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INFLUENCE OF ULTRASOUND PRETREATMENT ON THE NUTRITIONAL QUALITY OF YELLOW CASSAVA DURING CONVECTIVE DRYING

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OLADEJO, A. O.*, NYONG, R. N.
AND NKEM, O. M.

Department of Agricultural and Food Engineering,
University of Uyo, P.M.B 1017, Uyo, Nigeria.
*corresponding author: ayobamioladejo@uniuyo.edu.ng

ABSTRACT

Yellow cassava were pretreated in ultrasound with distilled water (DWU) and ultrasound with osmotic dehydration (UOD) before hot air drying in order to determine its effect on some physico-chemical qualities of the dried yellow cassava. The ultrasound frequency of 20 kHz, power of 600W and pretreatment time of 10 min was applied during ultrasound pretreatment. Yellow cassava samples without ultrasound pretreatment served as the control. The treated and the untreated samples were further subjected to hot air drying at 50, 60 and 70°C. Proximate analysis was carried out on the fresh, untreated and treated dried samples. The result showed that the highest total colour change was observed at DWU samples dried at 70°C. Also, at 70°C UOD samples had the lowest amount of protein. For fibre, there was no significant difference between the samples treated with ultrasound and the fresh samples, but samples treated with ultrasound (DWU and UOD) were significantly higher than the untreated dried sample. In the case of carotenoid content, DWU samples were significantly higher than that of the untreated and UOD after drying at 70°C. This work showed that incorporation of ultrasound pretreatment before convective drying could help to retain some nutritional qualities after drying.

Keywords: yellow cassava, ultrasound, carotenoid, nutritional quality, drying

Introduction

Yellow cassava is an hybrid crop of white cassava containing vitamin A. Cassava is widely consumed in many developing countries (Vimala *et al.*, 2011). In order to address the problem of vitamin A deficiency in the developing counties, yellow cassava can be consumed (Talsma et al., 2016). The largest producer of cassava in the world is Nigeria, producing about 59.5 million tons (FAOSTAT, 2017). Preservation of cassava after harvest is one of the problems facing the food industries. Drying is one of the methods generally used to preserve cassava after harvest. But convective drying usually results in loss of nutrients, deformation of structure and texture, colour change, long drying time and high energy usage (Chávez *et al*., 2007; Taiwo *et al*., 2014). In order to improve the drying process of agricultural crops, different drying methods have been used. Darvishi, et al. (2013) subjected potatoes to microwave drying in order to shorten the drying time. Head et al. (2010) used superheated steam to dry oat groats and found out that superheated steam could help to achieve oat groats of unique viscosity and enhanced bright colour. Martynenko and Zheng (2016) applied electrohydrodynamic drying for the drying of apple slices. They concluded that the drying rate was significant at the air velocity of 1.0 m/s with increased voltage. Oh *et al*. (2017) used the combination of infra-red and hot-press drying to dry mashed sweet potato. They stated that the combination is a good technique for mass production of crispy sweet potato snacks.

Recently, ultrasound pretreatment of agricultural crops prior to convective drying have been carried out by many researchers. Ultrasound is a green technology and has sound wave above 20 kHz. When ultrasound is used as pretreatment of agricultural crops in distilled water or osmotic solution, it brings about compression and expansion effects on the tissues of the crop. This leads to creation of microscopic pathway through which moisture diffuses out during convective drying. The incorporation of ultrasound as pretreatment prior to drying has been found to result in high drying rate, retention of some nutritional qualities, low energy usage and preservation of colour and texture. Romero and Yépez (2015) determined the effect of ultrasound pretreatment on the drying kinetic and antioxidant property of Andean blackberry (*Rubus glaucus Benth*). They concluded that ultrasound pretreatment enhanced the rate of drying and enhanced the extraction of antioxidant compounds from Andean blackberry. Azoubel, *et al*. (2015) investigated the effect of ultrasound assisted osmotic dehydration of papaya slices prior to drying on the retention of carotenoid. Their findings showed that papaya pretreated with ultrasound assisted osmotic dehydration had the highest retention of carotenoid compared to that of ultrasound in distilled water and the untreated samples.

In this work, the effects of ultrasound pretreatments on colour, carotenoid, protein and fibre of yellow cassava during hot air drying were investigated.

