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Process Technology for Preparation of Yam Chips

VISHAL KUMAR* AND MANISH KUMAR

Department of Processing & Food Engineering College of Agricultural Engg Rajendra Agricultural University
Pusa 848125, Samastipur, India
E-mail : vishal_phpfe@rediffmail.com
**Correspondence*

Abstract

The process conditions were optimized for the preparation of hot air dried yam chips. The effects of blanching time (0, 1, 3 and 5 min) and blanching temperature (80 and 90 C), and the drying temperature (70, 80 and 90 C) on the drying kinetics and various quality attributes of yam chips viz. texture and brown pigment accumulation and organoleptic evaluation were also investigated. It was found that drying took place entirely in the falling rate period. Longer blanching time and lower drying temperature resulted in better color retention and led to chips of lower browning index. Blanching also reduced the hardness and fracturability of the product. The final product showed optimum texture attributes for the blanching treatment of 90C for 3 minutes followed by the drying process at 80C for 480 minutes.
Key words : Blanching, Browning index, Color, Hot air drying, Organoleptic evaluation.

Yams (*Amorphophallus* spp.) is an important tropical tuber food crop rich in starch (1). They have the highest rate of dry matter production per day and are major calorie contributors. Yam has also been used as health food and herbal medicinal ingredients in traditional Chinese medicine. Yam extracts showed significant ant oxidative activity and modified serum lipid levels in humans. Yam chips can be a popular snacks and its production can generate a competitive industry like other snack products (2). Many works have been performed to study hot air drying of yam pieces of various shapes (3—5). Drying as one of the most common preservation methods could therefore be a feasible alternative for production of low-fat or fat-free yam chips with desirable color and textural characteristics. Prior to drying most food products are usually subjected to one form of pretreatments; among other methods hot water blanching is one of the most common techniques. Blanching helps inactivate enzymes that lead to some quality degradations. Blanching also facilitates starch gelatinization that leads to the change of internal structure and influences the drying rate and quality of the dried product (6). The combined effects of blanching and drying on the drying behavior and quality of the dried yam product are thus the interesting issues. The present work was made to assess the effects of drying and blanching conditions on the drying kinetics and quality of yam chips in terms of color, texture, and browning index, which can be used as an indicator of quality deterioration causing from excessive heat treatment (7).

Methods

Sample Preparation

Fresh yam of Gajendra variety was purchased from nearby local market. For the total dry materials determination in raw sample and for determining of the initial moisture content, the sample was heated in a drying oven (Model no-Indosaw-6745) at 105C for 48h, according to AOAC method (8).

Pre-Treatments. The sliced chips were blanched in hot water at 80 and 90C for 0, 1, 3 and 5 min with a definite amount of potassium bi-sulfite (0.5%) and sodium chloride salt (2.0%) with the ratio of to water of 0.015 g/g. Chips were then immediately cooled down in cold water to 4C and placed on a paper towel to remove excess water prior to drying.

Experimental Set-Up and Methods. A hot air cabinet dryer was used for drying purpose. It consists of a stainless steel drying chamber, which is connected to an electric heater rated at 6.0kW, which was used to heat up the air to the desired drying temperature; the heater was controlled by a PID temperature controller. The air velocity was controlled by a fan speed controller. In each experiment approximately 32 chips of were placed on the tray with a dimension of 30 × 40 cm^2. Samples from the tray were collected at every 15 min interval for moisture content determination. Drying temperatures used were 70, 80 and 90C while the constant inlet air velocity of 1.0 m/s was used.

The samples were dried until reaching the final moisture content of around 3.5% (db) (9), which is similar to that of commercially available chips (Pringle™ and Parle ™) of 2—3% (db). Moisture content (8), color, browning index, and hardness of the samples were measured. Preliminary test was also performed to evaluate the degree of starch gelatinization of chips after blanching.

