

Indonesia is the fifth largest sweet potato exporter in the world, but Indonesia's export value in the past five years has decreased [4]. This decrease in value can be affected by a decrease in the area of land for planting and the use of inherited seeds that may reduce its productivity. The use of newly introduced seeds is expected to overcome these problems. Sweet potato research using several types of clones from CIP-SEA (Centro International de la Papa-South East Asia) in Bogor as a provider of germplasm and diversification can be used to obtain tubers with suitable chemical content and preferred by consumers.

The chemical content of sweet potatoes is very much determined by its genetic and environmental factors such as climate and soil conditions. The status of the chemical content of sweet potato cultivars

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varies greatly depending on the variety of the plants, where they grow, such as type of climate, soil and other factors [5]. Along with the development of sweet potato germplasm that continues to increase, it is necessary to know its chemical content, because it is closely related to its utilization. In addition to chemical composition, it is also necessary to know the preferences of consumers. Varieties that are broadly adapted, and produce high are not necessarily accepted in an area because they may not be liked by farmers/consumers [6]. Therefore sensory testing is needed to determine the preferences of consumers. Sensory testing is testing with the senses, which is very widely used to assess food quality [7].

Assessment of texture, color, shape, aroma, and taste of food has high relevance to product quality because it relates directly to consumer tastes. However, the weaknesses and limitations of sensory testing are caused by sensory traits that cannot be described [8]. Information from the evaluation of chemical composition (moisture content, ash content, protein content, fat content and carbohydrate content) and sweet potato sensory test (tuber shape, tuber skin texture, tuber flesh texture, tuber skin color, tuber flesh color, tuber taste, overall acceptance of tubers) can be used as consideration in selecting the type of clone to contribute to the development of superior varieties and can be used as baseline data for the development of post-harvest sweet potato especially in the area where sweet potato is an alternative food commodity.

Existing sweet potato varieties are often decreasing its yields due to pests and diseases or have mutated further, so that new varieties are needed to expand markets. New types of sweet potato clones need to be continuously evaluated before being released to ensure favorable results and quality. Prior to this study, a site-specific adaptability test was conducted on sweet potato clones for its vegetative and tuber yields. This study extends prior study and focuses on chemical composition and sensory analysis. The types of clones with favorable nutritional contents and are accepted by consumers used as a reference to be introduced for food, as a substitute for rice. The purpose of this study is to find out clones with suitable chemical content and are preferred by consumers.

2. Materials and methods

2.1. Place and time
This research was conducted at the Laboratory of Animal Food at the Faculty of Agriculture, Universitas Syiah Kuala, which took place in September to October, 2015.

2.2. Planting materials and tools
The sweet potato clones used in this study consisted of 19 clones as introduced by the International Potato Center-South East Asia (CIP-SEA) in Bogor, namely: CIP-LSQ, CIP-1945, CIP-MAN, CIP-513, CIP-CER, CIP-BDG, CIP-WHI5, CIP-W86P, CIP-B9, CIP-204, CIP-440137, CIP-AC, CIP-B19, CIP-286, CIP-287, CIP-GA, SARI, CIP-W, CIP-W104, and five local Aceh clones, namely: Saree Cream, Saree Orange, Saree Purple, Saree Yellow, and Bener Meriah Yellow, which have been cultivated in Takengon, Bukit District, in the municipality of Central Aceh. Testing tools that were used in this study were oven, analytical scales, stoves, pans, knives, 80 mesh sieves, plates, spoons, furnace, Soxhlet, Kjledahl flask, distillation apparatus, destruction equipment, and water bath.

2.3. Tuber preparation
Sweet potatoes were harvested when the plants are at five months after planting. Harvesting was done with the characteristics that the leaves of the plant have begun to yellow and the tuber has enlarged. Harvesting was done by sampling the tubers on the beds using a small hoe and then taking the plants. Yields are put into plastic samples, then collected in the yield shelter according to the type of clone.

2.4. Chemical content analysis
The sample preparation for the chemical content was carried out at two days after harvesting. The samples were five tubers taken from each treatment, then washed, peeled, and slice to a size of 2 - 3
mm using a grated knife. The tubers were then heated in an oven at 60°C for 5 h. After removed from the oven, they are milled and sieved with 80 mesh size sieve, and the samples were ready for analysis. The samples for chemical tests, on a dry weigh base, were put into a plastic bag and during chemical analysis, the samples were kept in a refrigerator [9]. The chemical content analysis was conducted with the standardized method of analysis, namely the Association of Official Analytical Chemists Official [10]. The analysis included moisture content (oven method), ash content (furnace method), crude protein (Kjeldahl method), crude fat (Soxhlet method) and carbohydrate levels which were analyzed by difference method.

