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Influence of drying temperature and pretreatment on the drying characteristics and quality of dried cashew (*Anacardium occidentale L.*) apple slices

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ABSTRACT

This study evaluated the mineral content, browning extent, proximate content, the sensory analysis in the yellow variety of cashew apple slices, for both fresh and after being subjected to pretreatment, at three different drying temperatures. Fresh cashews were harvested, sliced into 7 mm thickness, pretreated by dipping the slices into ascorbic acid and dried at the temperature of 45 °C, 55 °C and 65 °C using the hot air convective dryer at a constant air velocity of 0.8 m/s. During the drying the weight loss was measured initially at an interval of every 30 minutes for the first five hours and later at an hour hour interval. The analysis of minerals content (magnesium and calcium) and proximate analysis which included pH, color, vitamin C content, and tannin content was carried out. In addition, sensory evaluation for taste, texture, aroma, appearance and overall acceptability was carried out according to the 9-point hedonic scale using raw cashew apple as a control. For each of the plots for the drying curves from the mechanical drying test, they are mostly in the failing rate period. The results showed that the moisture loss from the cashew slices increased with increase in drying temperature and time of drying. It was observed that drying temperature has an influence on the proximate content, browning extent and mineral content of the cashew slices. An increase in temperature leads to high losses of vitamin C, less browning effect and high losses of tannin. The result of the sensory evaluation revealed that the pretreated sample dried at a temperature of 55 °C was the most acceptable.

Introduction

The cashew apple is a pseudo-fruit of the cashew tree (*Anacardium occidentale* L.) which originates from the tropical region. It is considered to be native in the northern part of South America. India, Nigeria, Mozambique, and Tanzanian are also large producers of cashews. Africa produces more than 6 million MT of cashew apples per year (Ogunjobi and Ogunwolu, 2010). Even though it is extremely nourishing and high in vitamin C content, most of the cashew apples in Africa are disposed of harvest because of the wide production and processing of the nut. Latin Americans, Brazil, West Indians and some African countries like Mozambique and Tanzania sometimes process cashew apples into juice and or ferment the juice into wine (Dauthy, 1995; Morton, 1987). However, there is no such industry in Nigeria and this results in wastage of the pseudo-fruit.

The cashew apple contains five times more vitamin C than any citrus fruit and ten times more than a pineapple which makes it more nutritious. It has a number of medicinal uses, as a remedy for a sore throat and in treating chronic dysentery, stopping bleeding and so on. But its astringency is high due to the high tannin content and this limits the consumption of fresh apples. The cashew apple is a highly perishable fruit because it deteriorates faster than any other fruit. To avoid the loss and waste of

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the apple, it can be dried or dehydrated in order to increase the shelf life of the fruit. Drying has been the oldest form of preserving foods in the world. It brings about the extensive reduction in weight and volume which minimize packaging, storage, and transportation costs (Mohsenin, 1980) There are over four hundred types of dryers and drying methods existing in the world today (Sharma *et al.,* 2005). Hot air drying is a drying method that is commonly used. During the drying, vegetables and fruits undergo physical, structural, chemical, organoleptic and nutritional changes that mostly cause quality degradation (Di Scala and Crapiste, 2008; Roberts *et al.,* 2008). The aim of this research is to evaluate the effect of drying temperature and pretreatment on the drying rate, drying time and the nutritional value of the dried cashew slices.

Materials and method

Description of the mechanical cabinet dryer

The drying experiment was conducted in the processing and storage laboratory where the locally fabricated mechanical cabinet dryer is set (Olalusi, 2011). The dryer was designed and fabricated in the Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure (FUTA) Nigeria. It is operated by an electric current of 220 volts for hot air drying and with a fan motor power of 0.75 kW. Four sample baskets made of stainless steel are suspended in the drying chamber. The heating chamber has two heating elements. Each element has a power rating of 1.5 kW i.e. 3 kW in total. This provides heat which is used in drying agricultural materials. The exhaust air escapes out of the drying chamber through a chimney located on the top of the dryer. The entire dryer was insulated to avoid heat losses and substantial temperature differences during the test sections. Dry bulb temperature of the air stream was measured by means of Type K thermocouples and controlled by a power regulator to check accuracy. The air velocity was measured by means of a hot wire anemometer.

