Science Letters ISSN 2345-5463 – An International Triannually Journal

Research article
2019 | Volume 7 | Issue 2 | Pages 91-98

Open Access

Effect of Potassium Metabisulphite and Temperature on Hot Air Drying of Dasheri Mango Slices

Mustapha Muhammad Nasiru[1, 2*], John Diamond Raj[1], Kailash Chandra Yadav[1]

[1] Department of Food Process Engineering, Vaugh School of Agricultural Engineering & Technology, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad-211007, Uttar Pradesh, India
[2] Department of Food Science and Technology, Federal University, Dutsin-Ma, Katsina State, Nigeria

ARTICLE INFO

Received
February 23, 2019
Accepted
May 14, 2019
Published
August 15, 2019

***Corresponding Author**
Mustapha Muhammad Nasiru
E-mail
mustaphamnasiru@gmail.com
Phone
+2348035915739

Keywords
Dasheri mango slices
Hot air dryer
Pre-treatment
Potassium metabisulphite
Rehydration ratio

How to Cite
Nasiru MM, Raj JD, Yadav KC. Effect of potassium metabisulphite and temperature on hot air drying of Dasheri mango slices. Sci Lett 2019; 7(2):91-98

Abstract

Food products are pre-treated with chemicals to dry as quick as possible, retain product quality and minimize energy cost. In this study, the effect of temperature and potassium metabisulphite (KMS) pre-treatment on Dasheri mango slices dehydrated using hot air oven was studied. Three temperatures (50ºC, 60ºC and 70ºC) and KMS pre-treatment levels (0.5%, 1% and 1.5%), as well as control samples, were used for the study. From the dehydrating curve, it was observed that the drying of the mango slices occurred on the falling rate stage. Around 5.5%-31.7% of the final moisture was achieved on dry weight basis in the mango slices and the drying time ranges from 390-690 min at all the drying temperatures and pre-treatment levels. The rehydration ratio of the mango slices ranged from 2.52 to 3.54 while dehydration ratio ranged from 4.180 to 5.483. The color of the mango slices was analyzed based on the Hunter color scale. The assayed results showed that *L*, *a* and *b* color parameters of the pre-treated samples vary significantly compared to the control samples. Thus, the optimum combination for the drying of Dasheri mango slices could be attained when dehydration takes place at 60°C with 1% KMS pre-treatment.

Scan QR code to see this publication on your mobile device.

Introduction

Mango (*Magnifera indica* L.) which is referred to as the king of fruits originated from Southern Asia, Andaman, Burma Islands and Eastern India to be precise [1, 2]. More than 1000 named kinds of mango do exist throughout the world, amongst which 69 species are mostly confined to the tropical region [1]. Mango accounts for roughly half of all tropical fruits produced globally, it`s ranked second after pineapple in quantity and value [1, 3]. India and Nigeria are in the midst of principal mango producing countries in the world. India leads the list with a total production of 22,099,225 MT contributing 69% of global production, while Nigeria is eighth on the list with a total production of 860,000 MT [4, 5].

Mango is becoming more popular and acceptable globally due to its delicious taste, attractive flavor, diuretic and therapeutic significance [6]. However, need for mango in the global market is growing at a high rate, especially in the temperate countries because of societal variations, marketing of fruit sales in evolving nations and accessibility to international air transport [7]. Despite the stated importance, mango still is yet to realize its greatest capacity as an export-driven product due to its confined production [2]. The global production of mango stood at 48,989,062 MT, but unfortunately, the export volume is less than 10% of the total production and most of which is used for table purposes instead of being processed for commercial purposes [4, 7]. India is leading in the global trade of processed mango, whereas the percentage of the processed mango is nearly 2% compared to the total produce. Thus, the post-harvest losses of mango are very high, which were estimated around 25-40% from harvest to consumption and only 20% of the processed mango products are being exported, out of which mango pulp accounts for 80% of the exported products [2, 7]. Similarly, Nigeria is the leading producer in Africa and eighth on the global scale, the situation of mango is worse compared to India. The post-harvest losses reach up to 50%, mainly due to poor post-harvest practices along with environmental factors such as high temperature and relative humidity. Thus, the country is lagging behind in terms of utilization and export of fresh or processed mango. The processing of mango is entirely done locally at a very low scale and confined to only mango juice [8, 9].