2.5. Sensory test
Sensory test with descriptive analysis method was carried out on steamed tubers for 20 min after boiling with water. After the tuber was steamed, peel and cut into pieces of 2 × 2 cm and served on a plate by giving the treatment code. The sensory test used 24 panelists and a questionnaire. Panelists are semi-trained panelists from students of the Agrotechnology Study Program at the Faculty of Agriculture, Universitas Syiah Kuala. The questionnaire uses a scale of 1 - 15. Each panelist tested three types of samples and after completing the tuber testing, they were advised to take drinking mineral water, then take another steamed tuber testing.

2.6. Data collections
The attributes of testing were moisture content, ash content, crude fat content, crude protein content, carbohydrate content, and sensory tests on tuber shape, tuber skin texture, flesh texture of tuber, tuber skin color, flesh color of the tuber, tubers taste, and overall acceptance of tubers.

2.7. Experimental design
This study uses a Randomized Completely Block Design in non-factorial of the study on 24 types of clones, with two replications. The first chemical treatment test applied to five sweet potato clones. The second study was sensory testing with three replications.

2.8. Statistical analysis
Data was analyzed using ANOVA and if the treatment had a significant effect, it was continued to Duncan’s New Multivariate Range Test at the level of 5%. Data were analyzed using SPSS version 22.0.

3. Results and discussion
3.1. Effect of clone types on chemical properties of sweet potato tubers
The results of the F test showed that the clone types had a very significant effect on moisture, ash, crude protein and carbohydrates content, and had no significant effect on crude fat content. From the analysis of chemical properties of sweet potato tubers due to clone types the average moisture, ash, crude fat, crude protein, and carbohydrate content are shown in Table 1. The highest levels of water and ash of sweet potato tubers were found in Crea Saree clones each of 83.0% and 4.77%, while the lowest moisture content was in CIP-CER clone at 30.96%. The lowest ash content was found in the Yellow Saree clone at 1.91% and is still higher than the average ash content of 0.93% [11].

Food with higher moisture content will decay faster than food with lower moisture content [12]. The lower the moisture content the slower the growth and proliferation of microorganisms, so the decay process will last longer. According to Ref. [13], the moisture content can affect the decrease in food quality in terms of chemistry and microbiology, while the higher ash content in food shows a high mineral content but can also affect enzymatic reaction which causes a decrease in the degree of white flour. Sweet potato tuber fat level tends to be higher in CIP-287 clones which are 8.44% and lower in CIP-LSQ clones which are 3.55%, each with cream or yellow flesh color, although statistically not significantly different. The crude fat content of sweet potato tuber tends to be higher in
CIP-287 clone which is 8.44% and lower in CIP-LSQ clone which are 3.55%, each with cream or yellow flesh color, although statistically not significantly different.

The highest crude protein content of sweet potato tubers was found on CIP-BDG at 4.89% with dark purple tuber and in CIP-WHI5 at 4.58% with a white tuber, while the lowest was in CIP-AC at 2.24% with the orange tuber. These results are consistent with the study of [11]. In terms of protein level, CIP-BDG and CIP-WHI5 were higher than 3%. Reference [14] stated that the sweet potato protein content is between 1.4 - 9.4%, while Ref. [15] stated that sweet potato protein levels ranged from 1 - 3%.

The highest carbohydrate level of sweet potato tuber was found in CIP-CER, which was 56.10%, higher than Papua Salosa variety of 35.37% [11], while the lowest is in Cream Saree which was 1.07%. Clone of CIP-CER was higher in carbohydrate content with lower moisture content (30.96%). According to Ref. [15] carbohydrate composition of sweet potato is 10 - 30% and the moisture content is 70 - 80%. According to Ref. [16] carbohydrates in food generally show some changes during the processing or cooking process. Common changes include solubility, hydrolysis, and gelatinization of starch.

