

EFFECT OF DIFFERENT PRE-TREATMENTS AND DRYING METHODS ON QUALITIES OF SWEET POTATO FLOUR

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ABSTRACT

Sweet potato [*Ipomoea batatas* L. (Lam.)], is an important root crop has a much shorter shelf life of 2 to 3 weeks and it has been estimated that postharvest losses of sweet potato can range from 35% to 95% in developing countries. A possible alternative solution to this problem is to prepare best quality sweet potato flour by modern advance technique of pre-treatments followed by appropriate air drying method to get the combined benefits of these two valuable processes. Fresh sweet potato slices of 4 mm thickness were pre-treated by 0.1 % citric acid for 10 minutes (P_1), steam blanching for 10 minutes (P_2), 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes (P_3), hot water blanching at 100°C for 2 minutes (P_4) and without any pre-treatment (P_5) as a control treatment. The pre-treated samples were dried by three methods, viz., hot air drying at 60°C and 0.90 m/s using cabinet dryer, solar drying using commercial solar dryer and fluidized bed drying at 60°C and 6.25 m/s air velocity using fluidized bed dryer. Hot air drying treatments at 60°C and 6.25 m/s using fluidized bed dryer required the lowest drying time of 5 to 5.25 h, followed by hot air drying treatments at 60°C and 0.90 m/s using cabinet dryer (13 to 14 h) and solar dryer (15 h to 16 h). On the basis of overall quality evaluation of sweet potato flour, highest water solubility index (65.72 %), highest water absorption index (184.67 %), ascorbic acid content (42.93 mg/100 g), total sugar (45.56 %), titratable acidity (1.62 %), carotenoid (2.03 mg/100 g), crude fiber content (7.73 %), protein content (3.04 %) and sensory score (8.23) were obtained in treatment pre-treated with 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes of sweet potato slices followed by solar drying, among all the treatments.

KEY WORDS: Hot air drying, packaging, pre-treatment, storage, sweet potato, sweet potato flour

INTRODUCTION

Sweet potato [*Ipomoea batatas* L. (Lam.)], is an important root crop in the tropics and warm temperate regions of the world. It is grown in more than one hundred countries, with an annual production worldwide exceeding 106

million tons (FAO, 2010). Odisha, Bihar, Uttar Pradesh and Madhya Pradesh are the major states cultivating sweet potatoes in India. During 2013-14, India produced 1088 thousand tonnes of sweet potato from about 106 thousand hectares area (Anonymous,

2015). Most of the production of sweet potato in the world is shared by the developing countries; however China ranks first and is the leading producer of sweet potato followed by Nigeria and Uganda (FAO, 2012).

Sweet potato is consumed as a vegetable, boiled, baked or often fermented into food and beverages. Fresh sweet potato fruit contains about 70 to 72 % (wb) moisture content. There are more chances of the sweet potato getting spoiled or deteriorated. Also, sweet potato is a perishable root, it has shelf life of 2 to 3 weeks (Kapinga *et al.*, 1997) and marketing of sweet potatoes to different places is also one of major constraint, as about 35 % to 95 % post-harvest losses occur during post-harvest management (Rees *et al.*, 2001). Therefore, it is necessary to convert it into value added products which retain colour, flavour and nutrients with longer shelf life. So, to increase the shelf life of sweet potato, it is converted into various processed products like flour, dried slices, dried chips, RTS, beverages, etc. Sweet potato flour is used in cakes, biscuits, noodles, jam, jellies, sauces, fortified flour, juices, wines, ice-cream, alcohol, industrial starch, crackies and other dishes etc. (Nxumalo, 1998; Nungo, 2004).

Drying or dehydration techniques are used to remove the moisture from the product and convert it into flour or powder form (Srivastav and Kumar, 2002). But, these methods results in loss of nutrients, vitamins, minerals, anti-oxidants, poly-phenols, colour compounds, pigments, etc. Also, undesirable changes like discolouration, browning, off-flavour, agglomeration, etc., occur, which results in short shelf life of the final product during storage.

For the final product, several pre-treatments are applied prior to

drying of sweet potato, viz., salt and sugar solution, lemon juice, citric acid, sulphuring, osmotic pre-treatment and blanching to improve nutritional and sensory qualities of the final product. It also prevents undesirable changes during drying and increases shelf life of the final product during storage.

Specifically, the work was aimed to investigate the effect of different pre-treatment methods, drying methods on physical, biochemical, sensory and microbial characteristics of sweet potato flour.

