Effect of Thickness and Drying Temperature Physicochemical and Geometric Properties of Sweet Potatoes

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ABSTRACT

This study evaluated the effect of thickness and drying temperature on the physicochemical and geometric properties sweet potatoes. Sweet potatoes are an important root crop grown all over the world and consumed as a vegetable. Sweet potatoes are highly perishable due to high moisture content. Sweet potato plays an important role in ensuring food security and household income sources for local communities in Ethiopia. Drying temperature was influence the physico-chemical properties. At high thickness the physicochemical properties are high and vice versa. Drying sweet potato at different temperatures and by different thickness has a great difference in the moisture loss, the thickness which its 6 mm and dried at 80°C and which has 2 mm dried at 60°C their moisture contents were 82.33% and 79.53% respectively. Water activity which contribute microorganism growth also affected by thickness and temperature. It recommended that different materials are like slicer are needed and further researcher needed to study the texture, thermal properties and light power have to work properly without break in always. Therefore thickness and drying temperature affect the physico-chemical properties of the sweet potatoes.

Keywords: Sweet potato; Physicochemical; Thickness; Temperature

INTRODUCTION

Background

Sweet potato is a nutritious crop abundant in calories and bioactive compounds. It has been identified as a food security crop because it contains reasonable amounts of bioactive compounds such as b-carotene, ascorbic acid, polyphenols, dietary fiber as well as vitamins, minerals, and proteins [1-5].

The crop is still underutilized although it is rich in starch and carbohydrates and its flour can be used in different industrial applications [6-8]. The most commonly obtainable sweet potato varieties have purple, yellow, and white root tubers because of the distinct contents of phenolic compounds and pigments in their root tubers [9-12].

High quality sweet potato flour will be needed if the flour is going to be incorporated into other food products. However, there is lack of knowledge and understanding of physicochemical and geometric properties of sweet potatoes and the effect that the different processing methods have on these properties and functionality of the different components. Sweet potatoes are highly perishable due to high moisture content [13-18]. Drying and processing sweet potato into flour, which is an intermediate product, is one of the ways of minimizing post-harvest losses and increasing the utilization of sweet potatoes. Therefore, the aim of this study was to determine the effect of drying temperature on the physicochemical and geometric properties of sweet potatoes.

MATERIALS AND METHODS

Description study of area

The experiment was conducted in Jimma University College of Agriculture and Veterinary Medicine at department of Post-Harvest Management laboratory.

Sample collection and preparation

Fully matured and normal local sweet potatoes crops which are free from any defects were collected and purchased from Jimma city market town and it was transported into post-harvest management laboratory at Jimma University. After it was transported into laboratory, it put in deep freeze to maintain its shelf life as it is.

Data collected

Measurement of physico-chemical and geometric properties of sweet potatoes:

Materials and equipment

The following materials and equipment's were used for doing the experiment.

• Water
• Caliper
• Sweet potato
• Oven dry
• Rapeseed
• Knife
• Analytical Balance
• Sieve
• Graduated beakers/cylinders
• Bowl
• Water activity meter
• Desiccators
• Cuvette
• Aluminum foil

Moisture content determination: Moisture content of the sweet potatoes was determined according to methods. Clean by washing with tap water and the thickness of sample were sliced by 2 mm, 4 mm, and 6 mm using knifes and put in oven at different temperature (60°C, 70°C and 80°C) respectively. To do this first clean and dry moisture dish were prepared and the weight was weight as W_1. Representative sample (3 g) was placed on the dish and the weight taken (W_2). It was placed in a hot air drying air, dried at 130°C for 1 hour, and cooled to room
temperature. The weight after drying was measured as W_3. Then by using the following formula:

$$\% \text{ moisture} = ((w_2 - w_3) \div (w_2 - w_1)) \times 100$$

Where: W_1=Weight of moisture dish, W_2=initial Weight of the sample and moisture dish before drying.

W_3=Weight of moisture dish and sample after drying

Apparent density: Apparent density was determined according to by measuring weight and volume of the given sample. The volume of sample was determined by liquid displacement method. Then by dividing the sample weight to volume the apparent density will be obtained. First we measure the weight of sample using liquid displacement method and we measure the volume of sample using 1000 ml beaker having 600 ml of water then this volume was taken as V_1. Then we transferred

potato in to the beaker containing the water and we recorded the new volume as V_2. After this we determined the volume of sample by subtracting volume of the water and potato (V_2-V_1). Finally we calculate the apparent density by dividing the mass of sample by the volume (V_2-V_1).