Materials and Method

Materials

Freshly harvested yellow cassava roots were collected from a local market in Uyo, Akwa Ibom state. The samples were cleaned and peeled using knife. The roots were sliced using slicing machine (SL524B, Cuisinart Inc, UK) to an average thickness of 3mm. The initial weights of the samples were measured using analytical balance to an average weight of 5g.

Ultrasound pretreatment

Samples pretreated with ultrasound were done with ultrasound equipment (FS-600N, Yuchengtech Co. Ltd. China). The sample was immersed in distilled water and osmotic solution in a beaker and place in an ultrasonic device. The ultrasound frequency was 20 kHz, output power was 600w; pretreatment time was carried out for 10 min. The ratio of water to sample was 100:1. The ultrasonic on and off time was set at 5s and 1s respectively. For Ultrasound with Distilled water, distilled water made up to 500 mL volume inside a beaker for each experimental run and two slices each in the beaker were subjected to ultrasound treatment. For Ultrasound with Osmotic Solution**, f**ood grade salt (NaCl) was used as osmotic agent for the experiment. The salt concentrations (23% w/v) were prepared with water and made up to 500 mL volume inside a beaker for each experimental run and two slices each in the beaker were subjected to ultrasound treatment.

Oven Drying

After the pre-treatments using ultrasound, samples were drained, blotted with absorbent paper and weighed. The pretreated samples were put inside a convective hot air oven dryer at 50, 60 and 70℃. The weight of the samples were taken at equilibrium moisture content (dry bone mass).

Determination of Protein Content

The crude protein content was determined using Kjeldahl apparatus. One half (0.5g) grams of the yellow cassava sample (for fresh, treated and untreated) was weighed into a Kjeldahl digestion flask. 5g of Kjeldahl catalyst (9 part of potassium sulphate with 1part of copper sulphate) and 200ml of concentrated sulphuric acid was added and heated to red-hot temperature under a fume cupboard for 2 hours to obtain clear solution. The digest was made up to 100ml mark by diluting with distilled water in a volumetric flask. An aliquot of the digest (10ml) was added to equal volume of 45% NaOH solution in a semi- micro kjeldahl distillation apparatus. The mixture was distilled and the distillate collected into 10ml of 4% boric solution containing 3 drops of mixed indicator (meth1 red and bromocressol green). 50ml of the distillate was collected and titrated against $0.02NH_2SO_4$ solution. A blank experiment was set involving digestion of all the materials except the sample. The distillation is also carried out on the blank. The titre value of the blank was subtracted from that of the sample and the difference obtained was used to calculate the crude protein.

$$\text{Protein (\%)} = \frac{(A-B)\times N \times 1.4007 \times 6.25}{W} \qquad 1$$

Where A = Volume (ml) of 0.2N HCl used sample titration, B = Volume (ml) of 0.2N HCl used blank titration, N = Normality of HCl, W = Weight (g) of sample, 14.007 = atomic weight of nitrogen, 6.25 = the protein-nitrogen conversation factor for fish and its by-products

Crude Fibre Determination

Two gram (2g) of each sample was digested with 200ml of 1.25% H_2SO_4 solution under reflux for 30 min boiling. The digest was then allowed to cool and then filtered with Buckner funnel equipped with muslin cloth. The residue was washed three times with hot water, after which it was put in a conical flask and digested with 200ml of 1.25% NaOH solution for 30 min boiling under reflux. The digest was allowed to cool, then filtered and washed three times with distilled water. The residue was drained and placed in a previously dried and weighed crucible and then oven dried at 105ºC until constant mass was attained. After drying, the crucible with its content was reweighed and put inside the muffle furnace to ash at temperature of 550ºC for 3 h. The ash was then withdrawn, put in a bell jar and weighed. The difference in weight of the sample were calculated as crude fibre and expressed as a percent of the initial weight.