### Table 1. Analysis of chemical properties due to types of clones in sweet potato tubers.

| Clone Types  | Moisture content (%) | Ash content (%) | Crude fat content (%) | Crude protein content (%) | Carbohydrate content (%) |
|--------------|----------------------|----------------|-----------------------|---------------------------|--------------------------|
| CIP-LSQ      | 48.65                | 3.78           | 3.55                  | 2.91                      | 41.12                    |
| CIP-1945     | 71.90                | 2.91           | 6.63                  | 2.75                      | 15.81                    |
| CIP-MAN      | 65.20                | 3.33           | 5.78                  | 2.76                      | 22.93                    |
| CIP-513      | 73.55                | 3.09           | 5.89                  | 3.04                      | 14.42                    |
| CIP-CER      | 30.90                | 3.41           | 6.94                  | 2.64                      | 56.10                    |
| CIP-BDG      | 73.10                | 3.73           | 6.81                  | 4.89                      | 11.48                    |
| CIP-WHI-5    | 77.90                | 3.76           | 6.48                  | 4.58                      | 7.29                     |
| CIP-W86P     | 72.00                | 2.66           | 8.26                  | 3.18                      | 13.91                    |
| CIP-B9       | 71.45                | 2.92           | 5.91                  | 3.71                      | 16.01                    |
| CIP-204      | 76.35                | 2.85           | 6.55                  | 3.39                      | 10.86                    |
| CIP-440137   | 67.45                | 2.42           | 5.30                  | 2.51                      | 22.31                    |
| CIP-AC       | 69.80                | 2.21           | 7.04                  | 2.24                      | 18.70                    |
| CIP-B19      | 47.40                | 2.15           | 7.35                  | 2.26                      | 40.85                    |
| CIP-286      | 62.05                | 3.46           | 5.02                  | 3.63                      | 25.84                    |
| CIP-287      | 61.35                | 3.04           | 8.44                  | 3.09                      | 24.09                    |
| CIP-GA       | 69.75                | 3.38           | 6.82                  | 3.20                      | 16.86                    |
| SARI         | 78.45                | 3.63           | 7.95                  | 2.86                      | 7.11                     |
| CIP-W        | 69.50                | 3.61           | 8.32                  | 3.95                      | 14.62                    |
| CIP-W104     | 58.35                | 2.49           | 5.35                  | 2.83                      | 30.98                    |
| Cream Saree  | 83.00                | 4.77           | 8.17                  | 2.99                      | 1.07                     |
| Orange Saree | 72.50                | 3.15           | 6.69                  | 3.82                      | 12.89                    |
| Purple Saree | 70.85                | 3.21           | 5.78                  | 2.89                      | 17.28                    |
| Yellow Saree | 81.90                | 1.91           | 4.37                  | 2.44                      | 9.38                     |
| Yellow BM    | 60.20                | 2.87           | 7.52                  | 2.48                      | 26.93                    |

Notes: Numbers followed by the same letter in the same column are not significantly different at the 0.05 DNMRT test level. (BM= Bener Meriah).

3.2. Effect of clone types on sensory attributes of sweet potatoes

The results of the F test showed that sweet potato clones had a very significant effect on tuber skin texture, tuber flesh texture, tuber shape, tuber skin color, and tuber flesh color of sweet potato, and significantly affected the overall acceptance of sweet potato tubers. The average skin texture and tuber
flesh, tuber shape can be seen in Table 2, while the skin color and tuber flesh and overall acceptance of the sensory test result on sweet potato tubers due to the treatment of clone types can be seen in Table 3.

Food texture is a collection of a number of different characters, which are felt by various members of the human body [16]. The texture of food products is one component that is assessed in the sensory test of sweet potato tubers. Texture has an important influence on sweet potato tuber products, for example from the level of tenderness, hardness, and so on.

Table 2 shows that the smoothest texture of sweet potato tuber that was found on Local clones of CIP-513, while the roughest was found on CIP-LSQ (Table 2). Panelists tend to prefer the texture of sweet potato tubers that are soft and tend to reject the sweet potato tubers whose texture is rough and hard.

Table 2. Average skin texture, flash texture and shape of tubers from Sensory Tests due to the clone types.

