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Full Length Research Paper

Effects of boiling solution (trona) concentration and time on the proximate composition and physico-chemical propterties of flour from three-leaved yam (*Dioscorea dumetorum* pax) tubers

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Samples of three-leaved yam (TLY) tubers were subjected to different boiling times using different concentrations of trona solution. The effects of these conditions on the proximate composition and physico-chemical properties were analyzed. The fat and fibre contents were not affected by changes in trona concentration and boiling time. The moisture and ash content increased with increase in trona concentration and boiling time while protein showed a decreasing trend: The values for swelling index, water absorption capacity, blue value index and total soluble solids showed significant increases ($P \geq 0.05$) with increase in trona concentration and boiling time.

Key words: Three-leaved yam, boiling time, trona concentration, proximate composition, physico-chemical properties.

INTRODUCTION

Yam is one of the major staples in Nigeria. The tree-leaved yam (*Dioscorea dumetorum* pax) is one of the 600 species of the family of yam. However, the three-leaved yam (TLY) known as "ona" among the Ibo speaking people of Southern Nigeria is not a very popular specie among the other yam specie (Olorunda, 1979). This may be as a result of the long cooking time involved in its preparation, as well as its highly perishable nature. Medova et al (2005) reported an increase in hardening and longer cooking time, experienced with stored TLY tubers. Generally, soaking, application of chemical/ additives like trona, critic acid, sodium chloride, etc are used as means of softening to reduce cooking time. So far, TLY has found no industrial application. Some attempts have been made towards utilizing TLY as well as other yam species in some products such as yam fufu, farmstead bread making in Nigeria, yam soups and canned yam in Puerto Rico, yam flakes in Barbados (NRI, 1987; Ukpabi, 2010). However, these attempts have not been commercially successful due to high cost of raw material. The amino acid composition of TLY has been described by Alozie et al. (2009).

The research revealed protein content ranging from 7.0 to 11.37% and the presence of some essential amino acids. Until recently, research works on TLY has been scanty and most reports have been on its botanical and agronomical features (Coursey and Ferber, 1979). The aim of this work therefore is to find out effects of different trona concentration and boiling time on the physico-chemical properties of TLY flour. If these properties of the treated TLY flours are known, it will increase the level of utilization of the TLY thereby improve its commercial value. This will also help to curb the level of post harvest losses experienced with TLY since it is highly perishable.

MATERIALS AND METHODS

Materials

TLY tubers were purchased from Owerri main market. They were inspected to remove the cut, bruised and spoilt tubers. They were then washed, peeled and cut into slices of 5 cm thickness. The slices were placed into each of the six concentrations of trona solution (0.0, 2.5, 5.0, 7.5, 10.0 and 12.5% (m/v db), at a loading

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rate of 1.2 (mass: volume). Each of them was boiled for periods of 0, 30, 60, 90 and 120 min. At the end of boiling, the slices were drained, cooled and further cut into 5 mm thick slices. They were dried at 40 to 45°C, cooled and milled into flour to pass through 1 mm mesh sieve. The 30 samples obtained were then used for the subsequent analyses. Each analysis was carried out in triplicates. The results were subjected to statistical analysis to determine significant difference (p=0.05).

Methodology

Proximate analyses

The moisture, crude protein, crude fat, crude fibre, ash and carbohydrate contents were determined using AOAC (1990) methods.

Swelling index

The swelling index was determined according to the method described by Ukpabi and Ndimele (1990). Three gram portions (dmb) of each flour was transferred into clean dry graduated (50 ml) cylinders. The flour samples were gently leveled and the volumes noted. Distilled water (30 ml) was added to each sample, the cylinder was swirled and allowed to stand for 60 min while the change in volume (swelling) was recorded every 15 min. The swelling power of each flour sample was calculated as a multiple of the original volume.

Water absorption capacity

Water absorption capacity was determined by the method described by Abbey and Ibeh (1988). Flour samples (1 g dmb) of each treatment was weighed separately and placed into clean centrifuge tubes of known weights. Distilled water was mixed with the flour to make up to 10ml dispersion. The tubes were then centrifuged at 3500 rpm for 15 min. The supernatant was decanted and each tube together with its contents were reweighed. The gain in mass is the water absorption capacity of the flour sample.

