Original Research Article

Functional Properties of Blends from Water yam, Yellow maize and African yam bean Flour

Abstract

Functional properties of flour blends from water yam, yellow maize and African yam bean were investigated in this study. Standard method for dry- milling operation was used in the flour processing. Four flour samples were compounded in the ratios of (AFK) 40%WY: 30%YM: 30%AYB; (BGL) 50%WY: 20%YM: 30%AYB; (CHM) 60% WY: 10%YM: 30%AYB (DIN) and 100%WY (EJO) was used as control.Standard methods were used to determine the functional properties. The result showed that bulk density which influences packaging arrangement ranged from 0.58 to 0.76g/ml; water solubility index ranged from 5.80 to 9.20g/g and water absorption capacity ranged from 1.00 to 1.46g/g, the oil absorption capacity ranged from 1.44 to 2.02g/g. Addition of yellow maize and African yam bean improved significantly ($p<0.05$) the functional properties of the flour blend generally and particularly flour sample(DIN) 60%WY: 10%YM: 30%AYB. The improvement in the functional properties would enhance both the nutritional and sensory properties of the flour mixtures.

Key Words: Functional properties; water yam, yellow maize; African yam bean

1.0 Introduction

Milligan *et al*. (1981) defined composite flour as a mixture of flours, starches and other ingredients intended to replace wheat flour totally or partially in bakery and pastry products. This binary or ternary mixture may be with or without wheat flour. Wheat flour has being in use in Nigeria because of it functionality. However, local raw materials substitution for wheat flour is increasing due to the ban in the importation of wheat and growing market for confectioneries (Noor Aziah and Koma Thai, 2009) thus, several developing countries in the tropical region have encouraged the initiation of programmes to evaluate the feasibility of alternative locally available flour as a substitute for wheat flour (Abdelghafor*et al*., 2011). Interestingly, climate conditions in Nigeria as a tropical country is good for the cultivation of indigenous crops such as yam, maize and African yam bean among others.

Yam (Dioscorea species) is the most highly regarded food crop in the tropical West African countries and has become integrated into the cultural, religious, social and economic life of the people (Babu and Parimalavalli, 2012). Yam belongs to the Dioscorea genus which includes some 600 species. According to Diop (1998), yams are annual or perennial, tropical tuber-bearing and climbing plant. It is considered as a significant and highly priced starchy crop in West and Central Africa, but largely underutilized industrially. Nigeria is the largest producer of yam; accounting for over 70-75% of the world production. It is estimated that more than 25 % of yam produced is lost annually due to pests and disease. It is an important source of carbohydrate but has only minimal amounts of the other nutrients. Fresh yams are consumed roasted, fried, boiled or beaten into a smooth stiff porridge (pounded yam) in a mortar and eaten with soup. The combination of yam with other foods such as vegetables improves its nutrient content. Fresh yams are, however, difficult to store and are subject to post harvest losses. Yam flour can be stored for as long as 12 -18 months depending on the moisture content. Yam flour is processed by drying yam tubers/slices and milling. Water yam is the most widely distributed species of yam and contains about 80% starch.

Cereals are the most widely cultivated and consumed crops on globally. In Nigeria, specifically in the Northern part of the country, cereal provides a major food resource for man. It is the major source of energy and protein in the diet of many people. Maize is the second most important cereal crop in Nigeria ranking behind sorghum in the number of people it feeds. Estimated annual production of maize is about 5.6 million tones. (Central Bank of Nigeria report 1992).Maize is a multipurpose crop, providing food and fuel for human being and feed for animals (poultry and livestock). Its grain has great nutritional value and can be used as raw material for manufacturing many industrial products.The principal protein in maize is zein. This protein is deficient in lysine and tryptophan but has fair levels of the sulfur-containing amino acids (methionine, cysteine and cystine).Yellow maize is also a major source of starch with reasonable amount of dietary fibre (Shittu*et al*., 2007). Yellow maize has promising nutritional attributes. It contains a useful amount of the water-soluble B-complex vitamins. Yellow maize contains 65434% starch, 9-10% protein, 8348% carbohydrates, 12-15% moisture, 3-5% fat, 2-3% fiber and 3% ash.