Sample preparation

Ripe matured fruits (yellow variety) were harvested manually at a local cashew farm in Oro-Ago Village, Kwara state, Nigeria and they were transported to Akure, Nigeria by placing them inside egg crate and then refrigerated at the temperature of 6 °C. The nuts were detached from the apple manually and the apples were sorted, weighed and washed with running tap water and left inside a plastic crate to drain. The cashew apples were then sliced to be 7 mm thick. This thickness was chosen due to the previous research conducted by Kajuna *et al*., (2001) for the drying of cassava root cubes, and Hoque *et al*., (2013) for the drying of ginger rhizome. The cashew apples were sliced with sharp stainless-steel knife when the cashew was resting in longitudinal position and then placed on a perforated tray for drying processes.

Pre-treatment of the cashew apple slices

After slicing and weighing, the apples were divided into two parts - the first part served as control while second part was pretreated. Consumable ascorbic acid was used as the pretreating agent which was based on previous works (Demirel and Turhan, 2003; Ioannou, 2013). The sliced cashew apples meant for pre-treatment were dipped into 34g/100cl of ascorbic acid solution for 10 minutes. Afterwards, they were removed with a slotted spoon and drained.

Drying procedure

The moisture content of the pretreated and untreated cashew apple was measured by the oven-dry method (Rangana, 1986) and was expressed as the amount of water/ mass of dry matter. The dryer was run idle for about 30 minutes to achieve a steady state in respect of preset experimental drying condition before each drying run. 30 g of the cashew slices were uniformly spread on the net and placed in the basket inside the drying chamber. The weight of the cashew slices sample was measured in the intervals of 30 minutes within the three hours using a precision weighing balance and later increased to 1 hour. Drying procedure was stopped when there was no noticeable change in the weight of the slices sample and the moisture content of the dried sample was found at 120 °C. The mechanical drying was conducted at 0.8 m/s air velocity and 45 °C, 55 °C and 65 °C air temperature; these drying conditions are used mostly for hot-air drying of biological materials (Goyal *et al.*, 2007; Nguyen and Price, 2007). The procedure was repeated for each run in three replicate.

Analytical methods

After the cashew apple slices are dried, they were milled for the analysis of pH, ascorbic acid, tannin, ash, colour, magnesium, calcium and moisture content were determined according to the AOAC method (Horwitz and Latimer, 2000). The same analysis was done using the raw cashew apple to serve as a control.

Organoleptic properties

Ten panellists were chosen from the university community (FUTA) to assess some organoleptic properties of the dried cashews in a granular form. Questionnaires were given to these panellist for assessing the dried cashew powder. The product was evaluated on quality characteristics of texture, appearance, aroma, taste and general acceptability on a 9-point hedonic scale rating with 9 as like extremely and 1 as dislike extremely (Azoubel *et al*., 2009; Pandya and Yadav, 2014).

Statistical analysis

The data obtained from the drying experiment - proximate analysis, mineral content and questionnaire - were analyzed using Microsoft Excel 2010 and IBM SPSS version 19. Using ANOVA (analysis Of variance) the means were compared and Duncan post hoc tests were performed (Azoubel *et al*., 2009).

Results and discussion

Table 1 is presented to verify the influence of drying temperature on the proximate component and major mineral content on cashew apple slices through the means of the chemical composition of fresh and dried slices at a temperature of 45 °C, 55 °C and 65 °C.Table 2 shows the result of the sensory evaluation.

Effect of drying air temperature and treatment on the drying characteristics of cashew apple

The drying curves of cashew apple slices (untreated and pretreated) of thicknesses 7 mm at an air velocity of 0.8 m/s and air temperatures of 45 °C, 55 °C and 65 °C are shown in figure 1a and 1b. The drying curves are very similar to that of fruits and vegetables with high moisture content (Famurewa and Raji, 2011). The moisture content of the fruit was removed at a high rate in the first drying period and then the rate decreases as the drying time increases. As the temperature increases, the rate of moisture removal increases and the drying time decreases. The drying curves exhibit one drying phase which mostly occurs in the drying of fruits and vegetables with high moisture content. Graphs of drying rate against moisture content comparing treatment method based on each temperature are shown in Figure 2a – 2c. The drying rates increase with an increase in the drying air temperature which reduces the drying time. This is due to the presence of free water on the surface of the product that is being dried (Nguyen and Price, 2007).

