Solar and tray-drying methods and physicochemical properties of sweetpotato starch

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ABSTRACT

Two drying methods were investigated to determine if drying is possible without affecting the quality of starch. The drying methods were solar dryer (53-55 °C) and electrically powered tray dryer (60 °C). The physicochemical properties of starch from five sweetpotato were evaluated after dehydration using the two methods. The results showed that drying methods had effect on some physicochemical properties of sweet-potato starch. The tray-dried starches had higher moisture, ash, viscosity, and L* values. The swelling power and solubility values for tray-dried starches were significantly different from solar-dried ones, except for the tray-dried "Sauti" starch. Although the water binding capacity and amylase content were higher in solar-dried starches relative to tray-dried starches, statistically there was no significant difference(P<0.05) in amylose content. This study has shown that in the drying of starch, the drying method is very essential because it has effect on the final quality of starch. Therefore, in setting up a starch factory, the need is to consider the type of drying method to be used.

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RÉSUMÉ

Oduro, I., Ellis, W. O., Acquah, S. & Kyeremateng, F.: *Les méthodes de séchoir plateau-électrique et de sèchoir solaire et les propriétés physicochimiques de fécule de patate douce.* Deux méthodes de séchage étaient étudiées pour déterminer si le séchage peut être accompli sans modifier la qualité de fécule. Les méthodes de séchage étaient le séchoir solaire (53-55 °C) et le séchoir de plateau qui marche à l'énergie électrique (60 °C). Les propriétés physicochimiques de fécule de 5 variétés de patate douce étaient évaluées après la déshydratation employant les deux méthodes. Les résultats obtenus montraient que les méthodes de séchage avaient des effets sur quelques propriétés physicochimiques de fécule de patate douce. Les fécules séchées sur le plateau électrique avaient les valeurs d'humidité, de cendre, de viscosité, et de L* plus élevées. La capacité gonflante et les valeurs de solubilité pour les fécules séchées sur le plateau électrique étaient considérablement différentes de celles séchées d'énergie solaire à l'exception de la fécule de la variété sauti séchée de plateau électrique. Bien que la capacité de collage avec l'eau et le teneur d'amylase soient plus élevés en fécules séchées d'énergie solaire relative aux fécules séchées de plateau-électrique, statistiquement il n'y avait pas de différence (P< 0.05) en teneur d'amylose cette étude a montré qu'en séchant la fécule la méthode de séchage est très essentielle puisque ceci a un effet sur la qualité finale de fécule. Pour cette raison, avant d'établir une usine de fécule, il est nécessaire de considérer le type de méthode de séchage à employer.

Introduction

Sweetpotato *(Ipomea batatas)* is a starchy commodity grown extensively in the tropics and subtropics, and it suits all agro-ecological zones. It is a high-yielding, early-maturing, and high-calorie food crop; drought-resistant and not disease, weed and pest-friendly. Its nutrient requirements are moderate. It can be processed into flour and used in composite with wheat flour to bake bread, cake, and biscuits; thereby acting as a good import substitute. Sweetpotato can be used for alcohol production (Toyin, 2000), and the by-products used as animal feed (Nweke,1995). Starch is an important raw material for many industries.

In Ghana, cassava is now used in producing starch, because the extraction of starch from sweetpotato is not a common venture. Using sweetpotato as an alternative will, therefore, complement cassava usage. Drying is one of the processes that starch undergoes after extraction. In large factories, it is partly possible by centrifugation, which may dry the starch to 35-40 per cent, with final drying by evaporation to a moisture level of 10 to 14 per cent. Usually the quality of the starch is primarily determined by its physicochemical properties, which are influenced by the different handling methods of dehydration and storage. One of the common dehydration techniques used by small and medium-scale industries is solar and mechanical drying.

The objective of the study is to evaluate the effect of the tray-drying and solar-drying methods on the physicochemical properties of sweetpotato starch. The knowledge of the best drying method for producing good quality starches that would be in high demand will serve as important background information for the starch industries, especially now that the interest is in establishing starch industries in Ghana.

Materials and methods

Experiment design

A completely randomized block design (CRBD) was used. Statistical analysis of data was computed at the 5 per cent level of significance using the Analysis Toolpak Microsoft Excel programme. All analyses were applied in triplicate.

Source of raw materials

Sweetpotato tubers were collected from the Crops Research Institute (CRI) in Kumasi, Ghana. The varieties used were L/Red, "Santom pona", 86/0320, "Sauti", and "Dugbadza."

