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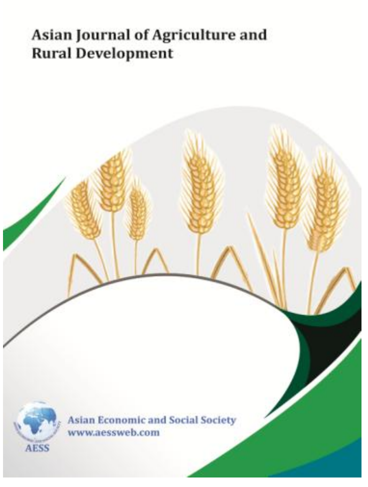

Effect of Temperatures, Air Velocity and Flow Rate on Quality Attributes of Dried Cassava Chips

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Effect of Temperatures, Air Velocity and Flow Rate on Quality Attributes of Dried Cassava Chips

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Abstract

In this work, cassava chips were dried in a tunnel dryer at temperature 60^0C, 70^0C and 80^0C using velocity 3.0m/s, 3.2m/s and 3.4m/s and load capacity of 7.5kg/m^2, 10.0kg/m^2 and 12.50kg/m^2 as the drying variables. From the drying of experiments, data were generated to open up insights for the study and understanding of the physical parameters of the dryer as they affected the chips. The physical parameters studied in the dryer were air velocity, tray load capacity and air temperature. The effect of these drying parameters were evaluated on the quality attributes of the chips such as moisture content, bulk density, water absorption capacity, swelling capacity, residual cyanide content and colour. The results showed that drying temperatures and load rates had great effect on the quality attributes of the chips.

Keywords: Tunnel dryer, cassava chips, temperature, tray capacity and air velocity

Introduction

Cassava is the fourth most important energy staple in the tropics and the sixth global source of calories in human diets apart from rice, maize and wheat (FAO, 1999) and its utilization for industrial purpose such as starch, alcohol, adhesives and livestock feed is yet to be maximally used in Nigeria. There is need to develop preservation technology to convert the product into stable form for industrial and export purposes. The vast potential of cassava should be developed and improved in terms of processing efficiency, hence there is need to pursue a good drying mechanism which is hygienic, cost effective and deliver standard product internationally which the traditional drying method fails to establish. Effective design and optimizing the drying mechanism for industrial/ commercial production of cassava chips and flour will be of great economic importance to food, paper, and pharmaceutical industries; hence there is need to study.

Various factors can be responsible for the quality of the chips being dried, Paul et al. (2009) suggested the influence of temperatures on food products being dried, Heldman and Hartel (1997) reported influence of humidity on drying rate of food products and Kudra and Ratti (2006) reported on energy utilization in food drying. The present study aims to investigate the effect of some drying parameters on quality attributes of dried chips

Material and Methods

(a) Drying Experiments

Mature cassava roots (*Manihot esculenta* Crantz) *TMS 421425* variety that were free from physical defects were used. They were obtained from the Ladoke Akintola University of Technology Teaching and Research Farm Ogbomoso, Nigeria. All reagents and solvents that were used in this work were of analytical grade. The drying experiment was performed in a tunnel dryer built in the Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso Nigeria. The dryer was installed in an environmental condition of 51% relative humidity and 29^0C ambient temperature. The drying experiments were done both in concurrent and counter-current mode. In operation, the trucks were loaded manually into the tunnel at the loading end and removed manually at the exit end after the chips have been dried. Drying of chips were done at temperatures 60^0C, 70^0C and 80^0C as reported by Aghbashlo et al. (2009), air velocity used were 3.0 m/s, 3.2 m/s and 3.4 m/s as recommended by Bulent et al. (2007), load rate used were 7.5 kg/m^2, 10 kg/m^2 and 12.5 kg/m^2 as recommended by Ospina and Wheatly, (2007). After the chips were dried to 12% moisture content or below, the chips were packaged and subjected to further analysis. The physical and chemical analysis performed were moisture content, bulk density, water absorption capacity, swelling capacity, residual cyanide content and colour. Moisture contents, bulk density, water absorption capacity, swelling capacity and residual cyanide were determined using official method of AOAC (1999), while colour of dried samples was measured using a colourimeter (Colour tech PCM, made in US, patent 5137364) to obtain L (lightness), a (redness) and b (yellowness) values, (Ali *et al.*, 2008). The colourimeter was standardized with white A4 paper measured as blank. The total colour difference was calculated using the equation 1 where subscript "0" referred to the colour reading of fresh chips

$$\Delta E = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2}$$

(b) Statistical Analysis of the Samples

The (2009) SPSS 15.0 version, a software package was used for statistical analysis. Analysis of variance (ANOVA) was carried out on the data obtained from the physical and chemical analysis of the samples. Duncan test was used to separate the means.

