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Full Length Research Paper

Development of trifoliate yam: Cocoyam composite flour for *fufu* production

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Trifoliate yam (*Dioscorea dumetorum*) tubers and two varieties of cocoyam (Nxs001 and Nxs003) were processed separately into flour and mixed at the following proportions: 100% trifoliate yam flour; 100% cocoyam flour; 85:15, 75:25, 25:75, and 50:50 cocoyam- trifoliate yam flour. The functional and pasting properties of the composite flours were determined. The trifoliate yam-cocoyam flours were then reconstituted, made into *fufu* and subjected to sensory evaluation. The study showed that there were significant differences (p>0.05) in the functional and pasting properties of the composite flours. The ratings of the sensory panelists showed that NXS003-trifoliate yam composites were preferred for *fufu* production than the NXs001-trifoliate yam composites. 85:15, 75:25 and 50:50 NXs003: trifoliate yam flours were specifically preferred for *fufu* production.

Key words: Trifoliate yam, composite flour, *fufu*, sensory evaluation and functional properties.

INTRODUCTION

Yam is one of the staple foods in Nigeria and other tropical African countries. Yam is grown and cultivated for its energy-rich tuber. Only a few species of yams are cultivated as food crops. *Dioscorea dumetorum* has not been widely studied as other yam species, notwithstanding that it grows readily on various soils, the yield being 3 to 7 times that of other widely grown yam species (Treche and Guion, 1980). This is because in some landraces, tubers with bruises cannot be cooked to softness few days after harvest due to a severe hardening which develops after harvest (Sefa-dedeh and Afoakwa, 2001). Some works have been done on ways of minimizing the post-harvest problem associated with trifoliate yam but no solution has been suggested yet. Processing the yam tuber into a shelf –stable product offers an alternative to fresh storage.

The production of cocoyam otherwise called taro is low compared to other roots and tubers (Aderolu et al., 2009) but its superiority in terms of digestibility of starch (98.8%), the size of starch grain (1/10th of potato) and the sulphur amino acid, make it a better choice than other root crops in developing a composite *fufu* flour with trifoliate yam (Ezedinma, 1987). Fufu is a thick paste usually made by boiling starchy root vegetables in water and pounding with a mortar and pestle until the desired consistency is reached. Cocoyam and *D. dumetorum* have been neglected in attempts to process roots and tubers into more durable forms. A greater part of these tubers are consumed fresh with oil, the rest if not boiled either harden or spoil. The objectives of this work are therefore to encourage the utilization of trifoliate yam and cocoyam and to determine which ratio of trifoliate yam and cocoyam that has the best rheological properties and is most acceptable.

MATERIALS AND METHODS

D. dumetorum setts and two varieties of cocoyam cormels (NXs 001 and NXs 003) were supplied by the yam and the cocoyam programmes respectively of the National Root Crops Research Institute, Umudike. The method of Martins et al. (1983) was used in the development of the *D. dumetorum* flour. The yams were peeled, cut into 0.3 to 0.4 cm slices, boiled for 45 min and spread thinly on perforated trays to dry. The dried slices were ground into flour. The cocoyam flours were developed with the method of Sanful and Darko (2010). The two varieties of cocoyam were washed, peeled, washed again, cut into 0.3 to 0.4 cm thick discs and then blanched at a temperature of 60°C. They were spread thinly on a tray and sun dried. The dry samples were then milled into flour with a double disc attrition milling machine.