Extraction of starch

Starch was extracted from freshly harvested sweetpotato tubers by the wet extraction method (Oduro *et al.*, 2000). The extracted starch was allowed to sediment and the supernatant liquid decanted. It was then washed several times with distilled water, divided into two portions, and then dried using the two dehydration methods.

Drying of starch

One set of the extracted starch was put in an electrically heated tray dryer which was operated at 62 °C for 24 h, and the other in a solar tent dryer operated at 53-55 °C for 72 h. The starch (500 g) was spread thinly in aluminium trays before drying. The dried starches from both dryers were then milled using the Cyclo-tec 1093 Sample mill and stored in plastic containers.

Moisture and ash

Moisture and ash were determined based on the methods of analysis of the Association of Official Analytical Chemists (AOAC, 1990).

p*H*

Ten grams of starch was dissolved in 20 ml of distilled water to form a slurry. The *p*H was then measured with the Corning *p*H Meter (Model 240, Corning Science products, Corning New York, USA).

Colour

The starch colour was determined using the Chromameter (Model Cr-200 Minolta Camera Co. Ltd, Japan) on the L*a*b* colour notation. About 15 g of sample was weighed, compressed, and levelled with a spatula in a Petri dish. The sensor of the Chromameter was then placed on the surface of the sample and the colour determined at four randomly selected points on the sample surface and the average calculated. The Chromameter was calibrated using a standard white tile [L* = 100.01; a* = -0.01; b*= -0.02].

Water binding capacity and amylose

The water binding capacity (WBC) was determined by the method of Yamazaki (1953) as modified by Medcalf & Gilles (1965), and the amylose content by the method of McCready& Hassid (1994).

Viscosity

The Brookfield Digital Viscometer (Model DV-ll +3.0 Version, Britain) was used. An aqueous suspension of 10 g of starch in 500-ml distilled water was prepared. The suspension was then heated in water bath with constant stirring for 30 to 40 min till the paste was at 90 °C. The viscosity of the hot paste was then determined at 73 °C, allowed to 35 °C and the viscosity re-determined. The readings were taken in centipores second (cps) at 100 rpm with spindle No. 1 for all the samples.

Swelling volume, swelling power and solubility

One gram of starch was weighed into a 50-ml graduated centrifuge tube. Distilled water was added to give a total volume of 40 ml. The starchy slurry was stirred sufficiently and heated at 85 °C in a water bath for 30 min with constant stirring. The tubes were removed and cooled to room temperature. It was then centrifuged for 15 min at 2,200 rpm. The swelling volume was determined by reading the volume of the swollen sediment on the graduated tube. The swelling power was expressed as the percentage weight (g) of swollen sediment per gram of dry starch. Solubility was determined by evaporating the supernatant and weighing the residue.

Results and discussion

The moisture content of the starch samples, using the solar tent dryer, ranged from 7.53 per cent (L/Red) to 11.6 per cent (Sauti). Except for "Sauti" (solar), which had moisture content of 11.65, all the values were less than 10 per cent; thus, these samples have the potential for longer shelf life. Generally, the tray-dried starches had slightly higher moisture content than the solar-dried ones, except for "Dugbadza" and "Sauti". This may be attributed to the drying time. The solar tent dryer samples were dried for about 3 days, while the tray-dried samples were dried for 1 day. Statistical analysis showed a significant difference ($P < 0.05$) between the drying methods.

The *p*H values for solar-dried starches ranged from 4.58 (Sauti) to 4.95 (86/0320), while those of the tray-dried starches were between 3.62 (86/0320) and 4.65 (Santom pona).

The *p*H values for the tray-drying method were significantly ($P<0.05$) lower than those of the solar tent dryer. However, the difference in the observed values was small (Table 1).

According to Onwueme (1982), good-quality starch should have an ash content of less than 0.2 per cent. Apart from 86/0320 (0.28%) and "Sauti" (0.37%), using solar and tray drying respectively, all the values were within the acceptable range. The tray-dried starches had relatively higher ash content than the solar tent-dried samples.