Considering the facts above and the problems of perishability and seasonality, the fruit is yet to realize its maximum potential as an export-oriented commodity in most of its leading producers. Therefore, the fruit must be stabilized and processed after harvest to overcome the problems of post-harvest losses and underutilization. The processing of mango would also help in avoiding a market glut during its season, stabilize its price, thereby ensuring income security to farmers and brings nutritional security to the society in general [10-12]. From the technical point of view, dehydration appears to be one of the most promising and widely used preservation technique that extends shelf life, reduces weight minimizing transportation cost and smaller space for storage of food products. It`s also suitable for developing countries where it`s incredibly unusual to launch the state-of-the-art systems of food preservation because of the erratic power supply and enormous funds needed for additional processes. Conversely, dehydration has a substantial influence on the steadiness of numerous health-enhancing antioxidant constituents in processed food material [10-14]. Dehydration is among the primordial techniques of preserving food and is an imperative part of food processing. Dehydration is a preservation method, in which water activity and its content are reduced to the barest minimum by heated air to inhibit microbiological, biochemical, and chemical activities in fruits and vegetables. It can also be described as a process during which a mass transfer occurs, thereby removing water or/and solvent from a food material through evaporation [14-17].

In order to dry food products as quickly as possible and at the same time retain product quality and minimize energy cost, pre-treatment drying should be employed. However, some pre-treatments such as using chemicals can increase the drying rate by removing the surface resistance as well as relaxing tissue structure of fruits and vegetables. Pre-treatments can also incapacitate enzymes, thus precluding color changes and produce a desirable dried product [13, 14, 18]. Consequently, the purpose of this study was to determine the influence of temperature and potassium metabisulphite (KMS) as pre-treatment on the drying attributes and physicochemical parameters viz. rehydration ratio, dehydration ratio and color of the dehydrated mango slices.

Materials and Methods

Sample preparation

Fresh mango fruits (*Magnifera Indica* var. *Dasheri*) were purchased from local fruit sellers in Mahewa, Allahabad, India. It was then washed, cleaned, and kept at refrigeration temperature until the time of conducting the experiment. Before conducting an experiment, the mangoes were removed from the refrigerator and kept at an ambient temperature of 30 ℃ for 2 hours to achieve equilibrium. It was then sliced into rectangular slabs of an average thickness of 5 mm each.

Pre-treatment

The mango slices were treated by dipping in KMS of 0.5 g/100 ml, 1.0 g/100 ml and 1.5 g/100 ml solutions at room temperature for 5 minutes. Mango slices dipped in an equal mass of water for 5 minutes were used as a control sample.

Hot air drying

The dryer (Make: Swastika Bio Remedies (P) Ltd, Ambala Cantt, India; Model: Alpine) was operated unloaded for 30 minutes to achieve a steady state condition. The pre-treated samples of mango slices were placed in Petri dishes and weighed, and subsequently placed on a drying tray and loaded into the dryer. The drying was conducted at temperatures of 50ºC, 60ºC, and 70ºC. The weight loss of the sample was noted at an interlude of 30 minutes up to equilibrium moisture content. The whole experiment was replicated three times for each temperature and pre-treatment level. An electronic balance (Make: National Scales; Model: Apolo) of 0.001g sensitivity was used in recording the weight of mango slices during the drying at intervals of 30 min. The samples were kept in dry and ambient conditions after they were placed in polyethylene bags until further experiments.