African yam bean (AYB) is among the lesser known legumes in the tropics. It grows wild throughout tropical Africa and is common in Central and Western Africa, especially in southeastern Nigeria. The bean grows well, producing good yields even on the acidic and highly leached sandy soils of the humid lowland tropics. The pods contain 20-30 smooth, hard roundish seeds which are white, brown, black or mottled (NSA, 1979). The dry seeds are consumed either roasted and eaten with palm kernel as relics or cooked with other staple foods like yams, maize or dried cocoyam. Occasionally, it is eaten as moin-moin. The seeds have crude protein levels varying from 21 to 29 percent which is lower than soybeans (38%). AYB contains high lysine levels while both methionine and tryptophan contents are low. Both lysine and methionine contents of the protein, however, are equal to or better than those of soybean (Okigbo, et al., 1977). It has been reported that AYB has high metabolic energy, low true protein digestibility (62.9%), moderate mineral content and an amino acid content comparable to most pulses. The seeds contain about 50 - 62% carbohydrate, and 54% fiber (Nwokolo, 1987). The fatty acid composition is similar to most of the common edible pulses (Nwokolo, 1987).

In considering the different flour which could be used as composite flour, factors such as compatibility; that is suitability for end-use and cost at the point of use must be factored in (Dendy, 1993).

Functional properties are the fundamental properties that reflect the complex interaction between the composition, structure, molecular conformation and physicochemical properties of food components together with the nature of environment in which these are associated and measured (Siddiq*et al*., 2009).

Functional characteristics are required to evaluate and possibly help to predict how proteins, fat, fibre and carbohydrates may behave in specific system as well as demonstrate whether or not such unconventional protein can be used to stimulate or replace conventional protein (Siddiq*et al*., 2009). It can determined the physical, chemical and/or organoleptic properties of food. It is a known fact that the functionality of flour has a direct relationship to finished product quality. Therefore, there is the need to understand flour functional properties to serve as a useful guide for processors and industry on how best a particular flour sample could be used to achieve the desirable end product. The objective of this study involves the collection of data on the functional properties of flour mixtures from water yam, yellow maize and African yam bean blend.

2.0 Materials and Methods

The water yam was identified as TDA 297 and bought from National Root Crop Research Institute (NRCI), Umudike, Abia State, Nigeria. The yellow maize and the cream colored African yam bean were identified and bought from National Institute of Horticulture (NIHOT) Mbato sub zone, Okigwe, Imo State.

2.1 Preparation of Raw Materials

2.1.1. Water Yam Flour

Water yam was washed, manually peeled, sliced (3mm x 5mm) with a stainless knife, under water containing 0.20% solution of sodium metabisulphate. The sliced water yam were removed and drain for 1h under air current and dried at 60^oC for 6h in a chirana type air convention oven (HS201A). Dried chips were cooled for 2h at room temperature under air current and milled using Brabender roller mill (Model 3511A). The flour sample was sieved through 0.50mm mesh size, packaged and sealed in polyethylene bag for further use.

2.1.2. African Yam Bean Flour

The cream coloured African yam bean seeds were sorted and cleaned in an aspirator (Model OB 123 BindapstHungary) located at the food processing laboratory of Federal Polytechnic, Mubi. Cleaned seeds were soaked for 1h at room temperature . The seeds were sun-dried for 4 days at ($30^o \pm 2^oC$) and milled with Brabender roller mill (Model 3511A) to pass through screen with 0.50mm openings. The flour was stored in an air tight plastic container at room temperature for further use.

2.1.3. Yellow Maize Flour

The yellow maize grain were sorted, and cleaned in an aspirator (Model OB 125 Bindapst Hungary) located at the food processing laboratory at Federal Polytechnic, Mubi. The cleaned maize grains were conditioned at 40^oC for 30min in a stainless steel container. The seeds were sundried for 4days at ($30^o \pm 2^oC$) and then cracked and milled with Brabender roller mill (Model 3511A). The seed coats were removed to obtain the maize flour to pass through a screen with 0.50mm openings. The flour was stored in an air tight plastic container at room temperature for further use.

2.2 Flour Blending Ratio

The flours from the water yam, yellow maize and African yam bean were blended in the ratio as shown in Table 1.

