White skin orange sweet potato grown in Limapuluh Kota District, West Sumatra Indonesia: Morphology and elemental analysis by energy-dispersive X-ray flourescence.

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Abstract. The white skin sweet orange potato (Ipomoea batatas Linn) was grown by organic method without using any synthetic fertilizer. It was harvested after 4 months of cultivation. Scanning electron photomicrograph of both transversal and longitudinal cross sections showed the formation of starch crystals having round or spherical and polygonal shape with sizes between 2 and 30 μm. Only carbon, oxygen as major elements and small concentration of potassium, calcium and magnesium were detected by energy-dispersive X-ray spectrometry. The absence of some important essential elements demands further investigation on soil-plant nutrient uptake relationship towards the production of highly nutritional potato.

1. Introduction
The history of sweet potatoes is quite interesting and has been studied and documented in great detail[1,2,3,4]. It is originated from tropical America and distributed around the world in the old days by Spanish or Portuguese sailors like Ferdinand Maggelon (around 1650), James Cook (1769) and other traders. It is interesting to know that the introduction of sweet potatoes into West New Guinea later known as Irian Jaya and now Papua probably by the traders has made Papua New Guinea the secondary centre of genetic diversity where the number cultivars grown is roughly about 5000[5,6]. However, the right distribution pathways of sweet potatoes to Papua and other parts of the world is still unclear [7]. What matter is that sweet potatoes has become one of the staple foods along with rice and corn. Nowadays, we can find varieties of different sweet potatoes from many countries including China, Japan and Australia in the hypermarkets. Indonesia is well known for its Cilembu sweet potato which is botanically classified as Ipomoea batatas, a member of Convolvulaceae family. It was officially named Cilembu after the Cilembu village of Sumadang in 2001 by the Indonesian Ministry of Agriculture. Cilembu sweet potatoes are widely grown in West Java and other parts of Indonesia. It was sold at local markets and through street vendors. Even though it is not sufficient to meet the local demand a small proportion of the sweet potatoes production is
exported to Singapore, Hongkong, Japan, Thailand and Malaysia. With higher demand, sweet potatoes have been studied in various aspects including genetics, cultivation, and finally processing to food products. One important aspect of studies is to look into the internal structure or morphology of the sweet potato and its chemical composition. These informations are relevant not only from genetic, plant physiology and quality standpoints but also in food processing and products. Varieties of sweet potatoes were grown at Payakumbuh polytechnic farming area including the orange sweet potato using organic method. The morphology by SEM and elements detected from EDX analysis of the popular orange sweet potato are presented.

2. Material and Methods

2.1 Growing of sweet potato
The potato was grown in the Payakumbuh polytechnic farming area. The potato was planted on 5 x 10 m² plot of a sandy-silt soil by inserting the stems into the soil. Cow dung fertilizer was applied at the beginning and in the middle of the cultivation with regular watering. Limapuluh Kota district, Payakumbuh is located at the latitude -0.22, longitude 100.63 and elevation of 517 meters above the sea level with annual temperature variation between 23 and 29 °C. The potato was harvested after 4 months of cultivation.

2.2 Sample preparation
The potato was cut into slab and dried in an open in open air under the sun light. After 2 days the dried potato slab was kept in a desiccator.

2.3 Scanning electron microscope
The dried slab was cut into a few small blocks and mounted on a circular aluminium stab. After coating with platinum by using sputter coater the two coated blocks were placed in the vacuum chamber of the scanning electron microscope. For morphology study, the sweet potato morphology was examined by using scanning electron microscope energy-dispersive X-ray spectrometry FE-SEM, ZEISS Merlin operating at 15kV. The spectrometer beam current can go up to 400nA with the lowest vacuum of few pA to 300nA. For the morphology experiment the accelerating voltage of 15kV was applied.

3. Results and Discussion

3.1 Growing orange sweet potato
Applying cow dung as fertilizer at the beginning and the mid-growth of potatoes seem quite acceptable as they shown a steady growth without any sign of defect or unhealthy behavior. The yield was 75kg which is quite acceptable equivalent to 15ton per hectare. The white skin and yellow flash potato as shown in Figure 1.