Drying attributes of Dasheri mango slices

Initial moisture content

The protocol of Association of Official Analytical Chemists (AOAC) [19] was used to determine the initial moisture content of the samples as follows:

$$MC_{db} = \left(\frac{WM}{DM}\right) \times 100 \qquad (1)$$

Where MC_{db} is the % moisture content (dry basis), *WM* is the mass of wet matter (g), and *DM* is the mass of dry matter (g).

The drying rate of the samples was calculated according to Chakraverty [20] as follows:

$$DR = \frac{W}{t \times \left(\frac{M_{bd}}{100}\right)} \qquad (2)$$

Where *DR* is the drying rate (g of water/min/100g material on dry basis), *W* is the amount of water removed (*g*), M_{bd} is the weight of bone-dry material (g) and t is the time (min).

Rehydration ratio

Rehydration ratio is the measure of food material to reabsorb moisture after being dehydrated. It is evaluated as the ratio of rehydrated sample to the initial dried sample. The rehydration test was conducted as recommended by Davoodi et al. [21] with a modified sample mass to water volume ratio of 1g: 30 ml of distilled water.

$$RR = \frac{M_{rh}}{M_{dh}} \qquad (3)$$

Where M_{rh} is the mass of the rehydrated sample (g) and M_{dh} is the mass of the dried sample for rehydration test (g).

Dehydration ratio

Dehydration ratio is the mass of mango slices before drying to the mass of dehydrated samples. Dehydration ratio (D_{ratio}) was calculated as the mass of sliced mango before loading to the dryer to the mass of dehydrated material at the time of removal from drier [22].

$$D_{ratio} = \frac{M_{after}}{M_{before}} \qquad (4)$$

Where M_{before} is mass of the sample before drying (*g*) and M_{after} is the mass of the sample after drying (*g*).

Colour

The color of the dehydrated mango slices was assessed based on the Hunter *L*, *a*, *b* color scale using the x-rite color lab. "*L*" is the measure of whiteness or blackness, "*a*" is the measure of redness or greenness, and "*b*" is the measure of yellowness or blueness of the sample [23].

Statistical analysis

Analysis of variance (ANOVA) was used to analyze the data using XLSTAT statistical software (2015 version, Addinsoft Inc., USA). The Tukey pairwise comparison test was used to compare the means of each treatment with a significance level of 5%.

Results and Discussion

Drying characteristics

During the period of the experiment, the average daily variation of temperature, relative air humidity and atmospheric pressure varies from 29.5 to 35.5 ℃, 57.2% to 67.2%, and 742.7 to 742.8 mmHg, respectively in Allahabad, India. Around 450% of drying was obtained as the initial moisture content of the mango slices. The correlation between moisture content and drying time (Fig. 1), at various temperatures and pre-treatment levels, showed a