Table 1: Flour blending ratio

CODED SAMPLES	WY (%)	YM (%)	AYB (%)	Total (%)
AFK	30	40	30	100
BGL	40	30	30	100
CHM	50	20	30	100
DIN	60	10	30	100
EJO	100	0	0	100

Sample EJO = Control (100%) Water Yam; WY = Water Yam; YM = Yellow Maize

AYB = African Yam Bean

2.3 Determination of Functional Properties

All determinations were done in triplicates. The bulk density of the sample was determined according to the method described by Iwe and Ngoddy (1998). The volume of 100g of the flour was measured in a measuring cylinder (250ml) after tapping the cylinder on a wooden plank until no visible decrease in volume was noticed, and based on the weight and volume, the apparent (bulk) density was calculated. The water solubility index (WSI) determination was done using method described by (Iwe and Ngoddy, 1998).

Water absorption capacity (WAC)/ Oil absorption capacity (OAC) determination was done using method described by Anderson (1982). One gram of sample mixed with 10ml distilled water for (WAC) and 10ml vegetable oil for (OAC) separately and where allowed to stand at ambient temperature ($30^o \pm 2^oC$) for 30min, then centrifuge for 30min at 3000rpm. Water absorption was examined as percent water bound per gram flour.

3.0 Results

Table 2: Functional Properties of Water yam, Yellow maize and African yam bean Flour blends.

Sample	Bulk Density (g/m)	WSI (g/g)	WAC (g/g)	OAC
AFK	$0.58^{e} \pm 0.10$	$9.20^{a} \pm 0.00$	$1.46^{a} \pm 0.01$	$1.99^{a} \pm 0.02$
BGL	$0.67^{b} \pm 0.00$	$9.20^{a} \pm 0.00$	$1.00^{c} \pm 0.00$	$1.89^{ab} \pm 0.06$
CHM	$0.76^{a} \pm 0.00$	$6.60^{c} \pm 0.00$	$1.00^{c} \pm 0.00$	$1.82^{b} \pm 0.06$
DIN	$0.66^{c} \pm 0.00$	$8.40^{b} \pm 0.00$	$1.42^{a} \pm 0.00$	$2.02^{a} \pm 0.10$
EJO	$0.62^{d} \pm 0.00$	$5.80^{d} \pm 0.00$	$1.20^{d} \pm 0.00$	$1.44^{c} \pm 0.10$

Values are means of triplicate determination ± standard deviation.

Means with the same superscript within the column are not statistically ($p>0.05$) different from each other keys

WY: Water yam, YM: Yellow maize: AYB: African yam bean.

AFK = 30%WY: 40%YM:30%AYB; BGL = 40%WY: 30%YM: 30%AYB; CHM = 50%WY: 20%YM: 30%AYB; DIN = 60%WY: 10%YM: 30%AYB;EJO = 100% WY WSI = Water solubility index; WAC = water absorption capacity

The bulk density (BD) values ranged from 0.58 to 0.76g/ml, with sample CHM having the highest value (0.76g/ml), while sample AFK had the lowest bulk density (0.58g/ml). The flour samples were statistically ($p > 0.05$) different from each other in bulk density. The water solubility index (WSI) value ranged from 5.80 to 9.2g/g, with flour samples AFK and BGL respectively having the highest water solubility index (5.80g/g). Sample AFK, and BGL were not significantly ($p>0.05$) different from each other and were higher than all other flour samples. Inclusion of yellow maize and African yam bean might have result to increase in the values of water solubility index of the flour sample. The water absorption capacity of the flour samples AFK and DIN and flour BGL and CHM respectively were not statistically ($p >0.05$) different between other. The water absorption capacity (WAC) ranged from 1.00 to 1.46 g/g, with flour sample AFK having the highest water absorption capacity (1.46g/g), while the flour sample BGL and CHM respectively having the lowest water absorption capacity of 1.00g/g. water absorption capacity decrease as yellow maize substitution decreased from 30 to 20% and increased at 10% yellow maize. The oil absorption capacity ranged from 1.44 to 2.02g/g; there was a significant ($p<0.05$) amongst the samples, with flour sample EJO 100% WY having the lowest value, while flour sample DIN having the highest value.