Oil absorption capacity

The method described by Abbey and Ibeh (1988) was adopted. Each flour samples (1 g) was weighed separately and introduced into clean centrifuge tubes of known weights. Groundnut oil was mixed with the flour in each tube to make up to 10 ml dispersion. The tubes were centrifuged at 3500 rmp for 15 min. The supernatant was discarded and the tubes reweighed. The gain in mass is the oil absorption capacity.

Blue value index

The blue value index (BVI) was determined by adopting the method by Kawabata et al (1984). Each sample (3 g dmb) was introduced into a 30 ml volumetric flask, dispersed with distilled water and then made up to the mark with distilled water. The dispersion was filtered through a Whatman No. 42 Filter paper. A 10 ml aliquot of the filtrate was titrated with 0.1N Iodine solution to a bluish-back end point, using phenolphthalein (4 drops) as indication. The BVI is calculated as follows:

BVI (ppm) = $(V_D/V_A)\ V_t/M_s)\ N_a/1000) \times 10^6$

Where V_D = Total volume of dispersion
V_A = Volume of aliquot used
V_t = Titre value
M_s = Mass (dmb) of flour used
N_a = Normality of iodine solution used.

Solubility

The cold water extraction method as described by Udensi and Onuora (1992) was used. Flour dispersions of samples were prepared by dispersing 1 g. of flour is distilled water and made up to 10 ml. It was allowed to stand for 60 min while it was stirred every 10 min. It was allowed to settle for 15 min after which 2 ml of the supernatant was transferred using a pipette into a weighed, dry petri dish. It was evaporated to dryness and reweighed. The total soluble solid (TSS) was then calculated.

TSS (%) = $(V_s/2M_s)\ (M_e - M_d) \times 100$
Where V_s= Total Supernatant/filtrate
M_d = Mass of empty petri dish
M_e = Mass of petri dish plus residual solids after evaporative drying
M_s = Mass of flour sample used in the preparation of the dispersion

Gelling and boiling point

The method by Narayana and Narasinya-Rao (1982) was adopted. The flour sample (10 dmb) was dispersed in a 100 ml volumetric flask and made up to the mark with distilled water. The suspension was poured into a beaker and then heated while stirring with a magnetic stirrer. A thermometer held on a retort stand was submerged into the suspension and is used to record the gelling point as well as the boiling point of the suspension

RESULT AND DISCUSSION

The results of the proximate analysis are shown on Table 1. Significant changes (P>0.05) were observed among the flour samples due to the effects of the different boiling solutions and boiling times. The moisture content of the TLY flours increased from a mean value of 11.92% when boiled in 0% concentration to a mean value of 15.52% when the TLY was boiled in solution with 12.5% trona concentration. Similar increase in moisture content was noted with increase in boiling time. These increases may be attributed to the high cell damage due to the coupled effects of high trona concentration and the long boiling time (Uzoma and Osuji, 2004). The highest protein concentration was noted at 0% BSC and 30 min BLT, with mean values of 9.86 and 8.42%. These values decreased with increase in boiling solution concentration (BSC) and boiling time (BLT). This is due to the denaturation of protein by the high temperature alkali treatment.

The ash content of the TLY flour also showed significant increase (P > 0.05) with increase in BSC and BLT. However, the fat and fibre content were not affected by changes in boiling solution concentration and boiling time. Significant increase (P>0.5) were recorded in the

Table 1. Mean values of proximate composition of flour from tubers of three leaved yam (TLY) pre-treated via boiling-only (BLGO) in Trona solutions, as functions of boiling solution concentration (BSC) and boiling time (BLT).