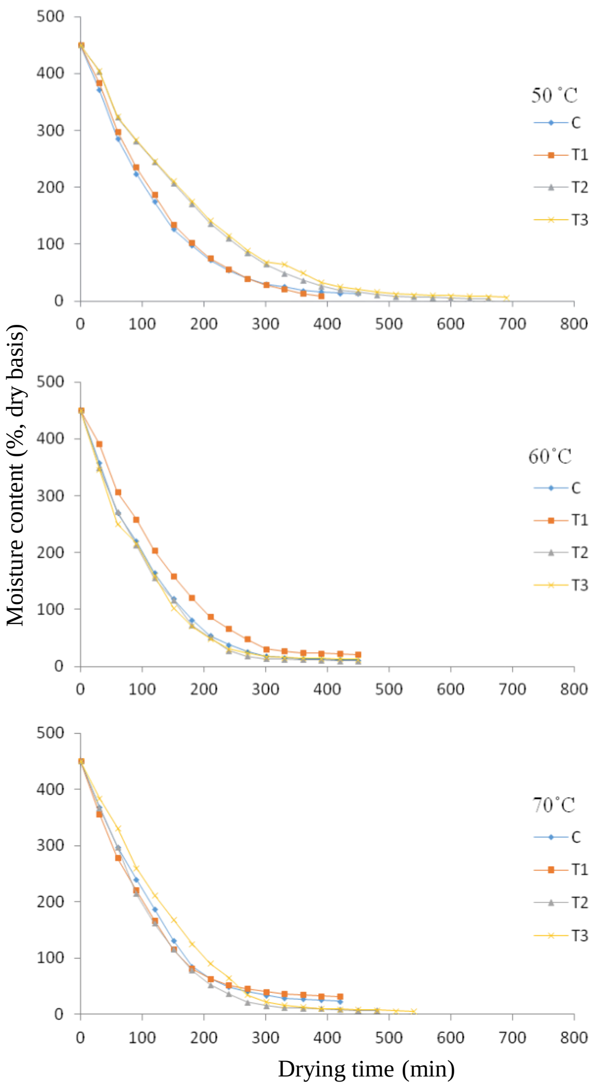

Fig. 1 Influence of drying temperature and pre-treatment of potassium metabisulphite on the moisture contents of mango slices. C = Control, T_1 = 0.5% KMS, T_2 = 1% KMS T_3 = 1.5% KMS

normal, exponential trend which agrees with previous investigations such as drying of pre-treated banana slices [24] and convective drying of Osmo-dehydrated sapota slices [25].

Table 1 shows the variations of moisture content with drying time as well as KMS pre-treatment levels. As it was anticipated, with the increase in drying time, the moisture contents of the mango slices were decreased. Several authors also find temperature as a factor that mostly influences the drying time of food products, such as long pepper [26]. From Table 1, it can be observed that KMS pre-treatment have significant effect on the drying time as well as the final moisture content of the product. The higher drying time observed at the higher level of KMS might be due to high moisture uptake as the pre-treatment level increased [27]. Furthermore, the higher resistance to both heat and mass transfer offered by KMS resulted in higher drying time [27].

The drying rate graph indicates that in the course of the entire drying process, constant rate phase was not seen. Thus, drying took place predominately under the falling rate period. This result corresponds to those obtained in the drying of various fruits and vegetables such as plantain slices [28] and green peas and okra [29]. During the falling rate phase, the surface of the mango slices was no longer saturated and diffusion was the prevailing physical process dominating the moisture movement in the samples [29, 30]. Hence, the absence of a constant rate period indicated that internal mass transfer resistance controlled the drying from the beginning [31]. The drying rate of the mango slices decreased as the moisture content decreased as observed at all temperatures and pre-treatment levels. For example, in Fig. 2, the drying rate decreases from 3.047 – 0.976, 2.031 – 0.954, 3.446 – 0.979 and 3.435 – 0.972 g of water/min/100g material for C, T_1, T_2, and T_3, respectively at 60℃. The variation was due to the fact that, at high moisture content, the liquid flow is as a result of capillary forces, and as the moisture content decreased, the amount of liquid in the pores decreased and a gas phase was built up causing a decrease in liquid permeability [31]. According to Doymaz & Kocayigit [32], shrinkage of the sample due to a reduction in porosity increases the resistance to movement of water leading to further fall in dehydration rates.

From the drying rate graph (Fig. 2), it was also noted that the drying of the mango slices occurred in two falling rate phases. The first falling rate phase was attributed with fast drying because the period is assumed to rely on both internal and external mass transfer rates; while the second stage, during which the drying was slower, is hypothesized to rely completely on internal mass transfer resistance [31]. The transient (heating up) period was observed in all the samples at drying air temperature of 50 ℃ and in some at a drying air temperature of 70 ℃. The dehydration rate upsurge during the heating up phase, then decreases continuously (Fig. 1).

Rehydration ratio

The rehydration ratio of the mango slices showed a range from 2.52 to 3.54 (Fig 3). The highest rehydration ratio between 3.31 and 3.54 was witnessed in the mango slices dried at the temperature

Table 1 Effect of different temperatures and pre-treatment of potassium metabisulphite (KMS) on dehydration time and final moisture content of mango slices.