Degree of Starch Gelatinization

Degree of starch gelatinization was evaluated using the differential scanning calorimetry method. Approximately 15 mg of sample was placed in an aluminum pan. The sample was then scanned from 25 to 160 C at a heating rate of 10C/min by a differential scanning calorimeter (DSC) (Mettler Toledo DSC 822^e , Switzerland). The degree of starch gelatinization was calculated using equation

$$DG = \left(1 - \frac{\triangle H_g}{\triangle H_{raw}}\right) \times 100$$

where DG is the degree of starch gelatinization (%), $\triangle H_g$ is the enthalpy of gelatinization of the sample (J/g), $\triangle H_{raw}$ is the enthalpy of gelatinization of the raw sample (J/g)

Browning Index

The browning index was determined using the standard procedure (10). The samples were ground and 2 g portion was extracted with 20 ml of 2% acetic acid solution and then filtered through a filter paper (Whatman No. 3). An aliquot of the filtrate was mixed with an equal volume of acetone and filtered again. The absorbance of the extracted color solution was measured at 420 nm using a spectrophotometer (Shimadzu, Model UV 2101 PC, Tokyo, Japan) using a 1 cm cell. The results are expressed in terms of the optical density.

Table 1. Degree of starch gelatinization of blanched chips.

Blanching time (min)	Blanching temperature (C)	Degree of starch gelatinization (%)
0	–	0
1	80	63.62
3	80	69.83
5	80	84.22
1	90	68.85
3	90	79.94
5	90	94.86

Texture Analysis

The texture of chips was evaluated by a compressive test using a texture analyzer (Stable Micro System, TA. XT. Plus, UK). The test involved applying a direct force to the sample, which was placed on the hollow planar base. The force was then applied to the sample by a 5-mm spherical probe at a constant speed of 2 mm/s until the sample was cracked. Force-deformation data were recorded to determine the textural characteristics of the chip. The maximum force of break under the force-deformation curve indicated the hardness/ crispness of the chip (11, 12). All tests were performed in triplicate and the average values were reported.

Organoleptic Evaluation

Dried chips were stored up to 3 months in polyethylene sheet bags at 30C. Consumer acceptance test prior to storage studies was conducted using 9-point hedonic scale. The sensory quality of dried and rehydrated litchi sample was evaluated by a trained panelist who evaluated the product for appearance, taste, flavors, aromas, texture and overall quality (13). The sample scoring an overall quality of 7 or above were considered acceptable and those receiving 6 or below 6 were considered unacceptable.

Results and Discussion

Effect of Blanching on Chips

To show the effect of blanching on product qual-

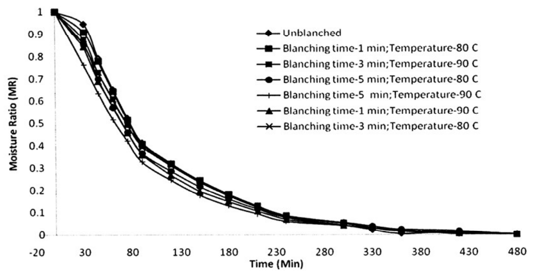

Figure 1. Drying curves of yam chips underwent blanching at (a) 0, (b) 1, (c) 3, and (d) 5 min at blanching temperature 80 and 90 C in a hot air dryer at 70 C.

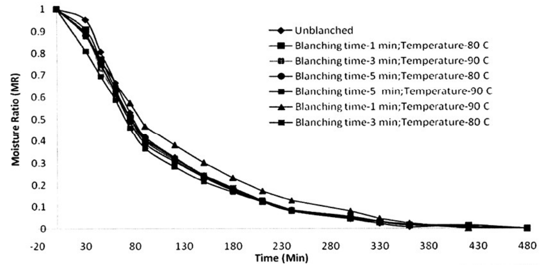

Figure 2. Drying curves of yam chips underwent blanching at (a) 0, (b) 1, (c) 3, and (d) 5 min at blanching temperature 80 and 90C in a hot air dryer at 80 C.

ity, various experiments were performed in hot air dryer with and without blanching. From peroxidase activity determination the results showed that peroxidase activity reduced drastically after blanching, even for 3 min. Thus, the effect of enzymatic browning during subsequent drying could be neglected in the case of blanched samples. Chips blanched at different temperatures and at various periods also had different degrees of starch gelatinization (Table 1). Figures 1, 2 and 3 show the effect of blanching temperature and blanching time on drying of yam. It was found that increasing blanching time can decrease drying time in dryers with air circulation. This phenomenon is due to the fact that in a convective dryer, the drying time is nearly large for unblanched samples and a resistant film layer may be formed on the surface of yam due to gelling of present starch. This film can reduce the mass transfer and hence increase the drying time. The unblanched samples didn't show a desirable appearance at all.