Determination of Carotenoid Contents

The carotenoid content was determined using Oladejo et al. (2017) method. The analysis was quickly carried out in order to avoid degradation by light and oxygen. 3g of sample was weighed and homogenized using mortar and pestle with continuous additions of 25 ml of cold acetone in order to extract the carotenoid. The mixture was suctioned and filtered through sintered funnel coupled with a Buckner flask under vacuum repeatedly until the sample became colourless. The extract was transferred to a 500ml separatory funnel containing 40ml of petroleum ether. Distilled water was added slowly on the wall of separatory funnel in order to wash away the acetone. The lower aqueous phase was then discarded. This process was repeated until there was no residual solvent remaining. In order to remove residual water from the extract, the extract was put in a 50 ml volumetric flask containing 15 g of anhydrous sodium sulphate. The volume was made up with petroleum ether and the absorbance read at 450nm using a spectrophotometer. The total carotenoid content was calculated using the following equation.

$$\text{Total carotenoid content } {}^{\mu g}/_{g} = \frac{A \times V(ml) \times 10^4}{A_{1cm}^{1\%} \times P(g)} \qquad 2$$

Where A = absorbance, V = volume of the extract (ml), $A_{1cm}^{1\%}$ = 2592 (B-carotene absorption coefficient in petroleum ether) and P = sample weight (g).

Determination of Colour

The colour of fresh, pretreated and dried samples were measured using a colorimeter. The high and low values of L*, a* and b* which represent whiteness–blackness, redness–greenness and yellowness–blueness, respectively were recorded. The total colour change (ΔE) was calculated using 3 (Oladejo, Ma, Qu, Zhou, Wu, *et al.*, 2017):

$$\Delta E = \sqrt{(\mathrm{L}*_i - \mathrm{L}*_t)^2 + (a_i^* - a_t^*)^2 + (b_i^* - b_t^*)^2} \qquad 3$$

Where L*, a* and b* stand for whiteness–blackness, redness–greenness and yellowness–blueness respectively. i = initial value of a parameter and t = value of the parameter at time t. The higher the values of ΔE, the greater the colour difference from the fresh yellow cassava.

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Effects of ultrasound pretreatment methods on the protein, fibre and carotenoid content of dried yellow cassava

The average protein content for fresh yellow cassava was 5.44% as shown in Table 1. This amount of protein was within the range stated by Ayetigbo et al. (2018). At a temperature of 70ºC, the untreated and UOD dried samples had the highest and least amount of protein, respectively. The least amount of protein observed in the UOD samples could be due to the combing effect of ultrasound and osmotic concentration which led to the degradation of the protein content compared to the untreated samples. However, there was no significant difference ($p>0.05$) between the DWU and the fresh samples. The fibre content of yellow cassava was found to be 0.383% for fresh sample. This value was close to the range reported by Aniedu and Omodamiro (2012). The fibre contents of the DWU and UOD samples were significantly ($p<0.05$) higher than that of the untreated samples, but not significantly different ($p>0.05$) from the fresh sample. This shows that ultrasound pretreatment could help in the retention of fibre content of dried yellow cassava. The carotenoid content of fresh yellow cassava was 34.567µg/g (wet basis). This value was a bit higher than the values reported by Ayetigbo et al. (2018), because of the difference in variants and possibly the age of the yellow cassava. Generally, there was loss in the carotenoid content of all dried samples due to pretreatment and drying. However, the carotenoid retention of yellow cassava for sample treated in DWU was significantly higher than that of UOD and untreated. This showed that DWU pretreatment had mild effect on the carotenoid content of the yellow cassava during drying. Azoubel et al. (2015) similarly reported that the papaya samples pretreated with ultrasound had higher retention of carotenoid than the untreated ones during drying.

Table 1. Effect of ultrasound pretreatments on the protein, fibre and carotenoid content of yellow cassava at 70℃

Sample	Protein (%)	Fibre (%)	Carotenoid (µg/g)
Fresh	5.444 ± 0.337^{b}	0.383 ± 0.076^{ab}	34.567 ± 0.221^{d}
untreated	6.611 ± 0.173^{c}	0.233 ± 0.058^{a}	7.519 ± 0.158^{b}
DWU	4.861 ± 0.337^{b}	0.483 ± 0.076^{b}	11.338 ± 0.428^{c}
UOD	1.408 ± 0.304^{a}	0.517 ± 0.076^{b}	5.982 ± 0.257^{a}

Values are represented as mean ± standard deviation of triplicate (3) replicate. Means in the same column bearing different superscripts differed significantly ($p<0.05$).