MATERIALS AND METHODS

Sweet potato fruits of “C-71” variety were procured from local market of Junagadh, Gujarat. The matured sweet potato fruits were selected after removing small sized and unripe fruits for the study, which were cleaned. The fruits were then peeled manually, such a way that a minimum loss of pulp occurred during peeling. The peeled fruits were manually sliced (4 mm thickness). Sweet potato slices of uniform thickness and round shape were selected for different pre-treatments. The physical and biochemical parameters of fresh sweet potato fruits were measured as per the standard methods.

Fresh sweet potato slices of 4 mm thickness were pre-treated by 0.1 % citric acid for 10 minutes (P₁), steam blanching for 10 minutes (P₂), 1 % sodium meta-bisulfite+1 % lemon juice solution for 10 minutes (P₃), hot water blanching at 100⁰C for 2 minutes (P₄) and without any pre-treatment (control). The four pre-treated samples and a sample without pre-treatment of sweet potato slices were dried by three methods, viz., hot air drying at 60⁰C and 0.90 m/s using cabinet dryer, solar drying using commercial solar dryer and fluidized bed drying at 60⁰C and 6.25 m/s air velocity using fluidized bed dryer.

Details of treatments

- T₁(P₁D₂) = Pre-treatments with 0.1 % citric acid for 10 minutes followed by hot-air drying at 60⁰C and 0.90 m/s using cabinet dryer (Abdulla *et al.*, 2014)
- T₂(P₁D₂) = Pre-treatments with 0.1 % citric acid for 10 minutes followed by solar drying using commercial solar dryer
- T₃(P₁D₃) = Pre-treatments with 0.1 % citric acid for 10 minutes followed by hot-air drying at 60⁰C and 6.25 m/s using fluidized bed dryer
- T₄(P₂D₁) = Pre-treatments with steam blanching for 10 minutes followed by hot-air drying at 60⁰C and 0.90 m/s using cabinet dryer
- T₅(P₂D₂) = Pre-treatments with steam blanching for 10 minutes followed by solar drying using commercial solar dryer (Tunde *et al.*, 2011)
- T₆(P₂D₃) = Pre-treatments with steam blanching for 10 minutes followed by hot-air drying at 60⁰C and 6.25 m/s using fluidized bed dryer
- T₇(P₃D₁) = Pre-treatments with 1 % sodium meta-bisulphite and 1 % lemon juice solution for 10 minutes followed by hot-air drying at 60⁰C and 0.90 m/s using cabinet dryer (Latapi and Barrett, 2006, Sanni *et al.*, 2007)
- T₈(P₃D₂) = Pre-treatments with 1 % sodium meta-bisulphite and 1 % lemon juice solution for 10 minutes followed by solar drying using commercial solar dryer
- T₉(P₃D₃) = Pre-treatments with 1 % sodium meta-bisulphite and 1 % lemon juice solution for 10 minutes followed by hot-air drying at 60⁰C and 6.25 m/s using fluidized bed dryer
- T₁₀(P₄D₁) = Pre-treatments with hot water blanching for 10 minutes followed by hot-air drying at 60⁰C and 0.90 m/s using cabinet dryer (Oyebanji *et al.*, 2013)
- T₁₁(P₄D₂) = Pre-treatments with hot water blanching for 10 minutes followed by solar drying using commercial solar dryer
- T₁₂(P₄D₃) = Pre-treatments with hot water blanching for 10 minutes followed by hot-air drying at 60⁰C and 6.25 m/s using fluidized bed dryer
- T₁₃(P₅D₁) = Without any pre-treatments followed by hot-air drying at 60⁰C and 0.90 m/s using cabinet dryer
- T₁₄(P₅D₂) = Without any pre-treatments followed by hot-air drying at 60⁰C and 0.90 m/s using hot-air drying at 60⁰C and 6.25 m/s using fluidized bed dryer
- T₁₅(P₅D₃) = Without any pre-treatments followed by solar drying using commercial solar dryer

The treatment samples obtained by different treatments were evaluated for physicochemical, organoleptic and microbiological evaluation. Ascorbic acid and titratable acidity were determined as per the methods suggested by Ranganna (2000). Total sugar estimation was performed according to the phenol sulphuric acid method as suggested by Sadasivam and Manickam (1996). The fiber content was estimated based on the Gerhardt

fiber bag method using fiber therm (Model: FT 12, Gerhardt Analytical System). Protein content was estimated as per the method suggested by Lowry *et al.* (1951). The standard procedure suggested by Downes and Ito (2001) was used for microbial analysis for stored sweet potato flour. The sensory evaluation of sweet potato flour carried out as per the method suggested by Ranganna (2000). The process flow chart was given here,