Table 1 Comparing the proximate and phytochemical analysis of cashew drying at result of the three temperatures using 7mm slice thickness

Factor	Treatment/Temperature	45^0C	55^0C	65^0C
Moisture Content (%wb)	A	10.28	9.54	8.2
	B	11.34	10.23	10
Ash	Fresh	**4.34^e**		
	A	$4.09^f \pm 0.01$	$6.267^a \pm 0.001$	$5.66^b \pm 0.01$
	B	$3.778^g \pm 0.001$	$5.3^c \pm 0.01$	$4.623^d \pm 0.001$
pH	Fresh	**4.3^a**		
	A	$3.65^d \pm 0.01$	$3.79^c \pm 0.01$	$3.677^d \pm 0.006$
	B	$3.48^e \pm 0.01$	$3.88^b \pm 0.01$	3.46^{ef}
Colour	Fresh	**1^e**		
	A	3^a	1.5^c	$1.333^d \pm 0.577$
	B	$2.333^b \pm 0.577$	$1^e \pm 0.577$	1.033^{de}
Tannin	Fresh	**$261.3^a \pm 1.114$**		
	A	$0.171^g \pm 0.001$	$0.201^f \pm 0.001$	$0.454^d \pm 0.001$
	B	$1.185^c \pm 0.001$	$2.028^b \pm 0.002$	$0.357^e \pm 0.001$
Vitamin C	Fresh	**$122.44^a \pm 1.027$**		
	A	$69.93^e \pm 0.01$	$68.46^e \pm 0.01$	$66.44^{ef} \pm 0.01$
	B	$118.88^b \pm 0.01$	$89.417^c \pm 0.06$	$76.923^d \pm 0.01$
Magnesium	Fresh	**$0.63^a \pm 0.01$**		
	A	0.5^d	$0.533^{bc} \pm 0.06$	0.4^e
	B	$0.3^f \pm 0.1$	$0.533^{bc} \pm 0.12$	$0.533^{bc} \pm 0.06$
Calcium	Fresh	**$42.667^a \pm 0.56$**		
	A	$1.1^{de} \pm 0.1$	$1.2^c \pm 0.1$	$0.767^{fg} \pm 0.06$
	B	$0.867^f \pm 0.058$	$1.333^b \pm 0.058$	$1.167^{cde} \pm 0.06$

A is untreated while B is pretreated. Similar letters in the exponential in the same row show there are no significant differences (p-value (0.05)

Table 2 Comparing the Sensory Analysis Result of the Three Temperatures using 7mm slice thickness

Factor	Treatment/Temperature	45⁰C	55⁰C	65⁰C
Taste	A	$6.2^{e} \pm 0.91$	$6.9^{c} \pm 0.88$	$7^{b} \pm 0.82$
	B	$6.4^{d} \pm 0.85$	$8.3^{a} \pm 0.68$	$6.4^{d} \pm 0.7$
Texture	A	$7.1^{a} \pm 1.45$	$5.5^{d} \pm 0.95$	$5.1^{e} \pm 0.74$
	B	$5.4^{c} \pm 0.7$	$6^{b} \pm 0.94$	$5.4^{c} \pm 0.84$
Appearance	A	$6.3^{bc} \pm 0.01$	$5.8^{d} \pm 0.63$	$6^{c} \pm 0.006$
	B	$6.6^{e} \pm 1.35$	$8.4^{a} \pm 0.52$	$6^{c} \pm 0.67$
Aroma	A	$5.3^{d} \pm 0.82$	$5.4^{c} \pm 0.84$	$5.2^{d} \pm 1.4$
	B	$5.8^{d} \pm 1.4$	$7.5^{a} \pm 0.53$	$5.4^{c} \pm 1.08$
General Acceptability	A	$5.6^{f} \pm 0.84$	$6.9^{b} \pm 0.32$	$6.1^{e} \pm 0.32$
	B	$6.4^{d} \pm 0.001$	$8.4^{a} \pm 0.52$	$6.6^{e} \pm 0.7$