Source of Variation	Components of variation	Proximate composition (%,db)					
		Moisture	Protein	Fat	Fiber	Ash	carbohydrate
Boiling solution Conc. (%)	0.0	11.92 ±1.13[e]	9.89± 0.68[a]	3.38±0.33[bc]	3.24 ±0.19[a]	2.78 ± 0.03[a]	69.386±4.18[bc]
	2.5	12.60 ±1.07[e]	8.02±2.13[b]	4.83±0.43[a]	2.80±0.40[a]	3.14±0.60[ab]	64.378±4.45[a]
	5.0	13.85 ±0.38[cd]	6.46±2.40[cd]	4.46±1.14[ab]	2.68±0.31[a]	3.04±0.52[a]	79.912±6.50[c]
	7.5	14.44 ±1.44[c]	6.83±1.47[c]	3.64±0.58[bc]	2.52±0.36[a]	4.10±1.32[b]	70.481±2.85[bc]
	10.0	14.80 ±0.96[ab]	5.16±0.79d[e]	3.60±0.44[bc]	3.23±0.62[a]	5.40±1.16[c]	68.990±2.68[ab]
	12.5	15.52 ±1.05[a]	4.48±0.58[ef]	3.44±0.52[c]	2.81±0.35[a]	5.75±1.39[c]	65.676±2.38[a]
	LSD (P = 0.05)	1.1022	1.5807	0.9121	0.5922	1.0587	4.8894
Boiling time, BLT (Min)	0	12.58 ± 1.88[c]	7.48 ± 2.10[c]	3.72 ± 4.49[a]	3.08 ± 0.31[a]	2.78 ± 0.55[a]	66.674 ± 4.35[ab]
	30	14.01 ± 1.98a	8.42 ± 1.98[c]	4.49 ±0.91[b]	3.00 ± 0.70[a]	4.50 ±1.70b[c]	64.662 ± 5..26[a]
	60	13.63 ± 1.05[ab]	7.21 ± 2.20bc	3.998±0.78[a]	2.86 ± 0.42[a]	4.28 ± 1.29[bc]	68.739 ± 3.24[ab]
	90	14.63 ± 1.14[a]	5.77 ± 1.97[ab]	3.92 ± 0.92[a]	2.78 ± 0.44[a]	3.77 ± 0.90[b]	72.750 ± 3.39[c]
	120	14.42 ± 1.34[a]	5.15 ± 1.77[a]	3.71 ± 0.37[a]	2.68 ± 0.28[a]	4.86 ± 1.81[c]	69.528 ± 3.51[bc]
	LSD (P = 0.05)	1.0062	1.4430	0.8327	0.5406	0.9665	4.4634

[a-f] Means with uncommon superscripts along columns differ significantly for each source of variation ($P \geq 0.05$); LSD→ least significant difference.

pH of the TLY flour samples with increase in BSC and BLT. It indicates that higher concentrations as well as high thermal conditions encouraged trona diffusion into the tissues causing an increase in pH of the flours. The results of the physico-chemical analyses are shown on Table 2. The mean values for swelling Index (SI) increased directly proportional to both BSC and BLT with the highest SI (4.06 cm^3/cm^3) recorded at 120 min. This value implied an increase of 168.87% in swelling.

The water absorption capacity (WAC), blue value index (BVI) and total soluble solids (TSS) increased significantly ($P > 0.05$) with increase in BSC and boiling time .These suggest an increase in cellular water uptake with increase in concentration for trona solution and increase in boiling time. But at very high concentration (12.5%) these values tend to decrease. This may be attributed to denaturation or disruption of cell wall leading to a release of cellular materials. The high concentration may also cause a breakdown of macromolecules leading to a lower water absorption capacity in the flour (Ihekoronye and Ngoddy, 1985). The water absorption capacity is a functional property used in determining the suitability of utilizing a material in baked foods such as bread where high WAC is needed (Natt and Narasinga, 1981). This therefore suggests that TLY intended for use in composite flours for bread and other flour confectioneries should not be treated with very high concentration (12.5%) of trona in order to maintain high WAC.

The oil absorption (OAC), gelling point (GP) and boiling point (BPT) all showed significant decrease ($P > 0.05$) with increase in BSC and BLT. A high oil absorption capacity is desirable in products such as meat extenders where it helps to maintain juiciness and improve mouth feel. However the lowering of the OAC with increase in BSC and BLT is advantageous in deep-fat fried snack products where high oil uptake may lead to short shelf life and consumer rejection (Natt and Narasinga, 1981). The decrease in gelling point and boiling point as BSC and BLT increases, suggests that treated sample flours should be incorporated into food mixtures at lower temperatures to avoid difficulties that may arise if handled at temperatures higher than the gelling temperature.

These values have great implications in the use

Table 2. Mean values of physico-chemical properties of flour from tubers of three leaved yam (TLY) Pre-treated via Boiling-only (BLGO) in Trona Solutions, as functions of Boiling Solution Concentration (BSC) and Boiling Time (BLT).