Results and Discussions

(a) Moisture Content

Moisture content analysis of the chips is as shown in Table 1 for the co-current mode. The values of the moisture content ranged between 7.81 and 12.91% (wet basis). The moisture content of the chips dried at 60^0C and velocity of 3.2m/s was found to be 12.91% (wet basis) which is the highest value and the chips dried at 80^0C and velocity of 3m/s had the lowest value of moisture content of 7.81% (wet basis).

However, there was significant difference among the samples at $p< 0.05$. Considering Table 2 for counter-current mode, the moisture content ranged between 8.2% and 12.80% (wet basis). In this case, the moisture content of the chips dried at 60^0C and velocity of 3m/s was 12.80% (wet basis) which also was the highest value while chips dried at 80^0C and velocity of 3m/s was 8.20% (wet basis) which was the lowest. At 7.5 kg/m^2 loading capacity, chips dried at 60 and 70^0C at 3.4 m/s and 60^0C at 3.2 m/s were not significantly different. The values of moisture content of the chips dried in both co-current and counter-current modes were comparable to the moisture content reported by other authors who worked on cassava chips. Lower moisture values of 7.81% and 8.20% (wet basis) for co-current and counter-current drying modes respectively were an indication of longer shelf- life stability of the chips. It has been reported by Franklin *et al.* (2009) that low moisture content confers higher shelf-life to the chips where microbial attack is minimum. By comparing the maximum moisture content recommended for cassava chips by previous authors such as FAO/WHO (1991), these values appear to be similar to the recommended maximum value of 14% and hence both chips dried in co-current and counter-current modes had good microbial safety due to lower water activity which lowered the risk of growth of pathogenic microorganism.

Another important characteristic exhibited by the chips was that as drying temperature increased from 60^0C to 80^0C, the moisture content of the chips decreased for all treatments in both co-current and counter-current modes (Table1 and 2). The same observation was reported by Paul et al. (2009).

Table 1: Quality Analysis of Chips Dried in Co-current Mode

Velocity (m/s)	Temperature (^{0}C)	7.5 Kg/m^2	10.0 Kg/m^2	12.5 Kg/m^2
Moisture Content (%)				
3.0	60	9.50±0.02^d	10.20±0.02^d	9.20±0.05^c
	70	9.15±0.02^c	10.10±0.06^d	8.90±0.10^b
	80	7.81±0.02^a	9.71±0.09^c	8.41±0.02^a
3.2	60	12.91±0.01^i	10.50±0.02^e	10.60±0.03^f
	70	11.92±0.03^g	9.90±0.03^c	10.30±0.04^e
	80	8.61±0.01^b	9.51±0.29^b	9.87±0.25^d
3.4	60	12.70±0.59^h	11.70±0.03^f	11.21±0.01^g
	70	11.61±0.01^f	9.60±0.03^b	9.11±0.01^c
	80	10.52±0.02^e	8.40±0.09^a	8.93±0.03^b
Bulk Density (g/cm^3)				
3.0	60	0.51±0.02^d	0.55±0.12^c	0.50±0.04 ^{b}
	70	0.49±0.01^d	0.53±0.02^c	0.48±0.03 ^{b}
	80	0.39±0.03^a	0.52±0.02^c	0.44±0.03 ^{b}
3.2	60	0.54±0.02^d	0.46±0.03^c	0.46±0.02^b
	70	0.46±0.02^d	0.44±0.04^b	0.46±0.01 ^{b}
	80	0.42±0.01^b	0.43±0.05^b	0.44±0.03 ^{b}
3.4	60	0.49±0.04^d	0.47±0.03^c	0.45±0.05 ^{b}
	70	0.46±0.04^d	0.43±0.03^b	0.43±0.05 ^{b}
	80	0.44±0.04^c	0.41±0.07^a	0.40±0.07^a

This suggests that drying at higher temperatures could be good obtaining lower moisture contents at good times but at temperature above 80^{0}C, Sidibe *et al.* (2009) had earlier reported the incidence of gelatinization of cassava starch which was an unwelcome attribute of the chips in the market.