The WBC values for the solar-dried samples ranged from 63.90 to 80.10 per cent for "Sauti" and L/Red, respectively (Fig. 1). The values of tray-dried samples were in the range of 63.56 to 72.16 per cent for "Dugbadza" and "Santom", respectively. Statistical analysis indicated a significant difference ($P<0.05$) in the two methods, with values of the solar dryer being generally higher than those of the tray dryer. The difference could be due to the relatively low moisture content of the solar-dried starches compared to the tray-dried starches as a result of the inverse relationship between the moisture and WBC observed by Aryeetey (1998) in his work on sweetpotato starches. The results showed that at 73 °C (Fig. 2), the viscosity of the solar dryer starches ranged from 28.50 cps (L/Red) to 42.25 cps (Dugbadza). At the same temperature, values recorded for the tray-dried starches ranged from 29.10 cps (Dugbadza) to 53.40 cps (Santom pona). For some varieties, especially L/Red and "Santom pona", the viscosity for the tray-dried starches were significantly ($P<0.05$) higher than those of the solar dryer. The values recorded at 35 °C (Fig. 3) were all higher than those at 73 °C. This could be due to retrogradation of the starch

TABLE 1

Physicochemical Properties of Milled Sweetpotato Starch Using Two Drying Methods: Solar Tent Dryer (53-55 °C) and Tray Dryer (60 °C)

Parameter	*Dugbadza*		*L/Red*		*Santom pona*		*Sauti*		*86/0320*	
	Solar	*Tray*	*Solar*	*Tray*	*Solar*	*Tray*	*Solar*	*Tray*	*Solar*	*Tray*
Moisture (%)	9.10 (0.03)	8.02 (0.01)	7.53 (0.11)	8.83 (0.05)	9.72 (0.03)	9.81 (0.20)	11.56 (0.05)	8.83 (0.02)	7.86 (0.01)	8.48 (0.16)
*p*H	4.88 (0.01)	4.64 (0.04)	4.84 (0.01)	3.91 (0.02)	4.67 (0.01)	4.65 (0.01)	4.58 (0.00)	3.76 (0.01)	4.95 (0.04)	3.62 (0.01)
Ash (%)	0.22 (0.04)	0.12 (0.01)	0.17 (0.04)	0.20 (0.15)	0.10 (0.01)	0.18 (0.01)	0.15 (0.07)	0.37 (0.06)	0.28 (0.02)	0.25 (0.09)
Colour L *	79.75 (0.91)	94.37 (0.79)	75.74 (0.74)	95.72 (0.52)	99.26 (0.30)	98.13 (0.59)	81.70 (0.15)	95.63 (0.33)	90.24 (0.05)	99.23 (0.96)
Colour b*	5.30 (0.16)	4.05 (0.14)	8.06 (0.21)	6.42 (0.20)	4.70 (0.26)	2.70 (0.01)	4.50 (0.21)	4.45 (0.14)	4.39 (0.19)	2.22 (0.02)
Amylose content (%)	26.24 (0.01)	29.33 (0.81)	28.85 (0.41)	27.81 (0.03)	30.46 (0.08)	29.93 (0.54)	32.22 (0.91)	33.05 (0.40)	27.71 (0.28)	27.07 (0.98)