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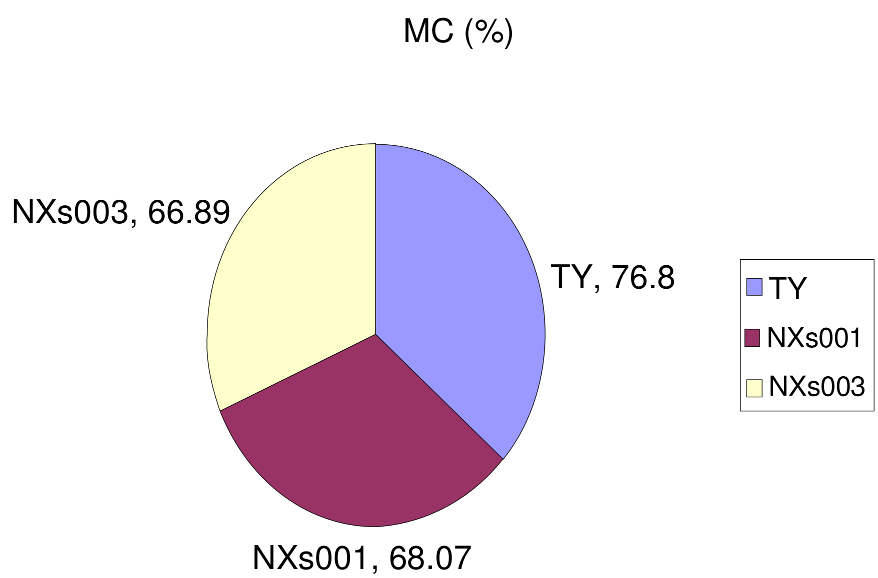

Figure 1. Moisture content of the fresh trifoliate yam and cocoyam (TY stands for Trifoliate yam).

Preparation of composite flours

The trifoliate yam flour and the cocoyam flours were combined at the following proportions: 85:15, 75:25, 25:75, 50:50 NXs001: Trifoliate yam flour and the same proportion for NXs003: Trifoliate yam flour. The moisture content was determined by the standard AOAC (1980) method.

Functional properties

Functional properties such as bulk density was determined using the method of Okezie and Bello (1998), water absorption capacity, swelling capacity and Gelatinization tem perature were evaluated using the method of Okaka et al (1997)

Pasting characteristics

The pasting characteristics of the composite *fufu* flours were determined using Brabender Amylograph (Brabender OHG Duisburg, kulturstrasse 51-55, type-800145010). Gelatinization temperature, peak viscosity, parameters analyzed were peak viscosity, set back viscosity, pasting time and pasting temperature.

Sensory evaluation

Fufu was prepared from the composite flour samples and the commercial yam flour (control). The colour, texture, mouldability and general acceptability of each *fufu* was evaluated by a 15 member panel using a 7-point hedonic scale, with 1 corresponding to dislike extremely and 7 corresponding to like extremely (Iwe, 2003).

Statistical analysis

Data obtained were subjected to statistical analysis of variance (ANOVA) using SAS (2009 version). Means were separated using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The moisture content and percentage dry matter of the fresh trifoliate yam and cocoyam samples are shown in Figure 1.

Functional properties

The functional properties determine the use of food material for various food products. The results for functional properties of the composite flours are shown in Table 1. Bulk density of the flours ranged between 0.687 to 0.87g/cm^3. There were significant differences between the bulk density of 100% NXs001, 100% NXs003 and 100% trifoliate yam ($p<0.05$). 100% trifoliate yam flour had the highest bulk density which means that trifoliate yam flour was denser than the cocoyam flours. The bulk density is influenced by particle size and the density of the flour and is important in determining the packaging requirement and material handling (Karuna et al., 1996).

Water absorption capacity is the ability of flour particles to entrap large amounts of water, such that exudation is prevented (Chen and Lin, 2002). There were significant differences in water absorption capacity of the flours. 100% NXs003 had the highest value of 5.50 g/ml while 100% NXs001 had the lowest value of 2.83 g/ml hence the NXs003: trifoliate yam composite flours have higher water binding capacity than the NXs001: trifoliate yam composite flours. This means that the NXs003-trifoliate

Table 1. Functional properties of the composite trifoliate yam: cocoyam flour.