Bulk density (ρB): Bulk density was determined according to method of (K°C, 2008) by Weighing each representative samples (4.71 g, 5.84 g, and 6.33 g) for 2 mm, 4 mm and 6 mm respectively. Measure the volume of each of the samples bulk approximately using 10 ml cylinders, record it as V_0 Calculate the bulk density by dividing the Mass (M) of the samples by its Volume (V_0).

$$\rho B = M / V_0$$

Sphericity: The sphericity of the three samples was measured using caliper instrument according to.

$$\text{Sphericity} = \frac{(ABC)^{1/3}}{As}$$

When a=length,

b=width and

C=thickness

Aspect ratio (RA: Aspect ratio of the three samples was determined from their width and length of sample.

$$\text{Aspect ratio} = \frac{b}{a}$$

Where a and b are length and width respectively

Specific gravity: The specific gravity was determined according to the ratio between the densities of an object to density of water.

$$S.g = \frac{density\ of\ the\ object}{density\ of\ water}$$

Water activity: It is free water used for biological function. By making the sample powder form or fresh it is possible to measure water activity. This activity was done by using water activity meter.

Size: Size of the samples after and before drying was determined by using caliper.

Mass: The mass of the sample before drying and after drying was determined by using analytical balance.

Data analysis

Data analysis was carried out by using narration and descriptive statics. An excel application was used for the analysis the raw data.

Table 1: Diameter (size) of sliced samples before drying.

Diameter (cm)	Sample slices		
	2 mm slice	4 mm slice	6 mm slice
Major	5	5.2	6
Intermediate	4.6	5.1	5.3
Minor	4.5	5	4.6

Table 2: Diameter of sliced sample after drying.

Diameter (cm)	Sample slices		
	2 mm slice	4 mm slice	6 mm slice
Major	4	4.5	5.6
Intermediate	3	4.4	5
Minor	2.5	4.1	4.2

Table 3: Mass of the sliced sample before and after drying.

Sample slice	Mass before drying	Mass after drying
2 mm	11.43 g	3.41 g
4 mm	14.71 g	3.81 g
6 mm	18.82 g	4.53 g

Apparent density:

$$\rho A = m \div (v_2 - v_1)$$
$$\rho A = \frac{364.05 \text{ g}}{920 \text{ ml} - 600 \text{ ml}}$$

$$\rho A = \frac{364.05 \text{ g}}{20 \text{ ml}} = 1.138 \text{ g/ml} \text{ or } = 1138 \text{ kg/m}^3$$

where V_2 is volume of water and sweet potato

V_1 is volume of water (600 ml)

RESULTS AND DISCUSSION

Based on the data recorded above the result of each parameter before and after drying is mentioned as follows (Tables 1-3).

$$\textbf{Specific gravity} = S.g = \frac{density\,of\,the\,object}{density\,of\,water}$$
$$= \frac{1138 \text{ kg/m}^3}{1000 \text{ kg/m}^3}$$
$$S.g = 1.138$$

Sphericity and aspect ratio: Sphericity and aspect ratio ranged from 0.59 to 0.67 and 0.5 to 0.6 respectively. Sphericity values of most agricultural produce have been reported to range between 0.32 and 1.00 and the more regular an object is, the lower the sphericity. Sphericity of sweet potatoes found in the given range and result shows, this commodity can be sorted with minimal damage, comfortable for hopping and conveying. This is important information for hopper, separation and conveying equipment design (Tables 4 and 5).

Table 4: Sphericity of sample.

No of fresh sample	Sphericity
Sample 1	0.64
Sample 2	0.59
Sample 3	0.67

Sphericity = $(abc)^{1/3}/a$

For sample 1 = $\dfrac{(9.3 \times 5 \times 4.6)^{1/3}}{9.3}$

= $\dfrac{(213.9)^{1/3}}{9.3}$

When a=length, b=width and c=thickness and 1/3 stands for only nominator

Sphericity for sample 1= $\underline{0.64}$

Sphericity for sample 2= $\dfrac{(10 \times 5 \times 4.2)^{1/3}}{10}$

Sphericity for sample 2 = $\underline{0.59..}$

Sphericity for sample 3 = $\dfrac{(9 \times 5.4 \times 4.5)^{1/3}}{9}$

Sphericity for sample 3= $\underline{0.67}$

Table 5: Aspect ratio value.