A is untreated while B is pretreated. Similar letters in the exponential in the same row show there are no significant differences (p-value (0.05)

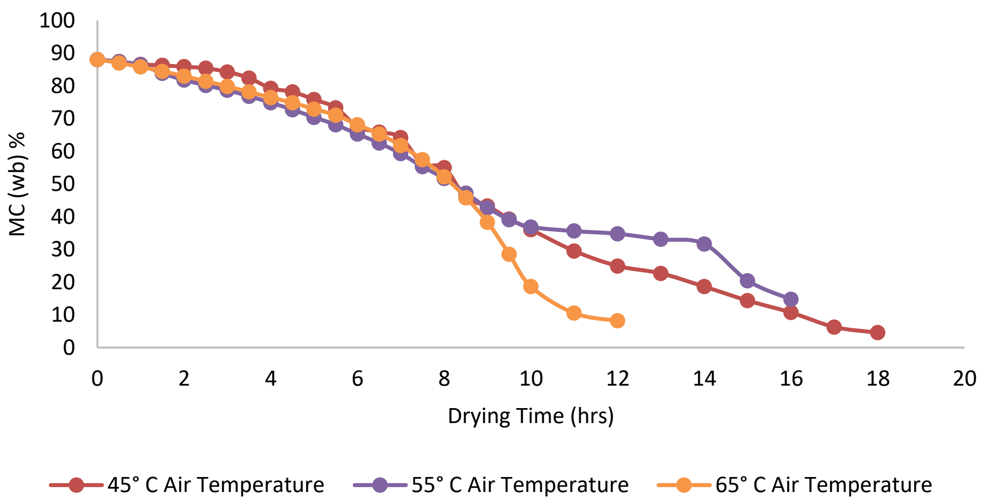

Fig. 1a The drying curves for dried 7mm untreated cashew slices at 45 °C, 55 °C and 65 °C air temperature

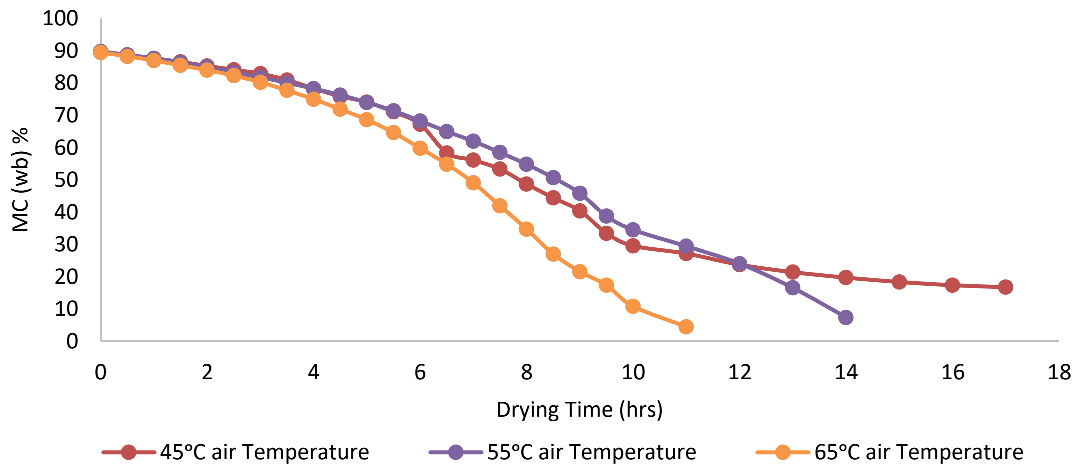

Fig. 1b The drying curves for dried 7mm treated cashew slices at 45 °C, 55 °C and 65 °C air temperature