RESULTS AND DISCUSSION

Physical parameters

The physical and biochemical parameters of fresh sweet potato fruits used for the experimentation work were determined and their mean values with standard deviation of respective five samples were reported in Table 1. The mean value of total sugar and crude fiber content of fresh sweet potato fruit with their standard deviation were found 25.46 ± 0.74 % and 4.84 ± 0.14 %, respectively. This indicated that the sweet potato fruit is a

good source of digestible sugar and fiber. USDA (2009) reported 31.56 % total sugar content (carbohydrates) of sweet potato for VSP-1 variety. Ellong *et al.* (2014) obtained the crude fiber content of 4.9 ± 1.0 % for sweet potato cv. CAM/09/001, which was in close agreement to that obtained in present investigation for sweet potato cv. C-71 fruit. The mean value of protein content of fresh sweet potato fruit pulp with their standard deviation was 2.02 ± 0.13 % (Table 2), USDA (2009) reported value of 2.15 % protein

content for sweet potato cv. VSP-1, which is slightly higher than the value of present investigation for sweet potato cv. C-71 fruit.

Effect of drying methods on drying time and drying constant

Drying time

It was observed (Figure 1) that hot air drying at 60°C and 6.25 m/s using fluidized bed dryer required lower drying time (i.e., T₃, T₆, T₉, T₁₂ and T₁₅) as compared to hot air drying at 60°C and 0.90 m/s using cabinet dryer (i.e., T₁, T₄, T₇, T₁₀ and T₁₃) and solar drying (i.e., T₂, T₅, T₈, T₁₁ and T₁₄). The highest value of drying time of 16 h was obtained in treatments dried by solar drying, i.e., T₂ (0.1 % citric acid for 10 minutes), T₈ (1 % sodium meta-bisulphite and 1 % lemon juice solution for 10 minutes) and T₁₄ (without any pre-treatment), whereas the lowest value of drying time of 5 h was obtained in treatments dried by fluidized bed dryer, i.e., T₆ (Steam blanching for 10 minutes) and T₁₂ (Hot water blanching at 100 °C for 2 minutes). Further more, it was also observed that the treatments with fluidized bed drying (i.e., T₃, T₆, T₉, T₁₂ and T₁₅) required 2.6 to 2.8 times and 3.0 to 3.2 times less drying time as compared to treatments with cabinet drying (i.e., T₁, T₄, T₇, T₁₀ and T₁₃) and treatments with solar drying (i.e., T₂, T₅, T₈, T₁₁ and T₁₄), respectively.

These might be attributed to drying of pre-treated sweet potato slices with high velocity of 6.25 m/s using fluidized bed dryer. Eventhough, the drying temperature of pre-treated sweet potato slices in cabinet drying and fluidized bed drying was same, i.e., 60°C, difference in air flow rate showed their significant effect on rate of moisture removal during fluidized bed drying. This might be attributed to higher air flow stream (6.25 m/s) cyclone suspend the whole sweet

potato slices in cyclonic stream resulted into higher rate of moisture removal. Higher drying times in treatments with solar drying attributed to weather dependent drying conditions, i.e., drying temperature variations, i.e., 30°C to 60°C (solar drying temperature) resulted into lower rate of moisture removal.

Drying constant

It was observed (Figure 2) that the hot air drying at 60 °C and 6.25 m/s using fluidized bed dryer has higher drying constant (i.e., T₃, T₆, T₉, T₁₂ and T₁₅) as compared to hot air drying at 60°C and 0.90 m/s using cabinet dryer (i.e., T₁, T₄, T₇, T₁₀ and T₁₃). However, lower drying constant were obtained in solar drying (i.e., T₂, T₅, T₈, T₁₁ and T₁₄) by solar dryer as compared to fluidized bed dryer and cabinet dryer. The value of drying constant was an indication of efficiency of drying process. The highest value of drying constant of 0.960 per hour was obtained in treatments dried by fluidized bed dryer, i.e., T₆ (steam blanching for 10 minutes) and T₁₂ (hot water blanching at 100 °C for 2 minutes), whereas the lowest value of drying constant of 0.220 per hour was obtained in treatments dried by solar dryer, i.e., T₅ (Steam blanching for 10 minutes).

This indicated that fluidized bed drying of pre-treated sweet potato slices was faster process of water removal as compared to cabinet drying and solar drying of pre-treated sweet potato slices. This also indicated that the fluidized bed drying required less time as compared to cabinet drying and solar drying of pre-treated sweet potato slices.

Quality evaluation of sweet potato flour prepared by different treatments

The sweet potato flour prepared by different treatments was light creamy in colour, free flowing in

crispness, crystalline in consistency and hygroscopic in nature. The quality evaluation of sweet potato flour for all 15 treatments was carried out on the basis of physical, biochemical and organoleptic parameters as described hereunder in following sub sections.

Physical parameters of sweet potato flour

The physical properties of sweet potato flour, viz., recovery, water solubility index (WSI) and water absorption index (WAI) were determined as per the standard methods. Their statistically analyzed values are reported in Table 3 and their mean data are given in Table 2.