Samples (%)	Bulk density (g/cm^3)	Water absorption capacity (%)	Swelling capacity	Gelation temperature (°C)
100 trifoliate yam	0.86^{ab}	3.33^{cde}	1283.33^{e}	89.17^{a}
100 NXs001	0.76^{ef}	2.83^{ef}	6500.00^{a}	89.33^{a}
100 NXs003	0.69^{h}	5.50^{a}	806.67^{f}	75.17^{e}
NXs001:trifol(85:15)	0.77^{d}	2.50^{f}	233.33^{i}	76.17^{d}
NXs003:trifol (85:15)	0.72^{f}	3.83^{c}	683.30^{fg}	71.83^{f}
NXs001:trifol*(75:25)	0.77^{de}	2.83^{ef}	700.00^{f}	70.50^{gh}
NXs003:trifol (75:25)	0.71^{g}	4.83^{b}	1733.33^{c}	75.67^{de}
NXs001:trifol (50:50)	0.85^{b}	3.17^{de}	516.67^{h}	80.83^{b}
NXs003:trifol (50:50)	0.76^{ef}	3.67^{de}	316.67^{i}	71.00^{g}
NXs001:trifol (25:75)	0.87^{a}	2.83^{ef}	1533.33^{d}	70.17^{h}
NXs003:trifol (25:75)	0.83^{c}	3.17^{de}	2666.67^{b}	76.00^{c}
Control^	0.62^{i}	2.33^{f}	533.33^{gh}	61.67^{i}

Means with the same superscript in the same column are not significantly different (p>0.05). *trifol stands for trifoliate yam flour, # Ratio of cocoyam flour to yam flour is in parenthesis, ^ control is the commercial yam flour.

Table 2. Pasting properties of the composite trifoliate yam: cocoyam flours.

Sample	Gelation start (°C)	Peak gelation (°C)	Peak viscosity (Bu)	Set back (Bu)	Stability (Bu)	Pasting time (min)
100 trifoliate yam	62.47^{f}	65.37^{j}	2500.00^{a}	626.67^{d}	1873.33^{a}	2.90^{i}
100 NXs001	61.40^{h}	85.70^{a}	2033.33^{b}	620.00^{d}	1484.00^{b}	24.30^{a}
100 NXs003	69.87^{d}	74.73^{f}	1933.33^{c}	883.33^{a}	1050.00^{g}	4.87^{h}
NXs001:trifol*(85:15)	72.63^{b}	81.53^{c}	2000.00^{b}	786.67^{b}	1213.33^{a}	2.90^{i}
NXs003:trifol(85:15)	74.87^{a}	76.17^{e}	1483.33^{f}	730.00^{c}	753.33^{h}	1.30^{j}
NXs001:trifol(75:25)	63.33^{f}	82.87^{b}	1550.00^{e}	416.67^{f}	1133.33^{f}	19.53^{b}
NXs003:trifol(75:25)	52.37^{k}	66.13^{i}	1000.00^{g}	716.67^{c}	283.33^{i}	13.77^{d}
NXs001:trifol(50:50)	60.93^{i}	67.53^{h}	2000.00^{b}	516.67^{e}	1483.33^{b}	6.60^{g}
NXs003:trifol(50:50)	70.37^{c}	78.03^{d}	1930.00^{c}	626.67^{d}	1303.33^{d}	7.67^{f}
NXs001:trifol(25:75)	64.43^{e}	67.37^{h}	2016.67^{b}	516.67^{e}	1500.00^{b}	2.93^{i}
NXs003:trifol(25:75)	62.03^{g}	67.50^{h}	1826.67^{d}	760.00^{bc}	1066.67^{fg}	5.47^{h}
Control^	56.17^{j}	72.73^{g}	2000.00^{b}	616.67^{d}	1383.33^{c}	16.57^{c}

Means with the same superscript in the same column are not significantly different (p>0.05). *trifol stands for trifoliate yam flour. ^ control is the commercial yam flour.

yam composite flours have better reconstitution ability (Adebowale et al., 2008) than the NXs001: trifoliate yam composite flours. Water absorption capacity varies with size, shape, presence of proteins, carbohydrates and lipids, pH and salts. Previous processing, such as heating, alkali processing, disulfide linking, etc may also influence it (Iwe, 2003).