( ) Standard deviation

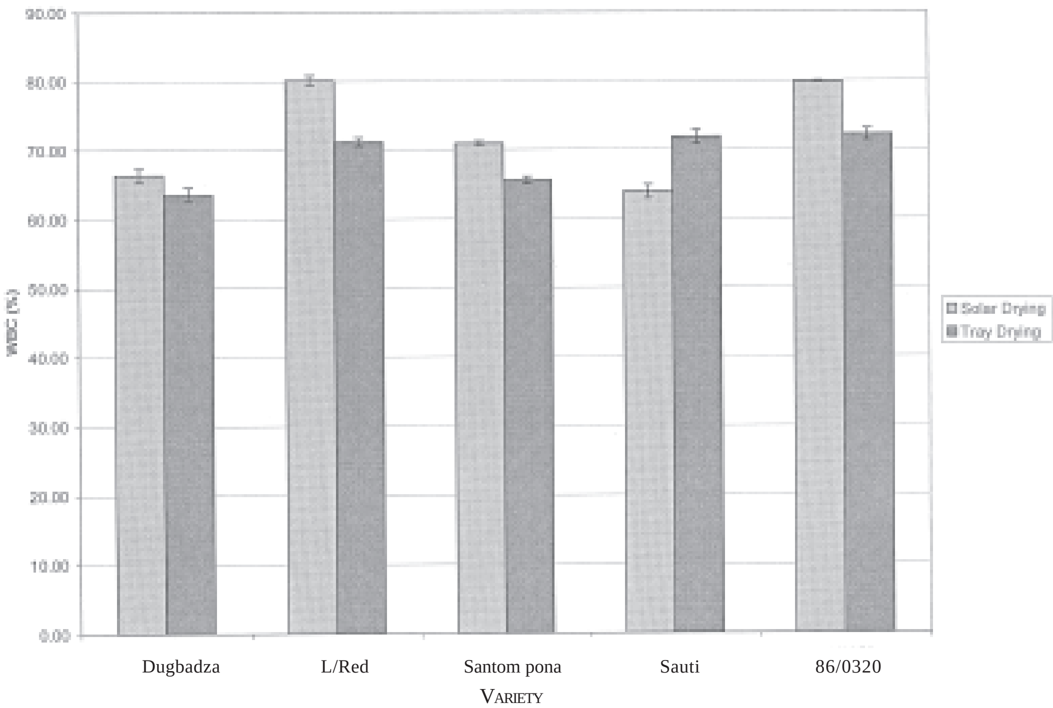


Fig. 1. Effect of drying methods on water binding capacity (WBC) of milled sweetpotato.

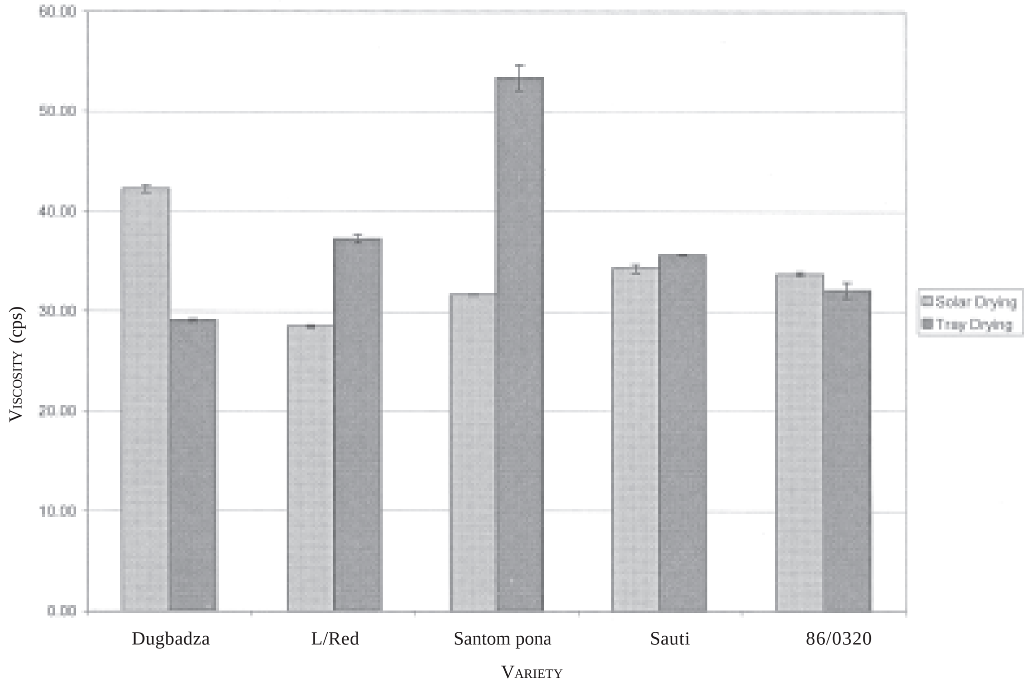


Fig. 2. Effect of drying methods on viscosity of milled sweetpotato starch at 73 °C.