(b) Bulk Density

The bulk density of cassava chips is recorded in Tables 1 and 2 for both co-current and counter-current drying, respectively. It ranged from 0.37g/cm^3 to 0.55g/cm^3 in co-current mode and from 0.35g/cm^3 to 0.49 g/cm^3 in counter-current drying. In co-current drying, values were not significantly different at the 12.5 kg /m^2 load except at 3.4 m/s, temperature 80^{0}C. However, there was significant difference between the samples for 7.5 kg/m^2 and 10 kg/m^2 loading rates. Table 2 showed the level of significant difference of chips dried in counter-current form; it was shown that there was no significant difference among samples for 10 kg/m^2 and 12.5 kg/ m^2 loading rate whereas there was a significant difference among the samples for 7.5 kg/m^2. Bulk densities of the chips were similar to the values reported by Audu and Ikhu- Omoregbe (1982) which ranged from 0.17g/cm^3 to 0.55g/cm^3 and Iyang *et al.* (2006) which ranged from 0.29 to 0.56g/cm^3 but were lower than the values reported by Sanni *et al*. (2005) which ranged from 0.85g/cm^3 to 0.97g/cm^3 and that of Udensi *et al*. (2006) which ranged from 0.64 to 0.76 g/cm^3. The values recorded in this study are generally lower than those reported and therefore can be considered as a good quality derived flour because lower bulk density enhances material handling especially packaging and transportation. Also from Table 1 and 2, it was observed that moisture content affected bulk density in such a pattern that as moisture content increased, bulk density also increased and vice versa. The same observation had been reported by Nwabanne (2009) to the effect that increases in moisture content increased bulk density of cassava chips.

Table 2: Quality Analysis of Chips Dried in Counter-current Mode

Velocity (m/s)	Temperature (^{0}C)	7.5 Kg/m^2	10.0 Kg/m^2	12.5 Kg/m^2
Moisture Content (%)				
3.0	60	10.00±0.50^c	11.41±0.19^c	12.80±0.10^g
	70	9.50±0.22^{ab}	11.20±0.05^c	12.60±0.30^g
	80	8.90±0.20^a	8.20±0.13^a	9.60±0.47^b
3.2	60	10.80±0.13^d	11.10±0.12^c	10.91±0.11^e
	70	10.00±0.45^c	10.90±0.83^c	9.20±0.20^a
	80	8.80±0.13^a	9.60±0.56^b	8.81±0.08^a
3.4	60	11.60±0.46^d	11.50±0.03^c	11.3±0.16^f
	70	11.10±0.06^d	9.30±0.17^b	10.50±0.48^{de}
	80	9.00±1.3^a	9.10±1.02^b	10.10±0.88^{cd}
Bulk Density (g/cm^3)				
3.0	60	0.48±0.08^c	0.47±0.11^a	0.49±0.01^a
	70	0.42±0.02^c	0.44±0.06^a	0.44±0.03^a
	80	0.37±0.05^b	0.36±0.05^a	0.39±0.02^a
3.2	60	0.45±0.02^c	0.49±0.04^a	0.48±0.08^a
	70	0.40±0.04^c	0.46±0.08^a	0.45±0.05^a
	80	0.35±0.07^a	0.42±0.09^a	0.41±0.19^a
3.4	60	0.49±0.08^c	0.45±0.08^a	0.43±0.08^a
	70	0.43±0.17^c	0.40±0.06^a	0.41±0.07^a
	80	0.37±0.02^b	0.38±0.05^a	0.40±0.04^a

(c) Water Absorption Capacity

Measurement of water absorption capacity of the chips at both treatments (co-current and counter-current) is as presented in Tables 3 and 4. The water absorption capacity ranged from 1.4 ml/g to 4.32 ml/g for co-current drying. There were significant differences among the samples. In counter-current drying, the values ranged from 2.21 ml/g to 3.66 ml/g. There was significant difference among the samples. Water absorption in this study is less than the values reported by Eke et al. (2007) which ranged from 3.52 ml/g to 10.5g/ml but comparable to the values reported by Tilahun (2009) which ranged from 1.9ml/g to 2.62 ml/g. It was observed from Table 3 and 4 that temperature affected water absorption capacity because as drying temperature increased, water absorption capacity increased. It has been reported that increase in temperature induced a decrease in moisture content of the chips. Decrease in moisture content of the chips would suggest a corresponding increase in solid content of the chips which encompasses all nutrients for instance the starch content. Water absorption capacity involves the ability of flour particles and water to associate under limited water supply. Although, Kinsella (1976) attributed water absorption capacity to protein and fat interaction in food samples but it is obvious from the literature that cassava flour is a poor source of protein and fat. Hence the water absorption capacity of cassava flour has been observed to be dependent on the starch content of the flour. Water absorption capacity is a useful index applied in the baking industries. The higher the water absorption capacity, the more opportunity to manipulate the functional properties of the gel to form different products which may include snacks and other bakery products.