Recovery

Highest recovery of 33.22 % (Table 2) was obtained in treatment T₄ (P₂D₂), i.e., steam blanching followed by solar drying, whereas the lowest recovery of 24.82 % was obtained in treatment T₁₅ (P₂D₂), i.e., without any treatment (control) followed by fluidized bed drying. It was noticed (Table 3) that the treatments with solar drying (i.e., T₂, T₅, T₈, T₁₁ and T₁₄) obtained higher percentage of recovery as compared to treatments with hot air drying (60 °C and 0.90 m/s) by cabinet dryer (i.e., T₁, T₄, T₇, T₁₀ and T₁₃). However, lower percentage of recoveries were obtained in fluidized bed drying (60 °C and 6.25 m/s) using fluidized bed dryer (i.e., T₃, T₆, T₉, T₁₂ and T₁₅). These might be attributed to drying of pre-treated sweet potato slices with high velocity of 6.25 m/s using fluidized bed dryer resulted into higher loss of some of ingredients of sweet potato slices in massive hot air stream during drying. The statistical analysis of data (Table 3) revealed that the effect of pre-treatment (P) and drying method (D) on recovery of sweet potato flour was found significant.

Water solubility index

The highest value of water solubility index (WSI) of 65.12 % (Table 2) was obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying, whereas the lowest of 57.32 % was obtained in treatment T₁₄ (P₄D₃), i.e., hot water blanching at 100 °C for 2 minutes followed by fluidized bed drying. The highest value of water solubility index (WSI) in treatment T₈ (P₃D₂) shows excellent dissolving characteristics of sweet potato flour. The highest value of WSI (65.12 %) is an indication of optimum processing conditions and best composition (i.e., texture, density and particles size) of prepared flour obtained in treatment T₈(P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying. The effect of pre-treatment (P) and drying method (D) on water solubility index (WSI) of sweet potato flour was found significant. Furthermore, the effect of the interaction between P x D on water solubility index (WSI) was found non-significant (Table 3).

Water absorption index (WAI)

The highest value of water absorption index (WAI) of 184.67 % was obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying, whereas the lowest of 161.07 % was obtained in treatment T₁₂ (P₄D₃), i.e., hot water blanching at 100 °C for 2 minutes followed by fluidized bed drying (Table 2). The highest value of water absorption index (WAI) in treatment T₈ (P₃D₂) shows excellent water absorbing characteristics of sweet potato flour. The highest value of WAI (184.67 %) is an indication of optimum processing conditions and best

composition (i.e., texture, structure, and porosity) of prepared flour obtained in treatment T₈ (P₃D₂) i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying.

Biochemical parameters of sweet potato flour

The physical properties of sweet potato flour, viz., ascorbic acid content, total sugar, titratable acidity, carotenoid, crude fiber and protein content were determined as per the standard methods. Their statistically analyzed values are reported in Table 3 and their mean data are given in Table 2.

Ascorbic acid content

The highest ascorbic acid of 42.93 mg/100 g (Table 2) was obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying, whereas the lowest ascorbic acid of 24.12 mg/100 g was obtained in treatment T₆ (P₂D₃), i.e., steam blanching for 10 minutes followed by fluidized bed drying. It was also observed (Table 3) that treatments pre-treated with sodium meta-bisulphite + lemon juice obtained higher ascorbic acid content as compared to other pre-treatments, viz., citric acid, steam blanching, hot water blanching and without any pre-treatments for the same drying methods. The effect of pre-treatment (P) and drying method (D) on ascorbic acid content of sweet potato flour was found significant. Furthermore, the effect of the interaction between P x D on ascorbic acid content was also found significant.

Total sugar

The highest percentage of total sugar of 45.56 % (Table 2) was obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes

followed by solar drying, whereas the lowest percentage of total sugar of 25.59% was obtained in treatment T₁₂ (P₄D₃) i.e., hot water blanching at 100°C for 2 minutes followed by fluidized bed drying. The treatments with solar drying (i.e., T₂, T₅, T₈, T₁₁ and T₁₄) obtained higher percentage of total sugar as compared to treatments with hot air drying (60°C and 0.90 m/s) by cabinet dryer (i.e., T₁, T₄, T₇, T₁₀ and T₁₃). However, lower percentage of total sugar were obtained in fluidized bed drying (60°C and 6.25 m/s) using fluidized bed dryer (i.e., T₃, T₆, T₉, T₁₂ and T₁₅). The statistical analysis of data (Table 3) revealed that the effect of pre-treatment (P) and drying method (D) on total sugar of sweet potato flour was found significant. Furthermore, the effect of the interaction between P x D on total sugar was also found significant.