Temperature (℃)	Pre-treatment	Drying time (min)	Final moisture content (%, d.b.)
50	C	450e	13.14c
	T_1	390g	8.52e
	T_2	660ab	6.18f
	T_3	690a	10.43d
60	C	450e	10.98d
	T_1	450e	21.23b
	T_2	450e	9.33de
	T_3	450e	12.57c
70	C	420f	23.10b
	T_1	420f	31.70a
	T_2	480d	6.64f
	T_3	540c	5.52g

C = control, T_1 = 0.5% KMS, T_2 = 1% KMS T_3 = 1.5% KMS, d.b. = dry basis. Different letters show significant differences at $P<0.05$.

of 50ºC while the lowest values between 2.52 and 2.99 were attributed to samples dried at 70ºC. The high values of rehydration ratio at 50ºC might be attributed to the fact that less cellular and structural disruption occurs at a lower temperature during dehydration of the mango slices. Similar results were obtained by Nour et al. [33] in the drying of KMS pre-treated button mushroom. Rehydration ratios of the pre-treated mango slices were higher than those of control samples at all drying air temperatures except at 70ºC. These results pointed out the effect of pre-treatment and drying air temperature on the rehydration ratio of dehydrated mango slices. These results corroborated with the results of Al-Amin et al. [27] for the drying of KMS pre-treated carrot and with the Doymaz and Kocayigit [32] for the convective drying of green peas.

Dehydration ratio

The dehydration ratio of the mango slices was found not significantly affected at all temperatures and KMS pre-treatment levels except 70ºC and the effect of drying air temperature were lesser than that of pre-treatment. (Fig. 4). The results of this study were not in accordance with the findings of Al-Amin et al. [27] who reported that dehydration ratio decreased further as the temperature decreased.

Color

The International Commission on Illumination (CIE) color parameters *L*, *a*, *b* values of the dried mango slices as a function of drying air temperature and pre-treatment with KMS are shown in Table 2. The recorded values range from 52.43 – 71.13, +22.63 – +29.76 and +44.56 – +73.40 for *L*, *a* and *b*, respectively. The *L* values of the mango slices increased significantly as the pre-treatment level increased except at 50ºC, which showed no

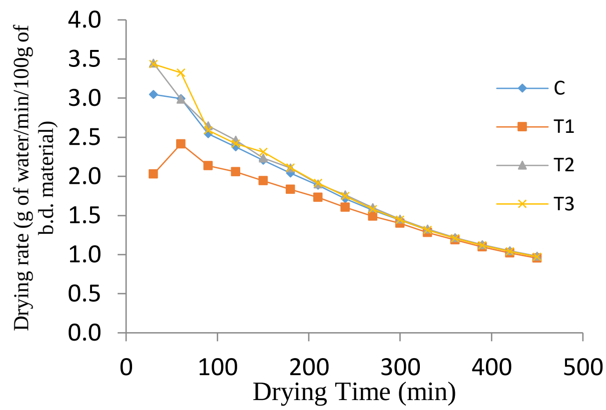

Fig. 2 Variation of the drying rate with the drying time of mango slice at 60ºC pre-treated with potassium metabisulphite (KMS). C = Control, T_1 = 0.5% KMS, T_2 = 1% KMS T_3 = 1.5% KMS