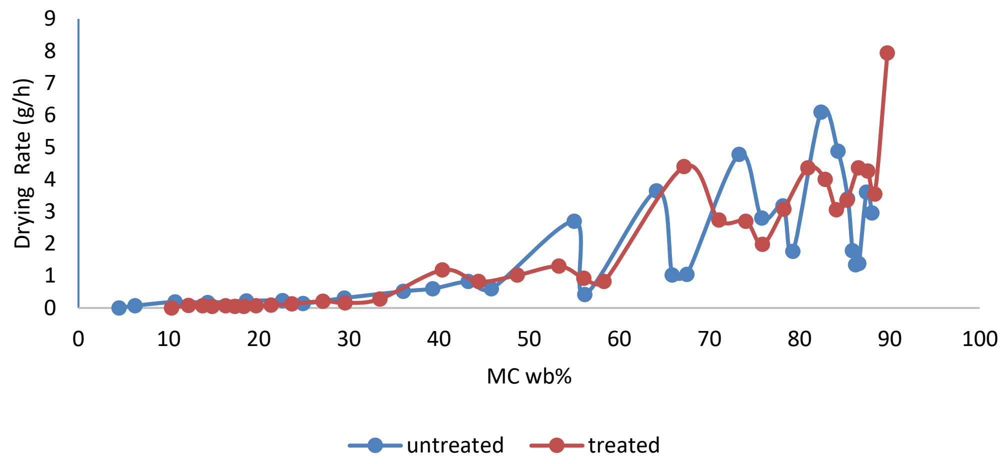

Fig. 2a Variation of drying rate against moisture Content (wet basis) for dried 45 °C and 7mm untreated and treated cashew slices

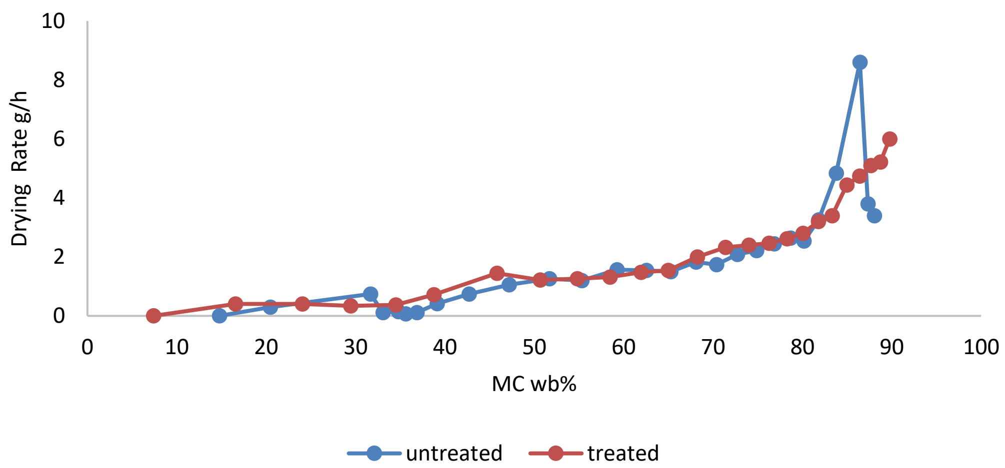

Fig. 2b Variation of drying rate against Moisture Content (wet basis) for dried 55 °C and 7mm untreated and treated cashew slices