Titratable acidity

The highest percentage of titratable acidity of 1.62 % was obtained in treatment T₈ (P₃D₂) i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying, whereas the lowest percentage of titratable acidity of 0.91% was obtained in treatment T₆ (P₂D₃) i.e., steam blanching for 10 minutes followed by fluidized bed drying (Table 2). It was also observed that treatments pre-treated with sodium meta-bisulphite + lemon juice obtained higher percentage of titratable acidity as compared to other pre-treatments, viz., citric acid, steam blanching, hot water blanching and without any pre-treatments for the same drying methods. The effect of pre-treatment (P) and drying method (D) on titratable acidity of sweet potato flour was found significant. Furthermore, the effect of the interaction between P x D on titratable acidity was also found significant (Table 3).

Carotenoid

The highest carotenoid content of 2.03 mg/100 g (Table 2) was obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying, whereas the lowest carotenoid content of 1.14 mg/100 g was obtained in treatment T₁₂ (P₄D₃) i.e., hot water blanching at 100°C for 2 minutes followed by fluidized bed drying. It was also observed that treatments pre-treated with sodium meta-bisulphite + lemon juice obtained higher carotenoid content as compared to other pre-treatments, viz., citric acid, steam blanching, hot water blanching and without any pre-treatments for the same drying methods. The statistical analysis of data (Table 4) revealed that the effect of pre-treatment (P) and drying method (D) on carotenoid content of sweet potato flour was found significant. Furthermore, the effect of the interaction between P x D on carotenoid content was also found significant.

Crude fiber

The highest percentage of crude fiber of 7.73 % (Table 2) was obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying, whereas the lowest percentage of crude fiber of 4.34% was obtained in treatment T₁₅ (P₅D₃) i.e., without any pre-treatments followed by fluidized bed drying. It was also observed that treatments pre-treated with sodium meta-bisulphite + lemon juice obtained higher carotenoid content as compared to other pre-treatments, viz., citric acid, steam blanching, hot water blanching and without any pre-treatments for the same drying methods. The effect of pre-treatment (P) and drying method (D) on crude fiber content of sweet

potato flour was found significant. Furthermore, the effect of the interaction between P x D on crude fiber content was also found significant (Table 3).

Protein content

The highest percentage of protein content of 3.04 % was obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying, whereas the lowest percentage of protein content of 1.71% was obtained in treatment T₁₂ (P₄D₃), i.e., hot water blanching at 100°C for 2 minutes followed by fluidized bed drying. It was also observed that treatments pre-treated with sodium meta-bisulphite + lemon juice obtained higher protein content as compared to other pre-treatments, viz., citric acid, steam blanching, hot water blanching and without any pre-treatments for the same drying methods. The effect of pre-treatment (P) and drying method (D) on protein content (Table 3) of sweet potato flour was found significant. Furthermore, the effect of the interaction between P x D on protein content was also found significant.

Overall results of different biochemical constituents, viz., ascorbic acid, acidity, total sugar, carotenoid, crude fiber and protein were found in lower percentage cabinet drying (60°C and 6.25 m/s) and fluidized bed drying (60°C and 6.25 m/s) using fluidized bed dryer (i.e., T₃, T₆, T₉, T₁₂ and T₁₅) as compared to solar drying. These might be attributed to drying of pre-treated sweet potato slices with high temperature (60°C) and high velocity of 6.25 m/s using fluidized bed dryer resulted into higher loss of soluble solutes from the tissues of pre-treated sweet potato slices in massive air stream during drying.

Sensory characteristics

The sensory evaluation of sweet potato flour prepared by different treatments was carried on the basis of color, flavor, taste, odor and overall acceptability. The highest sensory score of 8.23 was obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying using commercial solar dryer, whereas the lowest sensory score of 6.22 in treatment T₁₅ (P₅D₃) i.e., without any pre-treatments followed by hot air drying using fluidized bed dryer.

CONCLUSION

From the results it was summarized that on the basis of physical parameters of sweet potato flour, the highest water solubility index (65.72 %), highest water absorption index (184.67 %) were obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying using commercial solar dryer. On the basis of biochemical parameters of sweet potato flour, the highest retention of ascorbic acid content (42.93 mg/100 g), total sugar (45.56 %), titratable acidity (1.62 %), carotenoid content (2.03 mg/ 100 g), crude fiber content (7.73 %) and protein content (3.04 %) were obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying using commercial solar dryer. On the basis of sensory characteristics of sweet potato flour, highest sensory score of 8.23 in terms of colour, flavour, taste, odour and overall acceptability was obtained in treatment T₈ (P₃D₂), i.e., 1 % sodium meta-bisulphite + 1 % lemon juice solution for 10 minutes followed by solar drying using commercial solar dryer. Based on the above study, it

could be concluded that treatment T₈ (i.e., sodium meta-bisulphite + lemon juice followed by solar drying) was found to be the best among all the treatments on the basis of physical, biochemical and sensory characteristics of sweet potato flour.