Effects of ultrasound pretreatment methods and drying temperature on the colour of yellow cassava

Colour is a significant attribute of a food product that informs the choice of the consumers. The effect of pretreatment methods on the colour (L*, a*, b* and ΔE values) of yellow cassava can be observed from Figure 1 to 4. The L* values stand for brightness, the higher the value, the brighter the sample, and the lower the value, the darker. As the temperature increased from 50 to 60ºC, the L* value also increased for DWU and UOD samples, but declined at the temperature of 70ºC. This suggests that drying ultrasound pretreated yellow cassava above 60ºC can have adverse effects on the product. However, the L* values of the samples pretreated with DWU and UOD were higher than (brighter colour) the untreated samples at 60ºC. Nowacka and Wedzik (2016) also confirmed that dried carrot samples pretreated with ultrasound had higher L* value than the untreated. Bozkir et al. (2019) also reported highest lightness for dried Persimmon samples pretreated in ultrasound with osmotic dehydration for 30 min.

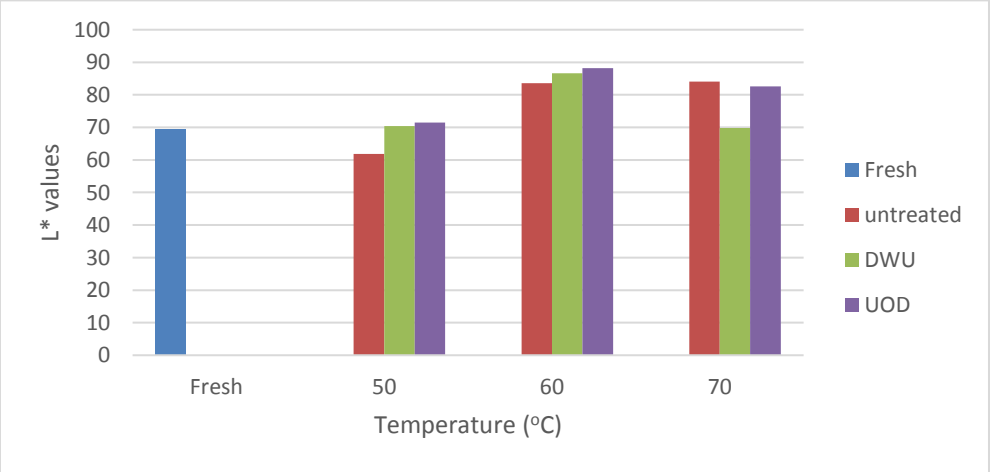

Figure 1. Effect of pretreatments on the L* values of yellow cassava.

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The effects of different methods on the a* values of dried yellow cassava is shown in Figure 2. The a* values stand for redness, the higher the value, the redder the sample, and the lower values tend to greenness. As shown in Figure 2, the samples pretreated in DWU and UOD had lower a* values at 50 and 70ºC compared to the untreated samples. Bozkir et al. (2019) similarly observed a decrease in the a* values of Persimmon samples treated in ultrasound with osmotic dehydration compared with the untreated samples. But the reverse is the case at the temperature of 60ºC, where the untreated samples had lower a* values than the pretreated samples. Non-enzymatic browning reaction could be responsible for the high a* values of the pretreated samples.

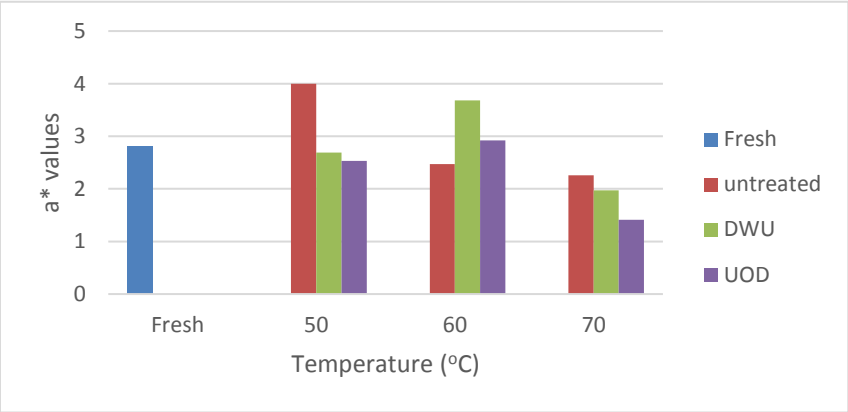

Figure 2. Effect of pretreatments on the a* values of yellow cassava.