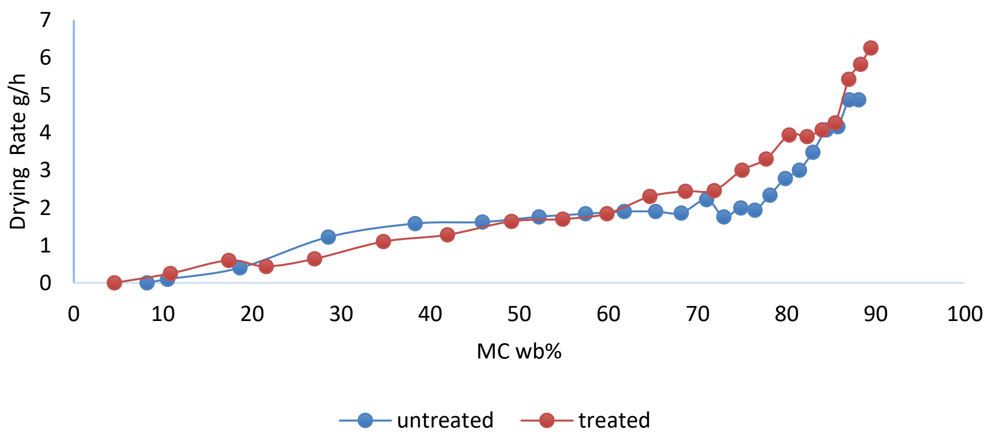

Fig. 2c Variation of drying rate against Moisture Content (wet basis) for dried 65°C and 7mm untreated and treated cashew slices

Effect on tannin and vitamin C content

There is a sharp decrease in tannin content in the dried cashew apple comparing to the fresh sample (from 261.3g fresh to 2.2028g pretreated 55 °C). High temperature decreases the tannin content. Table 1 shows that the highest tannin content was at 55 °C. Drying reduces the astringent taste in cashew apple. This astringent taste is actually caused by the presence of tannin (Morton, 1987).
The effect of drying temperature on the degradation of vitamin C was determined and compared with the fresh samples. Table 1 shows that vitamin C content increases with decreasing temperature. Pretreated sample dried at 45 °C had the highest content of vitamin C. Similar result was obtained by Karina and Guillermo (2008) for pepper; Kramkowski *et al*.(2001) for mushrooms; and Aghbashlo *et al.* (2009) for carrot slices. If there is an increase in the drying air temperature, it causes a destructive effect on the quality of the dried fruits, (Karina and Guillermo, 2008). It was also observed that the samples that went through dipping pretreatment had lower losses of vitamin C content. Pretreated sample at 45 °C had a loss of 3% of its original content while that of 65 °C had a loss of about 37.2%. The pretreatment slightly protects the samples from oxidations of the vitamin C during drying Higher temperature gave higher losses. (Azoubel *et al*, 2009).

Effect on moisture content, ash content, and pH

Table 1 shows that with the temperature increase the final moisture content decreases. Due to the high impact of heat which increases the speed at which the moisture travels from the centre of the material to the surface. Also, the pretreated sample has a slight decrease in water loss since more moisture was gained after dipping the samples. The initial moisture content of the untreated sample was 88.78% (wet basis, wb) while that of the pretreated sample was 91.2%. The samples dried at 55 °C had more ash content. It was found out that the pretreated cashew apple has lower ash content than the untreated but of a little significance as also shown by Pandya and Yadav (2014). The slices dried at 55 °C have the highest pH level.

Effect on browning

As the temperature increases, the browning effect reduces on the sample as shown in Table 1. The pretreated sample dried at 55 °C had the closest colour to that of the fresh sample. It was observed that pretreatment has a little significant effect on browning of a sample when dried. The longer the drying time the higher the chance the sample gets brown.

Effect on magnesium and calcium content

Table 1 reveales that heat has an extreme effect on the calcium content of the cashew slices, at an air temperature of 65 °C the Ca content was at 3% reduction of the fresh cashew value. For magnesium, there was no significant effect on the slices.

Sensory analysis

According to Table 2, the mean sensory scores for the samples were compared with the fresh sample in taste, appearance, aroma, texture and general acceptability and there were significant differences in most of the evaluated attributes. The samples at different temperatures were significantly different in taste and colour at ($p<0.05$) from pretreated samples (55 °C), chosen to be tasting better with less astringency; its appearance was also selected to be better than the other two temperatures. This could be due to the lower content of tannin, less impact of heated air and drying time. There was no significant effect on texture and aroma. The pretreated 55 °C was generally accepted, it has a sweeter taste, appealing aroma, better appearance and texture.

Conclusion

The drying curve exhibits mostly falling drying rate period and no constant drying rate period, also the drying time decreased with increase in drying air temperature. An increase in the drying air temperature had a negative effect on vitamin C because vitamin C is thermo-sensitive compound, browning was higher at 45 °C and 65 °C with untreated sample. It was also concluded that drying reduces the presence of tannin which in return reduce the astringent taste of the cashew.

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