| Clone types | Skin texture | Tuber flash texture | Tuber shape |
|-------------|--------------|---------------------|-------------|
| CIP-LSQ     | 8.70 a-f     | 12.17 b             | 2.17 a      |
| CIP-1945    | 7.27 a-f     | 11.83 b             | 12.67 e     |
| CIP-MAN     | 11.63 d-f    | 13.13 b             | 3.87 ab     |
| CIP-513     | 5.80 a-d     | 8.80 b              | 13.20 e     |
| CIP-CER     | 4.27 ab      | 12.27 b             | 9.40 de     |
| CIP-BDG     | 10.93 c-f    | 12.87 b             | 9.57 e      |
| CIP-WHI-5   | 8.90 b-f     | 13.17 b             | 7.53 cd     |
| CIP-W86P    | 6.57 a-d     | 8.43 b              | 9.37 de     |
| CIP-B9      | 8.50 a-f     | 10.13 b             | 10.97 de    |
| CIP-204     | 11.4 d-f     | 13.23 b             | 9.20 de     |
| CIP-440137  | 7.57 a-f     | 8.63 b              | 11.10 de    |
| CIP-AC      | 4.70 ab      | 8.43 b              | 11.50 de    |
| CIP-B19     | 11.10 d-f    | 12.93 b             | 12.60 e     |
| CIP-286     | 7.87 a-f     | 8.57 b              | 12.13 e     |
| CIP-287     | 9.63 b-f     | 9.83 b              | 10.83 de    |
| CIP-GA      | 12.53 c-f    | 11.70 b             | 11.43 de    |
| SARI        | 10.03 b-f    | 10.70 b             | 11.67 de    |
| CIP-W       | 3.30 a       | 3.03 a              | 9.73 de     |
| CIP-W104    | 6.37 a-e     | 11.87 b             | 5.27 bc     |
| Cream Saree | 13.20 f      | 13.27 b             | 11.17 de    |
| Orange Saree| 9.27 b-f     | 9.00 b              | 9.97 de     |
| Purple Saree| 5.00 a-c     | 13.23 b             | 12.13 e     |
| Yellow Saree| 7.23 a-f     | 9.57 b              | 11.60 de    |
| Yellow BM   | 7.87 a-f     | 9.90 b              | 11.33 de    |

Notes: Numbers followed by the same letter in the same column are not significantly different at 0.05 DNMRT test level. (BM= Bener Meriah)

The most preferred form of sweet potato tuber was the round shape which was CIP-513, while the less preferred was the small oval shape which was CIP-LSQ (Table 2). The shape and size of tuber were among the criteria for determining the selling price in the market. The ideal form of sweet potato
tubers is a rather long oval with a weight between 200-250 g per tuber, flat tuber shape (round and oval round) and not many grooves including good quality tubers.[19].

Table 3 shows the most preferred skin color of sweet potato tuber was local clones of Saree Cream with purple skin color, while the less preferred was CIP-LSQ with pale cream skin color. Among the characteristics of food products, color has a factor that attracts consumers' attention and most quickly gives the impression of being liked and disliked [7]. The determination of the quality of food, in general, depends on several factors including taste, color, texture, and nutritional value, but before other factors are considered, color factors are visually predetermined and sometimes determine consumer acceptance and provide a clue about chemicals changes in foodstuffs [12]. The color of tuber skin is one of the factors that influence consumer acceptance. Sweet potato tuber skin color varies greatly, but purple skin color is preferred by consumers, this is consistent with [20] who stated that purple tuber color is most preferred by consumers.

Table 3. Average skin color, flash color, taste and acceptance of all sweet potato tubers from Sensory Tests due to clone types.

| Clone types | Skin color | Flesh color | Taste | Acceptance of all |
|-------------|------------|-------------|-------|-------------------|
| CIP-LSQ     | 2.93 a     | 1.93 a      | 10.83 b-d | 2.20 ab           |
| CIP-1945    | 13.57 gb   | 10.00 gb    | 9.57 a-d | 3.77 a-d          |
| CIP-MAN     | 4.23 ab    | 3.17 ab-c   | 13.47 d  | 1.63 ab           |
| CIP-513     | 13.30 f-h  | 2.50 ab     | 13.27 d  | 1.30 ab           |
| CIP-CER     | 12.63 f-h  | 4.80 b-c    | 9.33 a-d | 1.47 ab           |
| CIP-BDG     | 14.00 h    | 13.70 h     | 6.57 a-c | 3.80 a-d          |
| CIP-WHI-5   | 5.87 a-d   | 3.17 ab     | 10.30 b-d| 2.10 ab           |
| CIP-W86P    | 12.33 f-h  | 7.17 e-g    | 11.17 c-d| 1.93 ab           |
| CIP-B9      | 7.20 b-e   | 5.57 c-f    | 13.53 d  | 1.17 a            |
| CIP-204     | 5.53 a-d   | 4.07 a-d    | 12.77 d  | 3.70 a-d          |
| CIP-440137  | 11.97 f-h  | 4.07 a-d    | 6.47 ab  | 1.97 ab           |
| CIP-AC      | 8.60 c-g   | 8.53 f-g    | 12.63 d  | 3.17 a-c          |
| CIP-B19     | 5.73 a-d   | 6.70 d-g    | 9.00 a-d | 2.63 a-c          |
| CIP-286     | 11.93 f-h  | 9.03 f-g    | 11.27 c-d| 2.93 a-c          |
| CIP-287     | 8.80 c-g   | 5.87 d-g    | 5.70 a   | 2.53 a-c          |
| CIP-GA      | 11.57 e-h  | 8.30 f-g    | 12.63 d  | 7.73 d            |
| SARI        | 11.30 e-h  | 8.20 f-g    | 9.80 a-d | 2.30 a-c          |
| CIP-W       | 12.77 f-h  | 13.03 b     | 9.57 a-d | 2.57 a-c          |
| CIP-W104    | 9.70 d-h   | 5.80 d-f    | 9.00 a-d | 3.47 a-d          |
| Cream Saree | 14.17 h    | 3.00 a-c    | 6.73 a-c | 6.33 c-d          |
| Orange Saree| 8.10 c-f   | 8.40 f-g    | 10.10 a-d| 4.60 b-d          |
| Purple Saree| 6.73 b-d   | 13.20 b     | 12.63 d  | 1.67 ab           |
| Yellow Saree| 4.80 a-c   | 7.93 e-g    | 10.27 b-d| 4.53 a-d          |
| Yellow BM   | 6.43 b-d   | 7.10 e-g    | 12.17 d  | 3.07 a-c          |