The b* values range from yellowness to blueness for high to low values, respectively. All the dried samples had highest b* values at 70ºC. This indicated that increase in temperature could enhance the yellowness appearance of the yellow cassava. Abano et al. (2011) reported an increase in yellowness of tomato samples as the temperature increased from 50 to 80ºC. Furthermore, DWU samples had the highest b* values at temperature of 70ºC. Similar observation was reported by de Medeiros et al. (2016) that the mango samples pretreated by ultrasound showed higher b*values than the untreated samples. The effects of ultrasound on the membrane wall of the yellow cassava could have exposed more of the yellow pigments, thus making it look more yellowish.

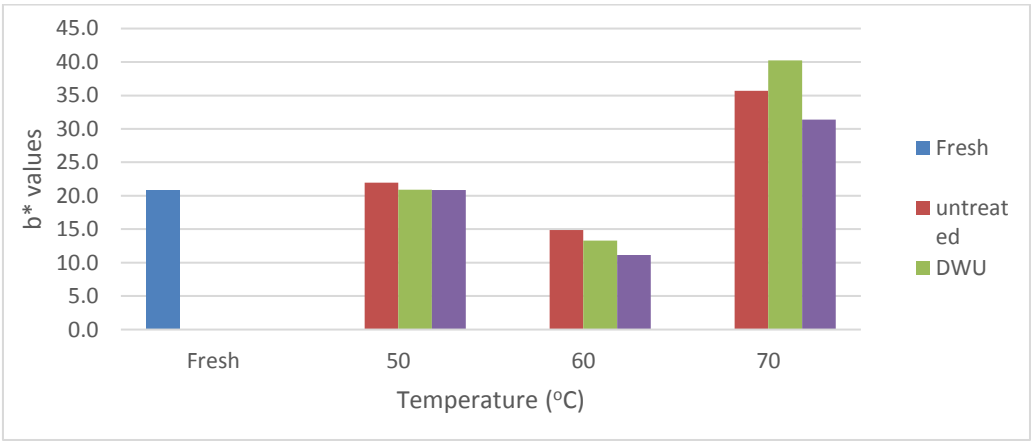

Figure 3. Effect of pretreatments on the b* values of yellow cassava

The total colour change, ΔE is used to determine the colour difference between processed and fresh food (de Medeiros *et al*., 2016). Figure 4 shows the total colour change of the pretreated and untreated samples. The highest effect of the colour change was observed at 70℃ for all the samples. On the other hand, the lowest colour change was observed at 60℃**.** Generally, the ultrasound pretreated samples had higher ΔE than the untreated samples for all temperature. This could be due to the fact that the ultrasonic action and the combined effect of osmotic dehydration in the case of UOD had great effect on the membrane structure of the yellow cassava, thus causing colour depigmentation of the sample.

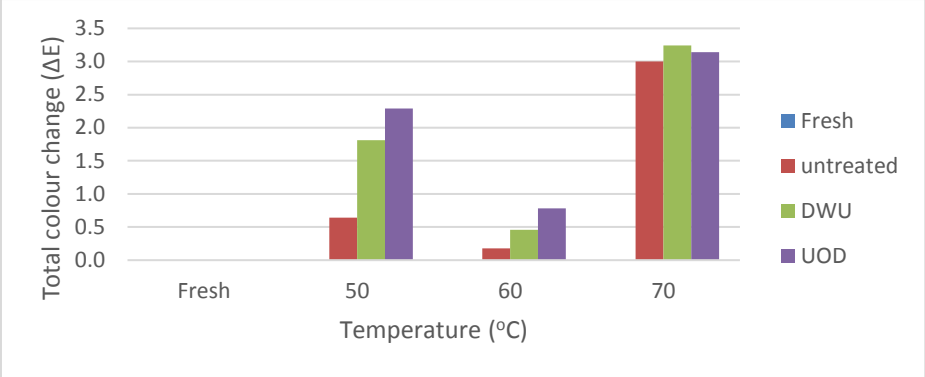

Figure 4. Effect of pretreatments on the ΔE values of yellow cassava

Conclusion

This work has shown the effects that ultrasound pretreatment can have on the nutritional quality of yellow cassava during drying. Fibre and carotenoid content of ultrasound pretreated yellow cassava were well preserved during drying compared to the untreated. Also, the ultrasound pretreated yellow cassava gave the best colour attribute when it was dried at 60 °C. Therefore, ultrasound pretreatment of yellow cassava before drying could help to significantly retain its nutritional quality.

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