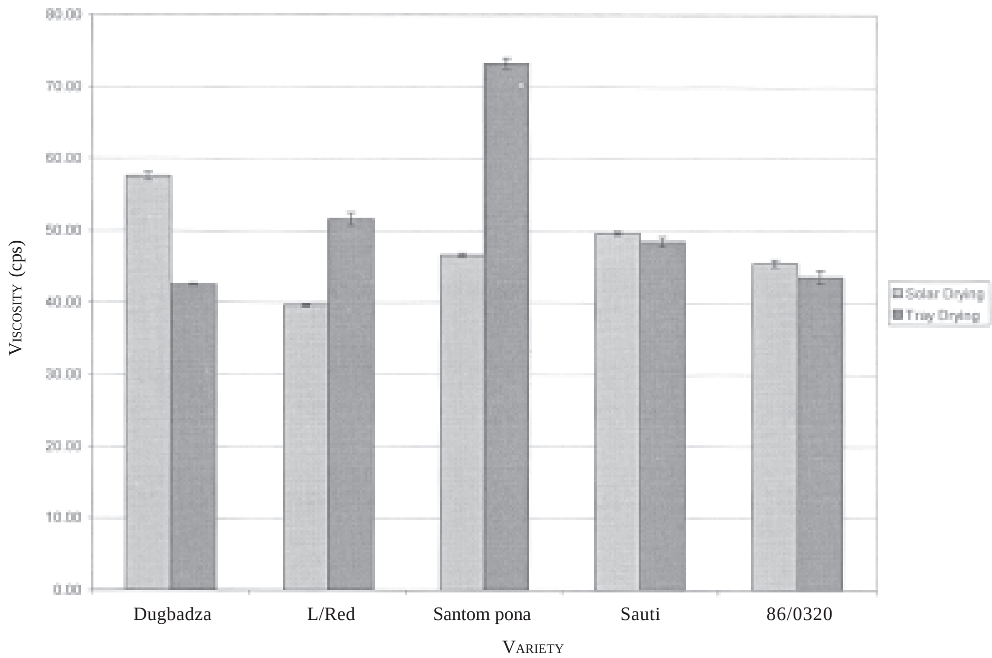


Fig. 3. Effect of drying methods on viscosity of milled sweetpotato starch at 35 °C.

paste as it cools from 73 to 35 °C.

Solubility values ranged between 9.03 and 17.04 per cent for "Sauti" and "Santom pona", respectively, in the tray dryer. The solar tent-dried starches had values ranging from 6.23 per cent for "Dugbadza" to 13.77 per cent for 86/0320 (Fig. 4). Except for "Sauti", the tray-dried starches had significantly (P<0.05) higher solubilities than the solar tent-dried samples. The swelling power for the tray-dried samples and the solar tent-dried samples differed significantly (P<0.05), with the tray-dried starches being higher than the solar tent-dried starches (Fig. 5). The tray-dried starches had values ranging from 24.95 per cent (Dugbadza) to 29.9 per cent (Santom pona), whereas the solar tent dryer values ranged from 23.53 per cent (L/Red) to 29.16 per cent (Dugbadza). This difference may be attributed to the fact that the tray-dried starches, having been dried at fairly high temperature, may have been partially gelatinized, resulting in a higher capacity to absorb moisture. This means that the tray-dried starches were physically modified.

The swelling volume values for solar tent dryer ranged from 22.0 ml (L/Red) to 27.50 ml (Dugbadza). For the tray dryer, the values ranged from 22.0 ml (L/Red) to 27.50 ml (Sauti) (Fig. 6). The values for tray-dried starches were not significantly different from those for solar-dried starches.

For colour, the L* values depicting whiteness ranged from 75.74 (L/Red) to 99.26 (Santom pona) for solar-dried starches. For the tray-dried starches, the L* values were in the range of 94.37 for "Dugbadza" and 99.23 for "Santom pona". The values recorded for the two methods varied significantly (P<0.05), with the tray dryer being slightly higher than the solar-dried starches. The b* values show the degree of yellowness. It ranged between +4.39 for 86/0320 and +8.06 for L/Red concerning the solar tent dryer starches. The tray-dried starches had values in the range of +2.22 (86/0320) to +6.42 (L/Red). The tray-dried starches were whiter than the solar tent-dried samples. Again, the values for the drying