Table 3: Quality Analysis of Chips Dried in Co-current Mode

Velocity (m/s)	Temperature (^{0}C)	7.5 Kg/m^2	10.0 Kg/m^2	12.5 Kg/m^2
Water Absorption Capacity (cm^3/g sample)				
3.0	60	2.80±0.03^d	1.40±0.2^a	2.83±0.02^b
	70	2.83±0.04^d	2.62±0.01^b	2.88±0.11^b
	80	4.32±0.20^e	2.68±0.18^b	4.18±0.05^e
3.2	60	2.42±0.06^c	2.97±0.01^b	2.86±0.02^b
	70	2.61±0.04^d	2.95±0.6^b	3.22±0.03^{cd}
	80	4.19±0.05^e	4.17±0.05^d	3.24±0.04^d
3.4	60	1.60±0.12^a	1.61±0.01^a	2.20±0.05^a
	70	1.80±0.29^b	2.74±0.04^b	2.85±0.19^b
	80	2.74±0.09^d	3.30±0.55^c	3.04±0.04^c
Swelling Capacity (g water/g sample)				
3.0	60	1.14±0.09^a	1.13±0.09^a	1.14±0.06^a
	70	1.15±0.03^a	1.16±0.08^a	1.17±0.13^a
	80	1.17±0.02^a	1.18±0.05^a	1.19±0.04^a
3.2	60	1.10±0.10^a	1.15±0.25^a	1.18±0.21^a
	70	1.13±0.01^a	1.17±0.04^a	1.20±0.03^a
	80	1.16±0.08^a	1.18±0.03^a	1.22±0.04^a
3.4	60	1.21±0.10^a	1.18±0.09^a	1.22±0.16^a
	70	1.23±0.24^a	1.20±0.09^a	1.25±0.04^a
	80	2.26±0.20^b	1.24±0.02^a	1.31±0.20^a

(d) Swelling Capacity

The swelling capacity of samples measured are as presented in Table 3 and 4 for the co-current and counter-current modes respectively. Values recorded ranged from 1.10 to 1.31 g water/g sample for the co-current mode and from 1.12 to1.27 g water/g sample for the counter-current mode. In co-current drying (Table 3), there was no significant difference among the samples for all temperatures, load rates and air velocities tested except at 3.4 m/s, 80^{0}C and 7.5kg/m^2. Also, there was no significant difference among the samples for all temperatures, load rates and air velocities tested as seen in Table 4. The results obtained in this study were greater than the values reported by Inyang et al. (2006) which is 0.24 to 0.26; the results obtained in this work were also greater than the values reported by Ikegwu et al. (2009) which is 0.05 to 0.6 g water/g sample but are comparable to the values reported by Sidibe et al. (2009) which ranged from 1.0 to 5.0 g water/g sample. The swelling power of cassava flour studied fell within this range. Swelling power is important in determining flour quality, the higher the swelling capacity the greater is its suitability in the formulation of products. Rakshit and Solomon (2003) defined swelling power as the swollen sediment weight per gram of dry flour and Franklin et al. (2009) reported that swelling capacity of a food sample is influenced by its starch content while Ayernor (1979) reported that swelling capacity indicated the ability of starch to swell which depends on weak internal bounding of amylase and amylopectin contents of the starch. Tilahun (2009) suggested that swelling power of flour depended on the capacity of flour to hold water through hydrogen bonding. However, Eke *et al*. (2007) reported that increase in lipid content may inhibit the swelling power of flour as lipids are hydrophobic in nature.