No of fresh sample	Aspect Ratio (Ra)
Sample 1	0.53
Sample 2	0.5
Sample 3	0.6

Aspect ratio (Ra) = $\dfrac{b}{a}$

Ra for sample 1 = $\dfrac{5}{9.3}$

= $\underline{0.53}$

Ra for sample 2 = $\dfrac{5}{10} = \underline{0.5}$

Ra for sample 3 = $\dfrac{5.4}{9} = \underline{0.6}$

Where a and b are length and width respectively.

Bulk density: From the result on the table below it is possible to deduce that variation in temperature of each slices has a significant effect on their bulk density. The highest bulk density was recorded on 6 mm (80°C) slice while the lowest bulk density was recorded on 2 mm (60°C) slice. And this finding was in contrary to in which they investigated that the density at given moisture content decreased with increasing drying air temperature. But in our investigation since there was variation in moisture content of each slices it was difficult to detect pure effect of temperature on their bulk density (Table 6).

Table 6: Bulk density value.

Sample sliced	Bulk density (kg/m³)
2 mm	471 kg/m³
4 mm	584 kg/m³
6 mm	633 kg/m³

$$\rho B = M / V_0$$

$$\rho B \text{ for 2 mm} = \frac{4.71 \text{ g}}{10 \text{ ml}}$$

$$= 0.471 \text{ g/ml} \times 1000 = 471 \text{ kg/m}^3$$

$$\rho B \text{ for 4 mm} = \frac{5.84 \text{ g}}{10 \text{ ml}}$$

$$= 0.584 \text{ g/ml} \times 1000 = 584 \text{ kg/m}^3$$

$$\rho B \text{ for 6 mm} = \frac{6.33 \text{ g}}{10 \text{ ml}}$$

$$= 0.633 \text{ g/ml} \times 1000 = 633 \text{ kg/m}^3$$

Where M is the mass of each powder sample

V_0 is constant volume (10) ml

Total moisture content: The highest thickness and temperature has highest moisture contents. The sweet potatoes 2 mm thickness and dry at 60°C has lowest moisture contents and the thickness which 6 mm which dry at 80°C has highest moisture content than thickness 4 mm and 6 mm dry at 60°C and 70°C. When the temperature is raised, the drying time will be

shortened, with a faster decrease of moisture content and the influence of temperature is more pronounced at higher moisture content. This situation occurred due to the moisture removal from the interior takes time since the evaporation process is not as easy as free water removal on the surface for the highest thickness and temperature. This might be because of low temperature which slowed the rate of moisture removal. Raising the drying temperature caused the acceleration of moisture loss and in this respect; the present observations are consistent (Table 7).

Table 7: Total moisture content.

Sample sliced	Moisture for sliced sample (%)	Moisture for powder sample (%)	Total moisture (%)
2 mm	70.2%	9.33%	79.53%
4 mm	73.9%	8%	81.9%
6 mm	75.9%	7.33%	82.33%

$$\%\text{moisture} = ((w_2 - w_3) \div (w_2 - w_1)) \times 100$$

$$\%\text{moisture for sliced sample 2 mm} = \frac{11.43 \text{ g} - 3.41 \text{ g}}{11.43 \text{ g}} \times 100$$

$$= 70.2\%$$

$$\%\text{moisture for powder sample 2 mm} = \frac{43.48 \text{ g} - 43.20 \text{ g}}{43.48 \text{ g} - 40.48 \text{ g}} \times 100$$

$$= \frac{0.28 \text{ g}}{3 \text{ g}} \times 100$$

$$= 0.09333 \times 100$$

% moisture for 2 mm=9.333%

Where: W_1=weight of moisture dish,

W_2=initial weight of sample and moisture dish before drying.

W_3=weight of moisture dish and sample after drying

Or %moisture=W_1-W_2/W_1 × 100

Where w_1=weight before drying

W_1=weight after drying

➤ Total moisture content = moisture for sliced sample + moisture for powder sample

= 70.2% + 9.33%

= 79.53%

% moisture sliced sample for 4 mm = (14.73 - 3.85 ÷ 14.73) x 100

= 73.9%

%moisture powder sample for 4 mm= ((45.79 g - 45.55 g) ÷ (45.79 g - 42.79 g)) x 100

= 8%

➤ Total moisture content = moisture for sliced sample + moisture for powder sample

= 73.9% + 8%

= 81.9%

%moisture sliced sample for 6 mm=((18.82 g - 4.53 g) ÷ (18.82 g)) × 100

= 75.9%

%moisture powder sample for 6 mm=((24.66 g-24.44 g) ÷ (24.66 g - 21.66 g)) × 100

= 7.33%

Total moisture content=moisture for sliced sample+moisture for powder sample=75.9%+7.33%