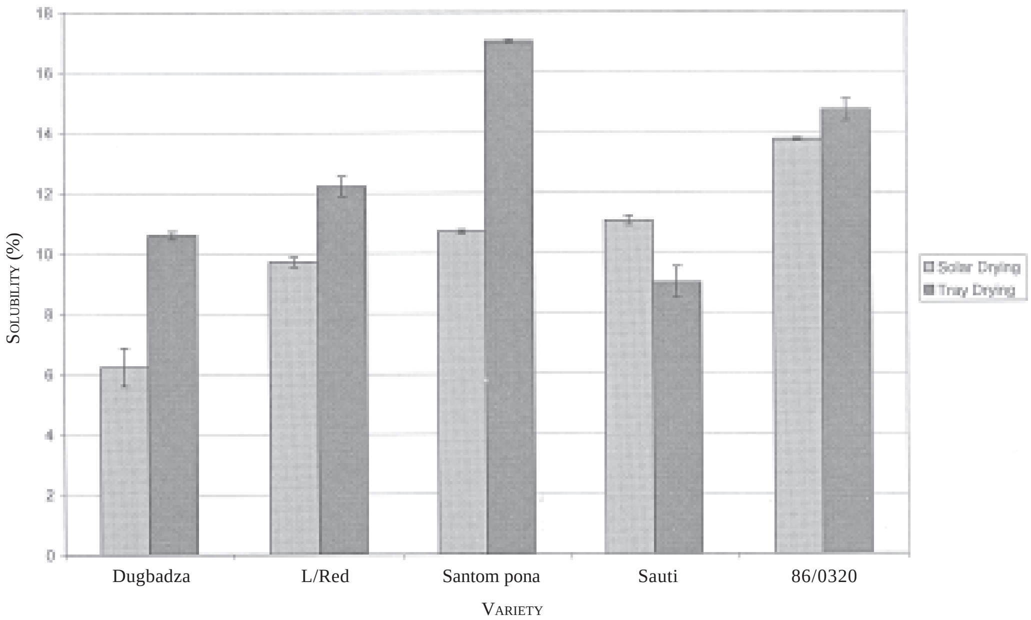
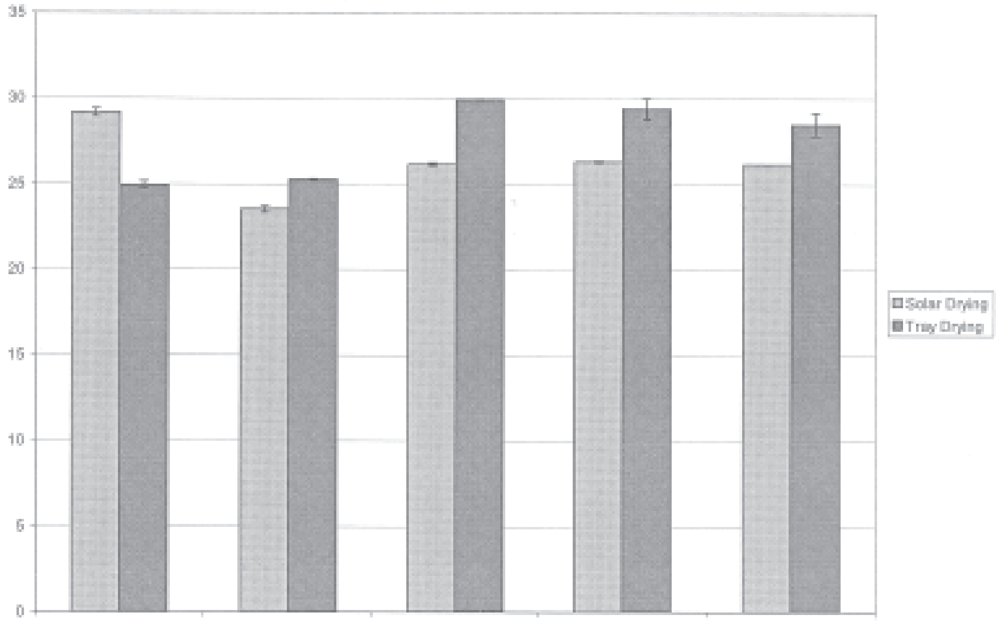


Fig. 4. Effect of drying methods on solubility of milled sweetpotato starch.