Table 4: Quality Analysis of Chips Dried in Counter-current Mode

Velocity (m/s)	Temperature (^{0}C)	7.5 Kg/m^2	10.0 Kg/m^2	12.5 Kg/m^2
Water Absorption Capacity (cm^3/g sample)				
3.0	60	2.77±0.06^b	2.70±0.17^b	2.30±0.25^a
	70	2.86±0.44^b	2.74±0.07^b	2.43±0.04^b
	80	2.90±0.09^b	2.92±0.11^c	2.79±0.45^c
3.2	60	2.76±0.04^b	2.60±0.13^b	2.74±0.04^c
	70	2.87±0.05^b	2.74±0.03^b	3.00±0.47^d
	80	3.12±0.01^c	2.94±0.08^c	3.06±0.06^d
3.4	60	2.21±0.01^a	2.24±0.03^a	2.72±0.05^c
	70	3.15±0.12^c	3.38±0.05^d	3.18±0.07^d
	80	3.66±0.22^d	3.48±0.08^d	3.33±0.11^d
Swelling Capacity (g water/g sample)				
3.0	60	1.13±0.02^a	1.12±0.04^a	1.17±0.08^a
	70	1.14±0.03^a	1.13±0.06^a	1.19±0.05^a
	80	1.18±0.07^a	1.15±0.06^a	1.23±0.06^a
3.2	60	1.12±0.11^a	1.14±0.13^a	1.15±0.11^a
	70	1.15±0.09^a	1.19±0.11^a	1.17±0.01^a
	80	1.17±0.05^a	1.23±0.09^a	1.18±0.02^a
3.4	60	1.18±0.03^a	1.12±0.11^a	1.21±0.16^a
	70	1.20±0.17^a	1.13±0.02^a	1.24±0,02^a
	80	1.23±0.19^a	1.16±0.04^a	1.27±0.18^a

(e) Cyanide Level

The effect of three drying temperatures 60^{0}C, 70^{0}C and 80^{0}C on cyanide removal from cassava chips are as recorded in Tables 5 and 6 for co-current and counter-current drying of chips. Values of residual cyanide content of the samples ranged from 3.78 to 11.41 mgHCN/kg solid for co-current drying in Table 5 while the values ranged from 4.32 to 11.91 mgHCN/kg solid in countercurrent drying in Table 6. In Table 5, there was significant difference among the values at different treatments. In Table 6, the same trend occurred in which the values also differed significantly. Values of cyanide levels recorded in this study were less than corresponding values reported by Enidiox et al. (2008) which is 2.76 mgHCN/kg solid. The values were also less than those reported by Iyang et al. (2006) and Eze (2010) which were 13.8 mgHCN/100g solid and 20.6 mgHCN/kg solid respectively. However, the values are comparable with those reported by Franklin et al. (2009) which ranged from 11.6 to16.6 mgHCN/kg solid. Almost all the values of cyanide reported in this study with few exceptions fell within the safe cyanide level recommended and approved by FAO/WHO (1991) which is 10mgHCN/kg solid. Therefore, the drying technique used in this study produced safe chips in relation to cyanide toxicity and can serve as a potential method for improving food security in the country in this respect. Also from the Tables 5 and 6, it was observed that cyanide reduction level was affected by temperature. The higher the temperature of drying, the higher the cyanide content of the chips. The reason for this must be that higher temperature induced faster rates of drying and generally less loss of cyanide. This observation was reported by Jansz et al. (1974). Also, at drying velocity of 3.4 m/s, the rate of cyanide removal was not only affected by temperature but also by loading rate. As the loading capacity increased, the level of cyanide content decreased. The reason for this may be that higher loading rates took longer drying time during which most of the cyanide was removed. The same observation has been reported by Enidiox et al. (2008).

(f) Colour

The results of total colour difference (ΔE) of the chips for the co-current and counter-current modes are as presented in Tables 5 and 6. From Table 5, the values ranged from 0.24 to 21.04 for the co-current mode while the values ranged from 2.61 to 21.04 for the counter-current mode in Table 6. There was significant difference among the samples in Table 5. The same trend occurred in samples from counter-current drying in Table 6. As a whole, the total colour change (ΔE) of the chips increased as the hot air temperature increased. This would mean that with increase in air temperature, the degradation rate of colour inducing compound in cassava became faster as a result of high heat transfer into the inside of the chips and this made the colour of the chips brown. Several authors have worked on total colour difference of food material in hot air drying.