Drying Kinetics of Yam Chips

Raw and blanched yam chips with initial moisture contents in the range of 76.27—80.80% wet basis (or 321.41 to 420.83% dry basis) were dried until reaching their equilibrium moisture contents. Drying at higher temperature took shorter time to reach the desired moisture content because of a larger driving force for heat transfer (Figs. 1—3). Drying rate showed an increase at the beginning of the process due to sample heating. After an initial short period the drying rate reached a maximum value and then it followed falling rate in all drying conditions. No constant drying rate period was observed. Similar results were reported by previous researchers (14, 15). Similar results were observed for chips underwent any blanching conditions. However, it was found that the blanched samples dried faster than the unblanched one. This behavior was probably due to structure softening due to blanching that might facilitate water removal (16, 17). When the tissue was blanched or cooked the cells might become more permeable to moisture. However, excessive blanching time decreased the rate of moisture removal. This might be due to the effect of starch gelatinization, structural changes, and water content absorbed during blanching. Higher degree of starch gelatinization might affect the cell structure and increase the internal resistance to moisture movement, which resulted in lower diffusivity (18). Therefore, the samples blanched for 1 min results in the highest drying rates followed by those blanched for 3 and 5 min, respectively; unblanched yam chips had the lowest drying rates for all drying conditions. However, it was found that, at higher drying temperatures, the drying rates of samples treated with different blanching periods were not obviously different. So, the effect of blanching was greater than the effect of drying temperature.

Quality of Dried Yam Chips

Browning Index. The effects of blanching and drying temperature on the browning index of yam chips are shown in Table 2. Drying resulted in a high browning index at higher drying temperatures. This is due to the difference in surface temperature of yam during drying. In the constant drying rate period the surface temperature of yam chips undergoing hot air drying at 70, 80, and 90 C were equal to the wet-bulb

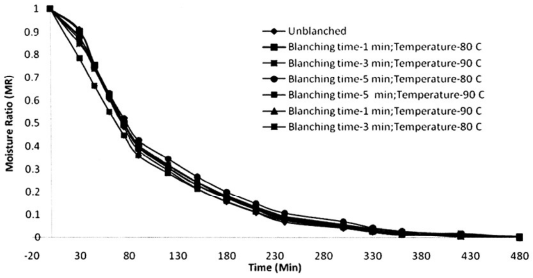

Figure 3. Drying curves of yam chips underwent blanching at (a) 0, (b) 1, (c) 3, and (d) 5 min at blanching temperature 80 and 90 C in a hot air dryer at 90C.

temperature, which was 43, 47, and 52 C, respectively. As the drying temperature increased, of course, the wet-bulb temperature also increased. This increase in turn led to larger differences in browning index between the chips at higher drying temperatures. The highest value of browning index wascobtained in air dried sample at 90C. A higher degree of non-enzymatic browning occurring during hot air drying might be due to both Maillard reaction and ascorbic acid oxidation.

The results of the browning index were also related to the color changes, especially the change of redness. The results showed similar trends for both physical and chemical changes. From the results of changes in browning index it might be concluded that drying resulted in significant chemical damage of yam chips.

Texture. Chip manufacturers are often interested in studying the effect of on hardness of the chips which is the maximum breaking force, and the results are shown in Table 3. It was found that blanching temperature and blanching time and drying temperature significantly affected the hardness of yam chips. Generally, blanching caused starch gelatinization, softening of structure and led to less hardness of dried starchy products. It was observed in this work that unblanched chips had the maximum hardness in all cases; blanching led to significantly less hard chips. This might be due to the effect of casehardening developed during moisture removal.