Figure 1. White skin orange sweet potato grown by organic method
3.2 Morphology of sweet potato
Several sweet potato morphological studies were focussed on the starch where it crystallized in the bulk property of the potato or tuber. The starch was isolated from the potato by removing the protein, lipid and ash [8]. The effect of heat, microwave and heat-microwave on the starch solution after being dried was also studied [9]. The microwave treatment was the most effective way to disintegrate the starch granules from the bulk. However, the ultrasound caused the granules to crack. With a minute of 180W heat treatment the starch will started to crack, while with 5 minutes treatment turned the granules into gel-like structure. In the present study the raw or native potato was cut into slabs and dried in an open air to remove the water content. Individul granules with spherical, oval and polyhedral shapes spreading throughout the slab can be observed clearly as shown by the SEM photomicrograph of the transversal cross section of the potato (Figure 2). The fibric chain can also be seen in the picture although not in the dominating way.

![Figure 2](image1)

**Figure 2.** Transversal cross section of the orange sweet potato at 500X magnification

At higher magnification we can see the spherical shape crystals together with oval and irregular shapes were observed with size between 2 and 25 μm as shown in Figure 3.

![Figure 3](image2)

**Figure 3.** Transversal cross section of yellow sweet potato at 2000X magnification
The dominating nature of the clean starch crystals can be understood from the content of 77% water and 20.7% carbohydrate compared to 3.3% dietary fibre, and 0.05% protein in most sweet potatoes [10, 11, 12, 13]. About 12% of the carbohydrate is starch. The crystallization must have occurred in a soft and watery environment. Besides biological and genetic factors, the distribution of starch crystals in the potatoes, may be contributed by the growth of the tuber in underground or soil. In contrast with the rice where the starch crystals occurred in silica casing during the transformation of milky latex into solid rice. Therefore, the overall nature and distribution of starch crystal in the amorphous environment of rice grain is very different.

3.3 Elemental analysis by energy-dispersive X-ray florescence (EDX)

Energy-dispersive X-ray florescence has been the easiest and quickest technique to detect and analyse elements in food samples. [14, 15]. Many studies have focussed on the iron and zinc content in fruit and foods [16, 17, 18]. Mg, Fe, Cu, Mn, Zn, Ca, P, K and Se were detected in sweet potatoes [19]. Mahlangeni et al [20] reported Cr, Ca, Cu, Fe, Mg, Pb, Zn, were presence in potato collected from several sites in the eastern part of South Africa. Pb and As were found higher than the permissible level in a few sites. While Cr and Mg appeared to be easily adsorbed by sweet potatoes. On the other hand, LeRiche et al[21] detected 14 elements, P, Ca, Mg, K, S, Fe, Cu, Na, Zn, B, Mn, Al, Si, Cl, using energy-dispersive X-ray florescence (EDX) and induced coupled argon plasma spectrometry and found that higher concentration of P, Mg, K, S, Zn and Cl at the centre of the tuber compared to the distal ends. Other potatoes displayed Ca decreased from stem end to bud end of the tuber. Na, Fe, Al and Si were greater near the distal ends of the tuber and decrease towards the centre. Cu and B showed no distribution pattern from the stem to the bud end. An other study by him reported that the Canadian potatoes grown with and without fertilizer by similar technique [22] showed higher concentration of P, Mg and Ca in tubers from fertilized compared to unfertilized potatoes. The pattern shown as: increase in P and Mg from stem end to the centre of tubers then decrease again towards the bud ends was observed. However, in the present study EDX application at several spots showed the presence of C (58%) and O (39%) as major elements with small amount of potassium (0.60%), Calcium (0.1%) and magnesium (0.1%) as shown in Figure 4. The presence of platinum is likely due the platinum coating.

![Figure 4. EDX spectrum of orange sweet potato](image-url)
No iron or zinc and other elements which are common in Canada or Nigeria sweet potatoes were detected. The absence of microelements in the potato indicates lack of exchangeable micro-elemental nutrients in the soil although it has a sandy-silt property. Further study on the effect of organic and conventional method of growing the potato on the same soil on the nutritional value of the product is necessary. The elemental mapping showed the uniform distribution of all the elements in the bulk potato (Figure 5).

4. Conclusion
Despite lack of microelements presence in the potato the starch crystallized almost in uniform shape throughout the bulk tuber. Elemental analysis data indicate further work on improving the nutritional value of the potato in term of microelements is necessary particularly on the soil fertility and fertilizer aspect.

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