REFERENCES

- Abdulla, G.; Gehan, A.; Shourbagy, E. and Sitohy, M. Z. (2014). Effect of pre-drying, blanching and citric acid treatments on the quality of fried sweet potato chips. *American J. Food Technol.*, **9**(1): 39-48.
- Anonymous. (2015). Horticultural Statistics at a Glance 2015. Horticulture Statistics Division, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi.
- Downes, F. P. and Ito, K. (2001). Compendium of Methods of the Microbiological Examination of Food. 4th Ed. American Public Health Association, Washington.
- Ellong, E. N.; Billard, C. and Adenet, S. (2014). Comparison of physicochemical, organoleptic and nutritional abilities of eight sweet potato (*Ipomoea batatas*) varieties. *Food Nutri. Sci.*, **5**: 196-211.
- FAO. (2010). Food and Agriculture Organization of the United Nations, Rome, Italy.
- FAO. (2012). Food and Agriculture Organization of the United Nations, Rome, Italy.
- Kapinga, R. E.; Jeremiah, S. C., Rwiza, E. J. and Rees, D. (1997). Preferences and Selection Criteria of Sweet potato in Urban Areas of the Lake Zone of Tanzania.

- Chatham, UK: Natural Resources Institute (Unpublished).
- Latapi, G. and Barrett, D. M. (2006). Influence of pre-drying treatments on quality and safety of sun-dried tomatoes. Part II. Effects of storage on nutritional and sensory quality of sun-dried tomatoes pre-treated with sulfur, sodium meta-bisulfite or salt. *J. Food Sci.*, **71**(1): 32-37.
- Lowry, O. H.; Rosenbrough, A. J.; Farr, A. L. and Randall, R. J. (1951). Protein estimation with folin phenol reagent. *J. Biol. Chem.* 193: 265-275.
- Nungo, R. A. (2004). Nutritious Sweet Potato Recipes, Training Manual No.1 for Extension workers (Unpublished).
- Nxumalo, M. H. (1998). The potential role of root crops in Swaziland. In: *Proceeding of the sixth triennial symposium of the international society for tropical root crops. Africa Branch Lilongwe, Malawi*, 22-23 October, pp.57-61.
- Oyebanji, A. O.; Ajani, A. O.; Adeize, A.; Oyelakin, M. O.; Ikotun, I.; Agboola, A. A.; Alimi, J. P.; and Awoite, T. (2013). Effect of pre-drying treatments on utilizability of sweet potato tubers for production of chips for confectionery flour. *African J. Food Sci.*, **7**(9): 258-263.
- Ranganna, S. (2000). Handbook of Analysis and Quality Control for Fruits and Vegetable Products. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- Rees, D.; Kapinga, R.; Mtunda, K.; Chilosa, D.; Rwiza, E.; Kilima, M.; Kiozya, H. and Munisi, R. (2001). Damage reduces both market value and shelf-life of sweet potato: a case study of urban markets in Tanzania. *J. Tropical Sci.*, **41**: 1-9.
- Sadasivam, S. and Manickam, A. (1996). Biochemical Methods. 2nd Ed. New Age International Private Ltd. Publishers, Coimbatore, India.
- Sanni, L. O.; Babajide, J. M. and Ojerinde, M. W. (2007). Effect of chemical pre-treatments on the physicochemical and sensory attributes of sweet potato-gari. *ASSET Int. J.*, **6**(1): 41-49.
- Srivastav, R. P. and Kumar, S. (2002). Fruit and Vegetable Preservation: Principles and Practices. 3rd ed, Army Printing Press, Lucknow, India, pp 11–20.
- Tunde, A. T. Y.; Akintunde, B. O. and Fagbeja, A. (2011). Effect of blanching methods on drying kinetics of bell pepper. *African J. Food, Agric. Nutri. Develop.*, **11**(7): 5457-5474.
- USDA (United States Department of Agriculture), Agricultural Research Service. (2009). USDA National Nutrient Database for Standard Reference, Release 22. Nutrient Data Laboratory Home Page, <http://www.ars.usda.gov/ba/bh/nrc/ndl>, Accessed 15May, 2015.