=82.23%

Water activity: As it can be seen from the below table the water activity of the sweet potato were vary from the temperature to temperature. The water activity of sweet potato sliced by 2 cm and dried at 60°C was higher than the others. The water activity of sweet potato sliced by 6 cm and dried at 80°C was smaller than the others. The result showed that the temperature and water activity are in direct proportional to each other's. This finding is also in line with who stated that the as the drying temperature increase the water activity of food decrease. The reason could be that as the temperature of air is increased, it can absorb more liquid and, therefore, the relative humidity is decreased. Lower relative humidity promotes faster drying. As temperature is increased, the amount of water required to saturate a specific volume of air increases and water activity decreased.

Table 8: Water activity of sweet potato sliced and dried at different temperatures.

sliced and dried sweet potato	Water activity
2 mm at 60°C	0.44
4 mm at 70°C	0.34
6 mm at 80°C	0.26

Weight loss of sweet potato dried at different temperatures: The following three graphs shows moisture loss per time with every 10 minutes at (60, 70 and 80°C. As we can see from the below three (3) graphs of three sweet potato samples sliced at different thickness (2 mm, 4 mm, 6 mm) and dried at different drying temperature (60°C, 70°C, 80°C), the change of mass (moisture loss) is fast initially and becomes constant gradually. As it is seen from the result, drying rate is clearly influenced by the drying temperature. As temperature increases the drying rate became fast and it takes short period of time to dry the sweet potato. Therefore drying sweet potato at different temperatures and thickness has a great difference in the moisture loss and drying rate (Figures 1-3).
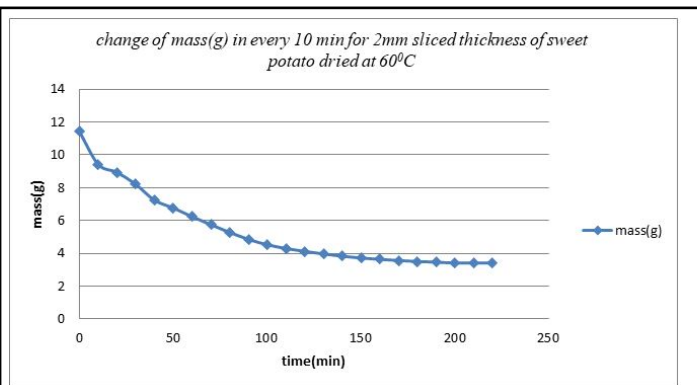

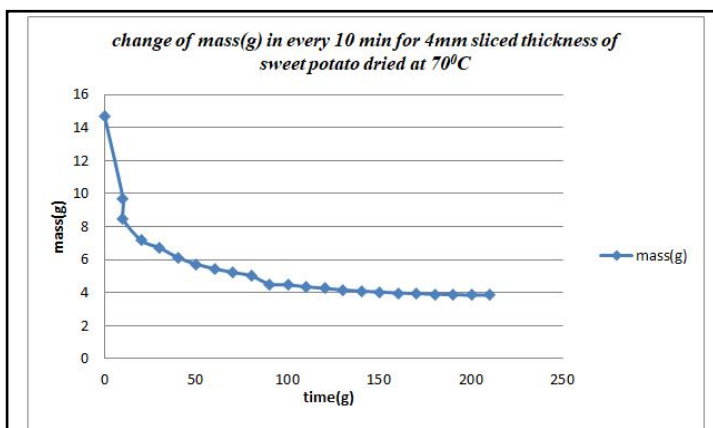**Figure 1**: Change of mass for sweet potato sliced at 2 mm and dried at 60°C.

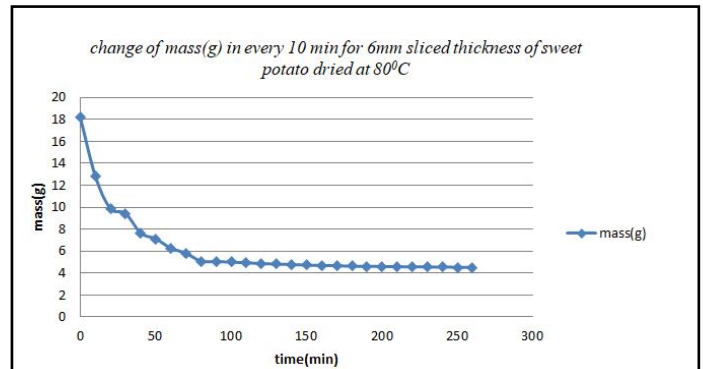**Figure 2**: Change of mass for sweet potato sliced at 4 mm and dried at 70°C.