Pasting properties

The pasting properties of the composite trifoliate yam: cocoyam flour is shown in Table 2. Visser and Thomas (1987) reported that heat causes thickening and then gelation in concentrations above 7% by weight, with a temperature threshold of 65°C. Rate of gelling and gel firmness are reported to depend on temperature, time of heating and protein concentration. Gelatinization and pasting affect the quality and aesthetic considerations in the food industry, since they affect texture and digestibility, as well as the end use of starchy foods (Adebowale et al., 2005). Viscosity is an important functional property of foods that affects mouth feel, the textural quality of foods and the design of processing lines. Peak viscosity is the ability of starch to swell freely before their physical breakdown (Sanni et al., 2004). 100% trifoliate yam had the highest peak viscosity of 2500 Bu which is even higher than that of the commercial yam flour (control), 2000 Bu. There were significant differences in the peak viscosity of the composite flours with the peak viscosity increasing with increased proportion of trifoliate yam flour. Stability is related to

Table 3. Sensory evaluation of the composite trifoliate yam: cocoyam *fufu*.

Samples	Texture	Colour	Mouldability	General acceptance
100% trifoliate yam	4.20[cd]	4.73[bc]	4.20[abcd]	4.60[abc]
100% NXs001	4.27[bcd]	4.73[bc]	4.20[abcd]	4.27[abcde]
100% NXs003	5.53[a]	4.33[cde]	5.40[a]	5.07[ab]
Nxs001:trifoliate yam (85:15)	4.07[cd]	6.20[a]	3.53[cd]	3.73[cde]
NXs003:trifoliate yam (85:15)	5.40[abc]	4.73[bc]	5.40[a]	5.40[a]
NXs001:trifoliate yam (75:25)	3.33[d]	4.60[bcd]	3.53[cd]	3.33[e]
NXs003:trifoliate yam (75:25)	4.87[abc]	5.67[ab]	4.87[ab]	4.73[abc]
NXs001:trifoliate yam (50:50)	4.80[bcd]	3.33[e]	4.60[abc]	3.87[cde]
NXs003:trifoliate yam (50:50)	5.00[abc]	4.53[bcd]	5.07[ab]	5.20[ab]
NXs001:trifoliate yam (25:75)	4.47[abcd]	4.73[bc]	3.87[bcd]	4.20[bcde]
NXs003:trifoliate yam (25:75)	3.93[cd]	3.53[de]	3.27[d]	3.40[de]
control	4.6[abc]	3.80[cde]	4.40[abcd]	4.53[abcd]

Means with the same superscript in the same column are not significantly different ($p>0.05$).

setback which is the rate at which the gel formed loses its water (retrogradation). The higher the setback value, the lower the retrogradation during cooling. 100% NXs003 had the highest setback of 883.33 Bu while 75:25 NXs001: trifoliate yam flour had the lowest setback value of 416.67 Bu. Stability is highest in trifoliate yam flour and lowest in NXs003: trifoliate yam flour (75:25).

SENSORY EVALUATION

Table 3 shows the mean scores of the sensory evaluation of the composite flours. There were significant differences on the level of preference of the different samples. The texture of 100% NXs003 was more preferred than the other samples while the texture of NXs001: trifoliate yam *fufu* (75:25) was least preferred. Colour is a quality attribute that plays an important role in food acceptability. NXs001: trifoliate yam *fufu* (85:15) had the highest mean score for colour, 6.20 while the colour of NXs001: trifoliate yam *fufu* (50:50) was least preferred. 100% NXs003 and NXs003: trifoliate yam *fufu* (85:15) had the highest score for mouldability (5.40) with score even higher than that of the control. NXs003: trifoliate yam *fufu* (85:15) was the most generally accepted of the composite flour samples, followed by NXs003: trifoliate yam flour (50:50) while NXs001: trifoliate yam flour (75:25) had the least general acceptability.

Conclusion

A study of the results obtained from the functional, pasting and sensory evaluation show that Nxs003 forms a better composite flour with trifoliate yam for *fufu* than Nxs001. Sensory evaluation result showed that there was no significant difference in the texture, mouldability and general acceptance of the NXs003: trifoliate yam composite flours and the control (commercial yam flour). 85:15, 75:25 and 50:50 NXs003: trifoliate yam flour are highly recommended for *fufu* production.

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