Table 1: Physical and biochemical parameters of fresh sweet potato (Cv. C-71) fruit

Sample No.	Physical Parameters			Biochemical Parameters					
	Fruit Weight (g)	Pulp to Peel Ratio	Firmness (kg)	Acidity (%)	Total Sugar (%)	Carotenoid (mg/ 100 g)	Ascorbic Acid (mg/100g)	Crude Fiber (%)	Protein Content (%)
1	106.70	2.21	3.82	0.25	25.50	0.67	29.40	4.70	2.00
2	111.30	2.29	4.11	0.21	26.40	0.71	28.30	4.90	1.90
3	101.30	2.24	3.90	0.28	25.20	0.72	31.40	5.00	2.10
4	105.23	2.27	3.87	0.24	24.40	0.69	28.60	4.90	2.20
5	98.55	2.18	3.92	0.22	25.80	0.68	29.10	4.70	1.90
Mean	104.62	2.24	3.90	0.24	25.46	0.69	29.36	4.84	2.02
SD	4.93	0.04	0.09	0.03	0.74	0.02	1.22	0.14	0.13

Table 2 : Mean values of physico-chemical parameters of sweet potato flour prepared by different drying methods

Sr. No.	Treatments	Physical Parameters			Biochemical Parameters					
		Recovery (%)	WSI (%)	WAI (%)	Ascorbic Acid (mg/100 g)	Total Sugar (%)	Titratable Acidity (%)	Carotenoid (mg/100 g)	Crude Fiber (%)	Protein Content (%)
1	T ₁ (P ₁ D ₁)	27.18	59.68	167.70	33.13	35.16	1.25	1.56	5.96	2.34
2	T ₂ (P ₁ D ₂)	30.24	62.74	176.30	37.37	39.66	1.41	1.76	6.73	2.64
3	T ₃ (P ₁ D ₃)	26.33	58.83	165.31	31.54	33.47	1.19	1.49	5.68	2.23
4	T ₄ (P ₂ D ₁)	29.23	60.97	171.33	25.18	29.53	0.95	1.31	4.63	1.97
5	T ₅ (P ₂ D ₂)	33.22	64.61	181.55	28.62	33.19	1.08	1.48	5.34	2.21
6	T ₆ (P ₂ D ₃)	28.14	60.04	168.71	24.12	27.56	0.91	1.23	4.48	1.84
7	T ₇ (P ₃ D ₁)	28.47	61.73	173.46	35.51	37.69	1.34	1.68	6.39	2.51
8	T ₈ (P ₃ D ₂)	32.11	65.72	184.67	42.93	45.56	1.62	2.03	7.73	3.04
9	T ₉ (P ₃ D ₃)	27.54	60.64	170.40	34.19	36.28	1.29	1.61	6.15	2.42
10	T ₁₀ (P ₄ D ₁)	26.84	57.97	162.90	27.83	26.72	1.05	1.19	5.01	1.78
11	T ₁₁ (P ₄ D ₂)	31.25	61.85	173.80	31.27	30.38	1.18	1.35	5.63	2.03
12	T ₁₂ (P ₄ D ₃)	25.87	57.32	161.07	25.97	25.59	0.98	1.14	4.67	1.71
13	T ₁₃ (P ₅ D ₁)	25.47	59.34	166.75	25.71	27.28	0.97	1.21	4.53	1.82
14	T ₁₄ (P ₅ D ₂)	29.35	63.75	179.14	29.68	31.50	1.12	1.40	5.15	2.10
15	T ₁₅ (P ₅ D ₃)	24.82	58.37	164.02	24.91	26.44	0.94	1.18	4.34	1.76

Table 3: Statistically analyzed data on effect of different treatments on Physico-chemical parameters of sweet potato flour prepared by different methods

Treatments	Physical Parameters			Biochemical Parameters					
	Recovery (%)	WSI (%)	WAI (%)	Ascorbic Acid (mg/100 g)	Total Sugar (%)	Titrateable Acidity (%)	Carotenoid (mg/100 g)	Crude Fiber (%)	Protein Content (%)
Pre-treatment (P)									
P₁ (CA)	27.92	60.42	169.77	34.01	36.09	1.28	1.60	6.12	2.41
P₂ (SB)	30.20	61.87	173.86	25.97	30.09	0.98	1.34	4.82	2.01
P₃ (SMLJ)	29.37	62.70	176.18	37.54	39.84	1.42	1.77	6.76	2.66
P₄ (HWB)	27.99	59.05	165.92	28.36	27.56	1.07	1.23	5.10	1.84
P₅ (C)	26.55	60.49	169.97	26.77	28.41	1.01	1.26	4.67	1.89
S.Em.±	0.18	0.38	1.76	0.26	0.20	0.01	0.01	0.06	0.02
C.D. at 5%	0.51	1.08	5.01	0.75	0.58	0.02	0.03	0.16	0.06
Drying method (D)									
D₁ (HAD)	27.44	59.94	168.43	29.47	31.28	1.11	1.39	5.30	2.09
D₂ (SD)	31.23	63.73	179.09	33.97	36.06	1.28	1.60	6.12	2.40
D₃ (FBD)	26.54	59.04	165.90	28.14	29.87	1.06	1.33	5.07	1.99
S.Em.±	0.14	0.29	1.36	0.20	0.16	0.01	0.01	0.04	0.02
C.D. at 5%	0.39	0.84	3.88	0.58	0.45	0.02	0.02	0.13	0.05
P X D									
S.Em.±	0.31	0.66	3.05	0.46	0.35	0.01	0.02	0.10	0.04
C.D. at 5%	NS	NS	NS	1.30	1.01	0.04	0.05	0.28	0.11
C.V. %	2.17	2.16	3.56	2.99	2.19	2.19	2.19	3.61	3.61