Figure 3: Change of mass for sweet potato sliced at 6 mm and dried at 80°C.

CONCLUSION

Sweet potatoes are perishable vegetables, which are rich in different nutrients like carbohydrates and proteins. Most of physico-chemical properties were affected by drying temperatures and thickness of the sample. Most of physico-chemical properties that were, affected by drying temperature like moisture contents highest thickness dried at highest temperature has high moisture contents. Drying sweet potato at different temperatures and by different thickness has a great difference in the moisture loss, the thickness which its 6 mm and dried at 80°c and which has 2 mm dried at 60°C their moisture contents were 82.33% and 79.53% respectively. Water activity which contribute microorganism growth also affected by thickness and drying temperature. The highest thickness dried at highest temperature has low water activity.

REFERENCES

1. Ahmed M, Akter MS, Eun JB. Peeling, drying temperatures, and sulphite-treatment affect physicochemical properties and nutritional quality of sweet potato flour. Food chemistry. 2010;121(1):112-118.

2. Akpapunam MA, Abiante DA. Processing and quality evaluation of sweet potato chips. Plant Foods Hum Nutr. 1991;41(4);291-297.

3. Aktas T, Polat R. Changes in the drying characteristics and water activity values of selected pistachio cultivars during hot air drying. J Food Process Eng. 2007;30(5):607-624.

4. AOAC (2002). Official method of analysis of the association of official analytical chemist.14th edn., association of official analytical chemists, Washington, DC, USA.

5. Bayram M. Determination of the sphericity of granular food materials. J Food Eng. 2002;68(3):385-390.

6. Eleazu CO, Ironua C. Physicochemical composition and antioxidant properties of a sweetpotato variety (Ipomoea batatas L) commercially sold in South Eastern Nigeria. Afr J Biotechnol. 2013;12(7).

7. Koc B, Ismail E, Figen KE. Modelling bulk density, porosity and shrinkage of quince during drying: The effect of drying method. J Food Eng. 2008;85(3): 340-349.

8. Labuza TP, Tannenbaum SR, Karel M. Water content and stability of low moisture and intermediate moisture foods. Food Technol. 1970;24:543-550.

9. Mohsenin NN. Physical Properties and Animal Materials. Gordon and Breach Science Publishers. New York. 1970.

10. Motsa NM, Modi AT, Mabhaudhi T. Sweet potato (*Ipomoea batatas L.*) as a drought tolerant and food security crop. S Afr J Sci. 2015;111(12):1-8.

11. Oyelade OJ, Odugbenro PO, Abioye AO, Raji NL. Some physical properties of African star apple (*Chrysophyllumalibidum*) seeds. J Food Eng. 2005;67(4):435-440.

12. Poncsak S, Kocaefe D, Bouazara M, Pichette A. Effect of high temperature treatment on the mechanical properties of birch (*Betula paparifera*). Wood Sci. Technol. 2006;40:647-663.

13. Su WH, Sun DW. Comparative assessment of feature-wavelength eligibility for measurement of water binding capacity and specific gravity of tuber using diverse spectral indices stemmed from hyperspectral images. Comput Electron Agric. 2016;130:69-82.

14. Taiwo KA, Baik OD. Effects of pre-treatments on the shrinkage and textural properties of fried sweet potatoes. LWT-Food Sci Tech. 2007;40(4):661-668.

15. Tanaka Y, Sasaki N, Ohmiya A. Biosynthesis of plant pigments: anthocyanins, betalains and carotenoids. Plant J. 2008;54(4): 733-749.

16. Tang Y, Cai W, Xu B. Profiles of phenolics, carotenoids and antioxidative capacities of thermal processed white, yellow, orange and purple sweet potatoes grown in Guilin, China. Food Sci Hum. 2015;4(3):123-132.

17. Van Hal M. Quality of sweetpotato flour during processing and storage. Food Rev Int. 2000;16(1):1-37.

18. Wang S, Pan D, Lv X, Song X, Qiu Z, Huang C, et al. Proteomic approach reveals that starch degradation contributes to anthocyanin accumulation in tuberous root of purple sweet potato. J Proteomics. 2016;143:298-305.