Table 5: Quality Analysis of Chips Dried in Co-current Mode

Velocity (m/s)	Temperature (^{0}C)	7.5 Kg/m^2	10.0 Kg/m^2	12.5 Kg/m^2
Free Cyanide (mgHCN/kg)				
3.0	60	7.10±0.07^b	6.48±0.02^a	7.12±0.08^b
	70	8.10±0.02^c	8.12±0.08^c	10.81±0.26^e
	80	10.80±0.45^g	9.18±0.10^e	11.41±0.02^f
3.2	60	3.78±0.38^a	6.48±0.03^a	6.34±0.12^a
	70	7.02±0.10^b	8.10±0.08^c	6.47±0.03^a
	80	8.64±0.40^d	10.30±0.11^g	7.22±0.19^b
3.4	60	8.64±0.18^d	7.56±0.05^b	7.12±0.08^b
	70	9.18±0.03^e	8.60±0.10^d	8.10±0.04^c
	80	9.72±0.20^f	9.70±0.81^f	9.52±0.02^d
Colour: ΔE (Total Colour Difference)				
3.0	60	2.44±0.16^{cb}	2.59±0.04^a	4.88±0.08^b
	70	4.28±0.12^c	4.62±0.07^c	5.86±0.09^c
	80	4.52±0.02^c	6.17±0.05^e	8.38±0.07^e
3.2	60	0.24±05a	5.63±0.08^d	6.27±0.09^c
	70	4.93±0.03^c	7.22±0.21^g	10.70±0.10^f
	80	21.04±1.02^d	13.20±0.20^i	14.84±0.17^g
3.4	60	2.83±0.03^b	3.35±0.18^b	4.26±0.32^a
	70	4.82±0.29^c	6.77±0.07^f	4.68±0.08^b
	80	4.89±0.07^c	7.97±0.52^h	7.02±0.85^d

For instance, Velic et al. (2007) studied colour change of Granny Smith apple in tray drying, Ali *et al.* (2008) studied the colour change of kiwifruit slices in hot air and El-Amin et al. (2006) studied the colour change of mango slices in hot air drying. Results from these indicated that a higher temperature produced greater colour difference; hence drying at lower temperatures (60-80^{0}C) was recommended for the drying of fruits.

Table 6: Quality Analysis of Chips Dried in Counter-current Mode

Velocity (m/s)	Temperature (^{0}C)	7.5 Kg/m^2	10.0 Kg/m^2	12.5 Kg/m^2
Free Cyanide (mgHCN/kg)				
3.0	60	5.40±0.10^a	7.02±0.06^c	4.31±0.01^a
	70	9.18±0.08^e	7.56±0.11^d	6.48±0.01^b
	80	10.80±0.10^g	8.10±0.09^e	8.10±0.07^d
3.2	60	5.94±0.17^b	4.32±0.31^a	8.10±0.10^d
	70	9.18±0.17^e	5.40±0.37^b	8.64±0.57^e
	80	10.26±0.2^f	7.56±0.44^d	10.15±0.09^f
3.4	60	8.30±0.20^c	7.02±0.01^c	7.00±0.05^c
	70	8.64±0.01^d	8.10±0.06^e	7.56±0.16^d
	80	11.91±0.2^h	9.72±0.02^f	8.64±0.29^e
Colour: ΔE (Total Colour Difference)				
3.0	60	4.40±0.20^b	4.73±0.03^a	5.06±0.85^b
	70	8.18±0.05^f	6.52±0.43^{cd}	6.99±0.92^e

	80	8.69±0.19[g]	6.77±0.59[d]	7.23±0.27[f]
3.2	60	2.61±0.08[a]	4.92±0.28[a]	4.31±0.05[a]
	70	6.78±0.15[d]	7.19±0.02[e]	7.58±0.87[f]
	80	21.04±0.08[h]	7.56±0.02[e]	8.25±0.05[f]
3.4	60	2.64±0.04[a]	5.94±0.04[b]	5.26±0.32[c]
	70	6.41±0.04[c]	6.46±0.08[c]	5.76±0.26[d]
	80	7.42±0.02[e]	15.63±0.92[f]	19.96±0.13[h]

The value of colour difference recorded in this study is comparable with the values for cassava flour reported by Franklin *et al.* (2009) on five cultivars in which the values ranged from 9.2 to 12.1. Consumers of cassava chips generally look for white colour in the product. Hence they prefer cassava chips dried at lower temperatures (60-80^{0}C) which is white in colour to that dried at higher temperature which may have noticeable browning effect (non-enzymatic).

Conclusion

From the study, it was concluded that drying temperatures had effect on moisture content of the chips in such a way as temperature increased, moisture content decreased in the samples. Moisture content affected bulk density directly; as moisture content increased, bulk density increased. Water absorption capacity was influenced by temperature in such pattern that increases in temperature increased water absorption capacity of the chips. All drying variables had no significant effect on swelling capacity of the chips. Cyanide content was affected by drying temperature; higher temperature of drying produced higher content of cyanide level while loading capacity affected cyanide content inversely; the higher the loading capacity the lower the cyanide content. Colour was temperature dependent; the higher the temperature of drying, the higher the total colour difference and hence the poorer the quality of the chips

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