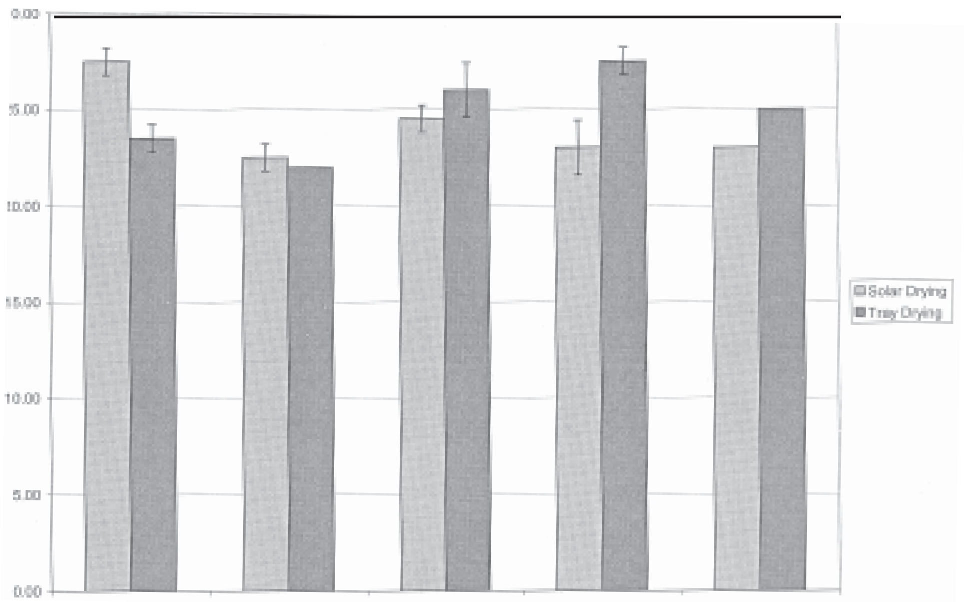


Swelling power (%)

Dugbadza L/Red Santom pona Sauti 86/0320

Variety

Fig. 5. Effect of drying methods on swelling power (SP) of milled sweetpotato starch.



Swelling volume (ml)

Dugbadza L/Red Santom pona Sauti 86/0320

Variety

Fig. 6. Effect of drying methods on swelling volume (SV) of milled sweetpotato.

methods differed significantly (P<0.05), with the solar tent-dried samples being higher at the tested significance level. The observed variations in L* and b* values may be due to the high temperature and shorter drying time of tray-dried samples; thus, ensuring a faster and more efficient drying with little change to the colour. The a* values show the degree of redness; so the values recorded were not considered in this study because a good-quality starch should be uniformly white (Onwueme, 1982). The amylose contents of the solar tent starches ranged from 26.24 per cent (Dugbadza) to 32.22 per cent (Sauti). For the tray dryer, 86/0320 had the lowest content of 27.07 per cent and "Sauti" the highest of 33.05 per cent. There was no significant difference (P<0.05) in the values recorded for the two drying methods. Thus, the drying methods had no effect on the amylose content. Barimah & Martey (2002) reported a similar result for cassava starch.

Conclusion

The study showed that tray-drying and solar tent-drying methods, with their corresponding temperatures, significantly affect the physicochemical properties of sweetpotato for most parameters determined, except for the swelling volume. The tray-drying method had starches of higher swelling power, swelling volume, viscosity, degree of whiteness, and solubility.

REFERENCES

AOAC (1990) *Official methods of analysis,* 15th edn. Association of Official Analytical Chemists, Washington DC.

Aryeetey, S. K. (1998) *Varietal effect on the physicochemical properties of sweet potato starch* (BSc Thesis). Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Barimah, J. & **Martey, Y. T.** (2002) Effects of different drying methods on some properties of starch. *J. Ghana Sci. Assoc.* **4**, 169-174.

McCready, R. M. & **Hassid, W. Z.** (1944) The separation and quantitative estimation of amylase and amylopectin on potato starch. *J. Am. Chem. Soc.* **6**5, 1154-1157.

Medcalf, D. G. & **Gilles, K. A.** (1965) Wheat starches: Comparison of physicochemical properties. *Cereal Chem.* **42**, 558-568.

Nweke, F. I. (1995) *Cassava, a cash crop in Africa.* COSCA Working Paper No. 14, Collaborative Study of Cassava in Africa, IITA, Ibadan, Nigeria.

Oduro, I., Ellis, W. O., Aryeetey, S. K., Ahenkorah, K. & **Otoo, J. A.** (2000) Pasting characteristics of starch from new varieties of sweetpotato. *Trop. Sci. J.* **40**, 25-28.

Onwueme, I. C. (1982) *The tropical tuber crop*. John Wiley and Sons Ltd, Chichester. 189 pp.

Toyin, B. 0. (2000) Ethanol industry and major technical development in the production of ethanol from cassava in Nigeria: In *Potential root crops for food and industrial resources,* pp. 121-124 (ed. Nakatani and Komakigeds), September l0-16, 2000. Tsukuba, Japan.

Yamazaki, W. T. (1953) An alkaline water retention test for the evaluation of Cookie in baking potentialities of soft winter wheat flour. *Cereal Chem.* **30**, 242-246.