Source of variation	Components of variation	Physico-chemical Properties							
		pH	Swelling Index, SI (cm^3/cm^3)	Water absorption capacity, WAC (ml.H_2O/g.dry flour)	Oil absorption capacity, OAC(ml.Oil/g.dry flour)	Blue value index, BVI (ppm)	Solubility, TSS (%, db)	Gel point temperature, GPT (°C)	Boiling point BPT (°C)
Boiling solution Conc. (%)	0.0	5.83 ± 0.52f	1.73 ± 0.14^{e}	3.64 ± 0.41^{a}	1.92 ± 0.28d	244.6 ± 19.61^{a}	5.36 ± 1.54^{a}	77.0 ± 2.61^{c}	91.0 ± 2.61^{a}
	2.5	8.77 ± 0.56^{de}	2.56 ± 0.23^{d}	3.83 ± 0.33^{a}	1.45 ± 0.18^{ab}	296.0 ± 40.55^{b}	7.20 ± 1.48^{b}	75.5 ± 2.94^{bc}	88.8 ± 2.21^{b}
	5.0	8.86 ± 0.57^{d}	3.07 ± 0.29^{c}	4.40 ± 0.32^{bc}	1.61 ± 0.15^{bc}	346.0 ± 45.32^{c}	9.63 ± 0.78^{c}	67.3 ± 6.92^{ab}	80.0 ± 4.06^{c}
	7.5	9.06 ± 0.46^{c}	3.28 ± 0.36^{b}	4.48 ± 0.41^{c}	1.70 ± 0.18^{c}	354.0 ± 37.14^{c}	12.88 ± 0.62^{d}	65.9 ± 5.15^{a}	79.1 ± 2.97^{c}
	10.0	9.44 ± 0.48^{b}	3.43 ± 0.33^{b}	4.88 ± 0.62^{c}	1.76 ± 0.13^{cd}	342.0 ± 25.61^{c}	15.10 ± 0.83^{e}	63.6 ± 6.37^{a}	76.6 ± 4.03^{d}
	12.5	9.70 ± 0.42^{a}	3.72 ± 0.22^{a}	3.88 ± 0.46^{ab}	1.38 ± 0.15^{a}	300.4 ± 25.14^{b}	13.58 ± 1.28^{d}	61.8 ± 5.78^{a}	72.6 ± 4.22^{e}
	LSD (P = 0.05)	0.1498	0.1588	0.5313	0.1684	27.3868	0.9140	8.6728	1.5241
Boiling time, BLT	0.	7.96 ± 1.28^{e}	2.68 ± 0.66^{d}	4.30 ± 0.60^{b}	1.91 ± 0.23^{c}	222.7 ± 93.99^{a}	9.00 ± 3.89^{a}	75.6 ± 4.00^{a}	85.7 ± 6.05^{a}
	30	8.27 ± 1.39^{d}	2.74 ± 0.58^{d}	4.17 ± 056^{ab}	1.67 ± 0.24^{b}	295.7 ± 42.26^{b}	9.96 ± 3.87^{b}	72.6 ± 4.00^{b}	84.2 ± 5.58^{b}
	60	8.57 ± 1.22^{c}	2.94 ± 0.67^{c}	4.81 ± 0.70^{c}	1.53 ± 0.18^{ab}	322.2 ± 49.82^{c}	11.50 ± 3.91^{c}	67.9 ± 6.14^{c}	81.2 ± 6.34^{c}
	90	8.84 ± 1.26^{b}	3.13 ± 0.69^{b}	3.72 ± 0.28^{a}	1.62 ± 0.22^{ab}	334.3 ± 46.98^{cd}	11.09 ± 3.17^{c}	64.2 ± 7.50^{d}	79.3 ± 6.99^{d}
	120	9.41 ± 1.28^{a}	3.35 ± 0.72^{a}	4.16 ± 0.52^{a}	1.47 ± 0.17^{a}	349.3 ± 38.99^{d}	11.58 ± 2.58^{c}	62.3 ± 7.56^{e}	76.5 ± 7.76^{e}
	LSD (P = 0.05)	0.1368	0.1445	0.4850	0.1538	25.0007	0.8344	7.9172	1.3913

[a-f] Means with uncommon superscripts along columns differ significantly for each source of variation ($P \geq 0.05$); LSD→ least significant difference.

of TLY flour in product formulations (such as in bakery products, weaning foods, etc) where these parameters are important.

Conclusions

From the results, it can be noted that the various BSC and BLT have significant effects on the characteristics of the TLY flours. The effects were much higher at the high concentrations of 7.5 to 12.5% especially with long boiling time (90 to 120 min). Therefore in order to achieve the desired softening effect on the TLY without altering most of the physico-chemical properties, it is advisable to use BSC of 2.5 to 5.0% (m/v,) for about 30 to 60 min. On the other hand, a manufacturer may be able to produce flour with any desired characteristics by combining the required levels of BSC and BLT according to the information provided in this research.

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