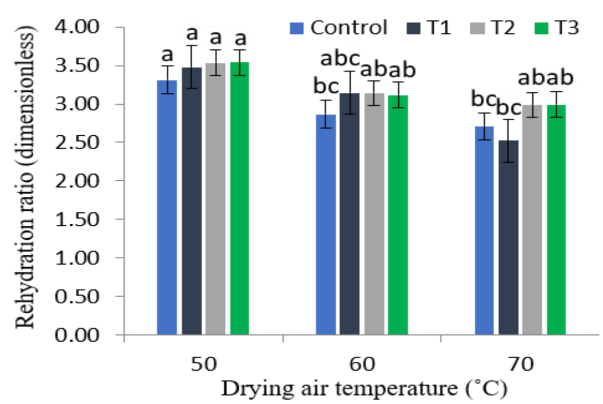

Fig. 3 Variations in rehydration ratio of mango slices pretreated with potassium metabisulphite (KMS) at different drying air temperatures. C = Control, T_1 = 0.5% KMS, T_2 = 1% KMS T_3 = 1.5% KMS. Error bars represent standard deviation.

Table 2 Effect of pre-treatment of potassium metabisulphite (KMS) and temperature levels on the color of dehydrated mango slices.

Temperature (°C)	Pre-treatment	*L*	*a*	*b*
50	C	52.43d	+26.49b	+54.59de
	T_1	62.42b	+23.89c	+44.56f
	T_2	60.25b	+29.76a	+60.41c
	T_3	61.88b	+29.47a	+64.21b
60	C	59.38c	+27.01b	+58.63d
	T_1	58.65c	+27.73b	+56.02d
	T_2	71.13a	+23.57c	+73.40a
	T_3	65.96a	+25.30b	+65.27b
70	C	56.29c	+22.63c	+52.25e
	T_1	60.05b	+25.95b	+62.81c
	T_2	64.41a	+23.76c	+67.45b
	T_3	63.49ab	+22.83c	+63.50c

C = Control, T_1 = 0.5% KMS, T_2 = 1% KMS T_3 = 1.5% KMS. Different letters show significant differences at P<0.05.

difference at all pre-treatment levels but still significantly higher than control. Hence, the luminance of the dried product was improved due to the KMS pre-treatment. A similar result was obtained by Darvishi et al. [34]. It can also be observed from Table 2 that the *a* values were influenced by the drying air temperature of 50ºC more than 60ºC and 70ºC as the highest value of +29.76 was recorded. The high values of redness at 50ºC indicated that higher Maillard reaction occurred [35]. The *b* values (yellowness) of the mango slices obtained indicated that the dominant color of the mango slices was yellowed and less browning took place during the drying of the mango slices [34]. It was also observed that the variation of *b* values of the control and pre-treated samples varied significantly at all temperature

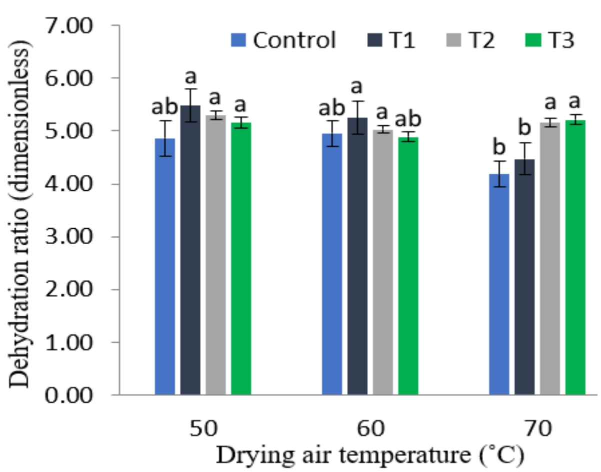

Fig. 4 Variations in dehydration ratio of mango slices pretreated with potassium metabisulphite (KMS) at different drying air temperatures. C = Control, T_1 = 0.5% KMS, T_2 = 1% KMS T_3 = 1.5% KMS. Error bars represent standard deviation.

values. Findings of Prajapati et al. [36] for the drying of KMS pre-treated aonla were in polyethylene bags agreement with our results.