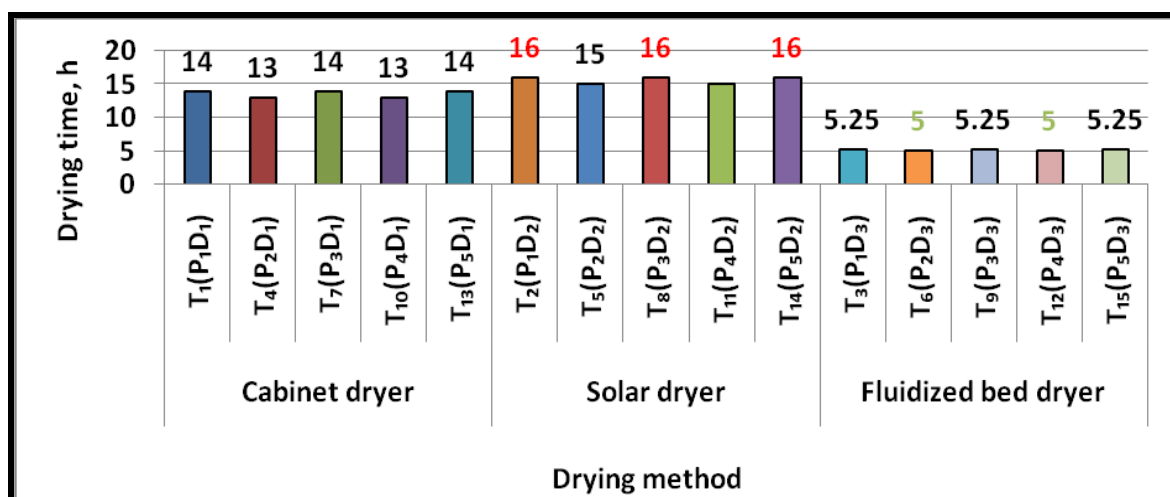


Figure 1: Effect of drying methods on drying time of pre-treated sweet potato slices of different treatments

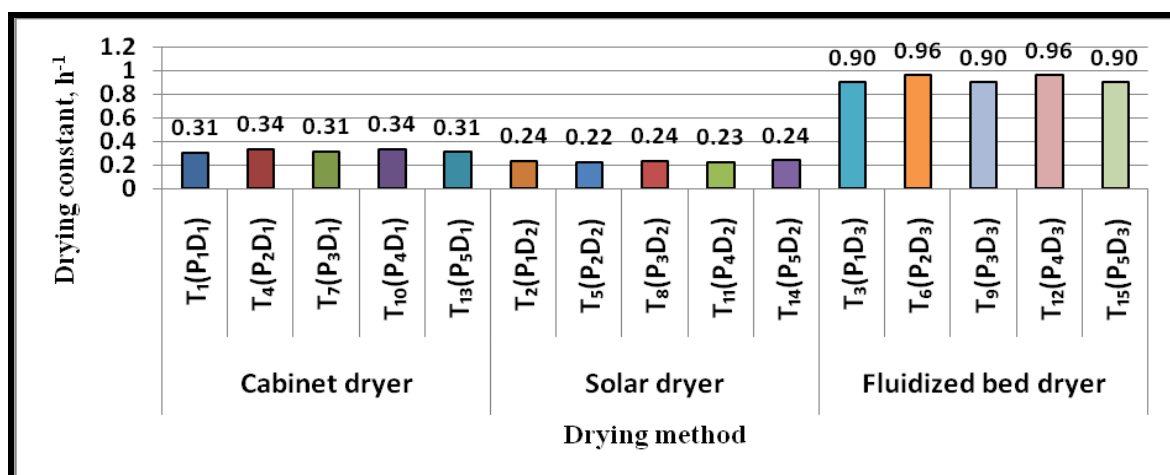


Figure 2: Effect of drying methods on drying constant of pre-treated sweet potato slices of different treatments

[MS received: August 05, 2016]

[MS accepted: September 25, 2016]