For the effect of drying temperature it was found that drying temperature significantly affected the hardness, especially at higher temperatures. The hardness of the samples dried at 90C was lower than that dried

Table 2. Effects of drying method, drying temperature, blanching time and blanching temperature on color changes and browning index of dried yam chips.

Drying temp (C)	Blanching time (min)	Blanching temperature (C)	Browning index
70	0	–	0.081 ± 0.012
	1	80	0.070 ± 0.042
	1	90	0.068 ± 0.002
	3	80	0.036 ± 0.011
	3	90	0.0387 ± 0.033
	5	80	0.042 ± 0.056
	5	90	0.0398 ± 0.023
80	0	–	0.206 ± 0.054
	1	80	0.195 ± 0.027
	1	90	0.188 ± 0.034
	3	80	0.134 ± 0.045
	3	90	0.150 ± 0.018
	5	80	0.133 ± 0.067
	5	90	0.245 ± 0.008
90	0	–	0.555 ± 0.030
	1	80	0.411 ± 0.041
	1	90	0.425 ± 0.44
	3	80	0.396 ± 0.021
	3	90	0.416 ± 0.005
	5	80	0.306 ± 0.003
	5	90	0.321 ± 0.044

at 70C but was not significantly different from that dried at 80C. This might be either due to the effect of puffing that occurred more at higher temperatures and probably increased the porosity and resulted in a decrease of hardness and less shrinkage of the samples or due to a large variation of the experimental results caused by the non-uniform or heterogeneous nature of raw yam.

It was found that chips treated with at air drying temperature at 90C (with 5 min blanching time at 90C), required the lowest force of compression were still harder than the commercial products (For Lay™ and Parle ™ the hardness were 1.861 and 1.934 N respectively). Also, the time of break is an indication of fracturability or crispiness, and so may also be of interest. The shorter the time to fracture, the more easily the product is fractured. Hence, in terms of crispiness, samples dried at 90C took less time to fracture than that dried at 80 and 70 C.

Consumer acceptance test was conducted for the yam chips using 9-point hedonic scale. The result of the sensory analysis showed that 45% of the responses marked the sample as "like very much"

Table 3. Effects of drying temperature and blanching on hardness of dried yam chips.

Drying temp (C)	Blanching time (min)	Blanching temperature (C)	Hardness (N)	Time to fracture (sec)
70	0	–	6.107	0.490
	1	80	4.898	0.386
	1	90	4.771	0.374
	3	80	5.142	0.367
	3	90	4.725	3.212
	5	80	4.993	0.312
	5	90	4.4270	2.866
80	0	–	5.935	0.395
	1	80	4.605	0.344
	1	90	4.520	0.310
	3	80	4.653	0.318
	3	90	4.476	0.303
	5	80	4.693	0.190
	5	90	4.491	2.664
90	0	–	5.128	0.370
	1	80	4.679	0.332
	1	90	4.056	0.2885
	3	80	3.421	0.2891
	3	90	3.013	0.2694
	5	80	3.113	0.2452
	5	90	2.918	0.200

and remaining 55% as "like moderately" (significant at $P < 0.05$ level). Sensory evaluation of all the samples were found to be acceptable but the dried sample (90 C hot air drying, 80C blanching temperature and 3 min blanching time) showed high sensory scores as compared to other samples with respect to their color, flavor, texture (crispness) and overall quality.

Conclusion. The effects of drying and blanching conditions on the drying kinetics and quality of yam chips were examined in this study. In terms of drying kinetics blanching time and drying temperature were found to have effects on the moisture reduction rate of samples. It was found that blanching could increase the drying rates. The quality study showed that blanching led to better color retention, less hardness and lower degree of browning of chips. In addition to the drying temperature pretreatments also possessed significant effects on the drying rates, especially at lower drying temperatures. Regarding the textural quality the hardness of dried chips was significantly influenced by the pretreatment methods but was lower at higher drying temperature. The crispness increased as the drying temperature increased but the toughness decreased with increased drying temperature.

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