Conclusions

The present study revealed that the dehydration of the mango slices took place under two falling rate periods. The temperature and KMS pre-treatment have a significant effect on drying time as well as on the final moisture content of the mango slices, but a superior outcome was observed at drying air temperature of 60ºC. The rehydration ratio of the pre-treated mango slices was higher than those of control samples at all drying air temperatures except 50ºC, and dehydration ratio was also not significantly affected by pre-treatment except 70ºC. A significant effect was observed on the *L*, *a*, *b* values with a superior outcome at 60ºC. In a nutshell, it can be recommended that optimum dehydration of the mango slices can be accomplished at a dehydration air temperature of 60 ºC and KMS pre-treatment level of 1%.

Acknowledgment

The authors would like to acknowledge the help rendered by the Food Analysis and Research Laboratory of the University of Allahabad, India. They would also like to acknowledge the Kano State Government, Nigeria for providing support for this research through the Kwankwasiyya Scholarship Scheme.

Conflict of Interest

The authors certify that they have no affiliation with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter of the materials discussed in this manuscript.

References

[1] Medina DLCJ, García HS. MANGO: Post-harvest Operations. Food and Agricultural Organisation of the United Nation. 2002. p. 1-48.

[2] Jha SN, Narsaiah K, Sharma AD, Singh M, Bansal S, Kumar R. Quality parameters of mango and potential of non-destructive techniques for their measurement – a review. J Food Sci Techol 2010; 47:1-14.

[3] Anees M, Tahir FM, Shahzad J, Mahmood N. Effect of foliar application of micronutrients on the quality of mango (*Mangifera indica* L.) cv. Dusehri fruit. Mycopath 2011; 9:25-28.

[4] National Horticulture Board, Indian Horticulture database - 2014. New Delhi: IG Printer Pvt. Ltd. 2015. p. 1-262.

[5] Subramanian KS, Sekar C, Meneka SS, Prakash VL. Reducing post-harvest losses in mango in South Asia. WRENmedia. 2014. p. 1-4.

[6] Maqbool M, Malik AU, Jabbar A. SAP dynamics and its management in commercial mango cultivars of Pakistan. Pak J Bot 2007; 39:1565-1574.

[7] Vijayanand P, Deepu E, Kulkarni SK. Physico chemical characterization and the effect of processing on the quality characteristics of Sindura, Mallika and Totapuri mango cultivars. J Food Sci Technol 2015; 52:1047-1053.

[8] Alaka OO, Aina JO, Falade KO. Effect of storage conditions on the chemical attributes of Ogbomoso mango juice. Eur Food Res Technol, 2003; 218:79-82.

[9] Saave N. Export Factsheet ECOWAS: Mangoes. Geneva. 2011. p. 1-34.

[10] Kumar SP, Sagar VR. Drying kinetics and physico-chemical characteristics of osmo- dehydrated mango, guava and aonla under different drying conditions. J Food Sci Technol 2014; 51:1540-1546.

[11] Korbel E, Attal E, Grabulos J, Lluberas E, Durand N, Morel G, et al. Impact of temperature and water activity on enzymatic and non-enzymatic reactions in reconstituted dried mango model system. Eur Food Res Technol 2013; 23:39-46.

[12] Akoy EOM. Experimental characterization and modeling of thin-layer drying of mango. Int`l Food Res J 2014; 21:1911-1917.

[13] Alakali JS, Kucha EI, Ariahu CC. Drying Characteristics of osmo-foam-mat mango pulp. J Agric Biotechnol Ecol 2010; 3:87-98.

[14] Doymaz İ, Kocayigit F. Effect of Pre-treatments on drying, rehydration, and color characteristics of red pepper ('Charliston' variety). Food Sci Biotechnol 2012; 21:1013-1022.

[15] Kadam DM, Goyal RK, Singh KK, Gupta MK. Thin layer convective drying of mint leaves. J Med Plants Res 2011; 5:164-170.

[16] Owa TW, Agbetoye LAS, Akinbamowo RO. Effects of pre-treatment on drying rate and protein content of yam slices. Schol J Engin Technol 2015; 3:1-4.