Notes: Numbers followed by the same letter in the same column are not significantly different at 0.05 DNMRT test level. (BM=Bener Meriah).

The most preferred sweet potato tuber color was CIP-BDG, with the flesh color of dark purple, while the less preferred color was CIP-LSQ with creamy tuber color. The color of tuber flesh consists of several colors: white, yellow, orange, and purple. Yellow tuber color is due to the presence of carotene pigments, while the purple color is due to the presence of anthocyanin pigments. Carotene content in sweet potatoes is an advantage of tubers because this carotene is a pro vitamin A. The difference in the color of tuber flesh causes differences in sensory, physical and chemical properties of tubers and processed products [21].
Taste is the next factor assessed by panelists after shape, texture, and color. Taste arises due to chemical stimuli that can be received by the taste senses or tongue. Taste is one of the factors that influence a person's acceptance of a food ingredient or product. The acceptance of panelists towards taste is influenced by several factors, including chemical compounds, temperature, concentration, and other components of taste interactions [12]. It is also argued that, if the components of aroma, color and texture are good but consumers do not like the taste, consumers will not accept these food products [22]. The results of Ref. [23] and [24] states that tuber color is not an important factor, but taste and texture are preferred sensory attributes. The sweetest tuber taste of this study was CIP-B9, while less sweet was CIP-287.

The overall acceptance test is an assessment of all observed quality factors, which include tuber skin texture, tuber flash texture, tuber skin color, tuber flesh color, tuber shape, and tuber taste. This test is intended to determine the level of acceptance of a product by the panelist. The highest overall acceptance of sweet potato tubers was CIP-GA, while the lowest was CIP-B9 clone.

Physical and chemical testing, as well as nutritional testing, can show the quality of food product, but there will be no meaning if the product cannot be consumed because it is not tasty or sensory properties do not arouse appetite or are not acceptable to consumers [25]. It is found that fine texture and sweetness were the preference main drivers of sweet potatoes, whereas bitter, fibrous and rather coarse texture was negative attributes from consumers view [24]. The taste of cooked sweet potatoes comes from a combination of taste and aroma [26]. Sensory attributes regarding taste, aroma, and texture are the important factors to determine the overall acceptance of sweet potato cultivars [27].

Acceptance of sweet potato tubers was also influenced by individual tastes, culture, and age of the panelists. Food preferences vary according to individuals, age groups, sexes, sometimes cultures, and geographical locations [18]. The least preferred sweet potato clones have watery, sweet, fibrous and firm properties. The most preferred tubers of sweet potatoes are associated with starchy descriptions, attractive colors, sweet, soft and sticky.

4. Conclusion
The highest moisture and ash content of sweet potato tubers were found in the Cream Saree, a local clone, each of 83.0% and 4.77%, while the lowest moisture content was CIP-CER clone at 30.96%. The highest crude protein levels were found in CIP-BDG and CIP-WHI5 clones (4.89%; 4.58%), and the highest carbohydrate levels (56.10%) were found in CIP-CER clone. Sensory test of tuber skin texture found that the smoothest texture of tuber flash was found on CIP-MAN clone, CIP-BDG, CIP-WHI5, CIP-204, CIP-B19, CIP-287, CIP-GA, SARI, local Cream Saree, and local Orange Saree, the best tuber shape with a round shape was found in CIP-513 clone, the most preferred tuber skin color and the color of tuber flesh with purple color was found in CIP-1945, CIP-BDG, and CIP-W clones, while the sweetest taste of tuber flash was found in the CIP-B9 clone. The best overall acceptance of the tuber was CIP-GA clone.

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