[17] Doymaz İ, İsmail O. Drying and rehydration behaviors of green bell peppers. Food Sci Biotechnol 2010; 19:1449-1455.

[18] Azoubel PM, De Oliveira SB, Araújo AJDB, Silva ÍRA, Park KJ. Influence of osmotic pretreatment on the total carotenoids content of dried mango. Proceedings of International Conference of Agricultural Engineering. Brazil: CIGR; 2008. p. 1-3.

[19] Official Methods of Analysis. In: Official Methods of Analysis of the Association of Official Analytical Chemists, Horwitz W, editor. Maryland, USA: AOAC International; 2000.

[20] Chakraverty A. Post harvest technology of cereals, pulses and oilseeds. 3rd ed. New Delhi: Oxford & IBH Publishing Company Pvt. Ltd. 1981.

[21] Davoodi MG, Vijayanand P, Kulkarni SG, Ramana KVR. Effect of different pre-treatments and dehydration methods on quality characteristics and storage stability of tomato powder. Food Sci Technol 2007; 40:1832-1840.

[22] Tunde-Akintunde TY. Effect of soaking water temperature and time on some rehydration characteristics and nutrient loss in dried bell pepper. Agric Engin Int`l: the CIGR Ejournal 2008; 10:1-7.

[23] Hunter Associates Laboratory Inc. Insight on Colour: Hunter L, a, b Colour Scale. In: Application Note. Technical Services Department, Hunter Associates Laboratory Inc. Reston, Virginia, USA. 2008.

[24] Abano EE, Sam-Amoah LK. Effects of different pretreatments on drying characteristics of banana slices. ARPN J Engin Appl Sci 2011; 6:121-129.

[25] Gupta SV, Patil BN. Convective Drying of osmo-dehydrated sapota slices. Int`l J Agric Food Sci Technol 2014; 5:219-226.

[26] Bhagyashree P, Vanita B, Sneha D. Thin layer drying of long pepper (Piper longum L.). J Spices Arom Crops 2013; 22:31-37.

[27] Al-Amin M, Hossain MS, Iqbal A. Effect of pre-treatments and drying methods on dehydration and rehydration characteristics of carrot. Univ J Food Nutri Sci 2015; 3:23-28.

[28] Ayim I, Amankwah EA, Dzisi KA. Effect of pretreatment and temperature on the air drying of French and False horn plantain slices. J Anim Plant Sci 2012; 13:1771-1780.

[29] Doymaz I. Drying of green peas and okra under solar energy. Chem Ind Chem Engin Quart. 2011; 17:199-205.

[30] Doymaz I. Determination of infrared drying characteristics and modelling of drying behaviour of carrot pomace. J Agric Sci 2013; 19:44-53.

[31] Rahman MS, Perera CO. Drying and food preservation. In: Handbook of food preservation. M.S. Rahman, editor. Boca Raton, Florida, USA: CRC Press, Taylor & Francis Group, LLC; 2007. p. 404-427.

[32] Doymaz I, Kocayigit F. Drying and rehydration behaviors of convection drying of green peas. Drying Technol 2011; 29:1273-1282.

[33] Nour V, Trandafir I, Ionica ME. Effects of pre-treatments and drying temperatures on the quality of

dried button mushrooms. South West J Hort Biol Environ 2011; 2: 5-24.

[34] Darvishi H, Khoshtaghaza MH, Minaei S. Drying kinetics and colour change of lemon slices. Int`l Agrophysics 2014; 28:1-6.

[35] Abdulla G, El-Shourbagy GA, Sitohy MZ. Effect of pre-drying, blanching and citric acid treatments on the quality of fried sweet potato chips. American J Food Technol 2014. 9:39-48.

[36] Prajapati VK, Nema PK, Rathore SS. Effect of pretreatment and drying methods on quality of value-added dried aonla (Emblica officinalis Gaertn) shreds. J Food Sci Technol 2011; 48:45–52.