4.0 Discussion

4.1. Raw Flour Bulk Density:

The bulk density value of the individual raw flour and their blends are shown in table 2. The bulk density ranged from 0.76 – 0.58g/ml. This value was close to the reported value on wheat flour by (Nneoma, 2012). The value of bulk density value for composite flour was comparable to the reported value by (Egbedike et al., 2016; Onwurafor et al., 2016).Bulk density is influenced by the structure of the starch polymers and loose starch polymers could result in low bulk density (Malomo et al.,2012). Moreso, bulk density has been found to affect starch noodles sensory acceptability as well as transport cost. (Nwabueze et al 2009; Adebowale et al., 2010; Akpata and Akubor, 1999) reported that bulk density would be an advantage in the formation of complementary foods. Therefore the present study suggests that higher bulk density of composite flour samples might be suitable for use in child feeding.

4.2. Raw Flour Water Solubility Index

The water solubility index value of the raw flour and their blends are shown in table 2.

The water solubility index value in this study ranged from 5.80 – 9.20g/g. This was higher than the value reported on wheat flour according to (Julianti, 2014). (Oke*et al*., 2013) reported a higher value of water solubility index of water yam. Similarly, the value of water solubility index observed for the flour blends in this study was higher than earlier reported values. Swelling power and solubility patterns of flours have been used to provide evidence for associative binding force within the granules (Leach *et al*., 1959).The value of swelling power of the composite flours obtained in this study was characterized in the category of high restricted swelling starch. This characteristic is desirable for the manufacture of value –added products such as noodles, with expected high cooking weight.

4.3. Water Absorption Capacity (WAC)

The water absorption capacity values of the raw water yam flour and the blends are shown in table 2. The water absorption capacity of the raw flour and their blend ranged from 0.58 – 0.76g/g. The observed value in this study were higher than the range of values as reported by (Adebowale*et al*., 2010), but lower than the value reported on wheat flour according to Julianti, (2014). Earlier researchers such as Moorthy and Ramanujam, 1986 attributed such variations to the differences of the species, and other environmental factors amongst other things under which the yams were grow. Yam has good potential for use due to its low water capacity. Since water absorption capacity is considered a critical function of protein in vicious foods like soups, graves, and baked goods (Padmashere*et al*., 1987). Therefore, increase in water absorption capacity in the composite flour compared to water yam flour is acceptable. The result in this study is similar to the report by (Egbedike*et al*., 2016) who reported increased water absorption capacity in formulated flour. Water absorption capacity is an important processing parameter and has implications for viscosity. It is also important in bulking and consistency of products, as well as in baking application (Niba*et al*., 2001).

4.4. Oil Absorption Capacity (OAC)

The water absorption capacity values of the raw water yam flour and the blends are shown in table 2.The oil absorption capacity ranged from 1.44 to 2.02g/g, the value here was within the range of value reported by Julianti (2012). The higher the oil in the flour the least affinity to absorb oil. Sample DIN had the highest oil absorption capacity due to less affinity to absorb more oil whereas other samples tend to behave differently. The oil absorption index is influenced by the lipophilic nature on the granula surface and interior which were influenced for functional properties of starches (Babu and Parimalavalli, 2012). The major chemical affecting oil absorption index is protein, which is composed of both hydrophilic and hydrophobic parts. Non-polar amino acid side chains can form hydrophobic interactions with hydrocarbon chains of lipid (Eltayeb et al., 2011) and has implication in functional properties of flours. Oil absorption index is importance since oil acts as flavor retainer and increase the mouth feel of foods, improvement of palatability and extension of shelf life particularly in bakery or meat products where fat absorptions are desired (Aremu et al., 2007).

5.0 Conclusion

Addition of yellow maize and African yam been especially at the ratio of 60%WY:10%YM: 30% AYB improved the functionality of the composite flour. Some parameters tested in this study demonstrated promised as a replacement for wheat flour. However, test baking should be performed to ensure that desirable end product could be achieved using this composite flour in the nearest future.

References

Abddelghafor, R.F., Mustafa, A.I Ibrahim, A.M.H and Krishman P.G. (2011). Quality of Bread from composite flour of sorghum and had white winter wheat. *Advance Journal of Food Science and Technology* **3**:9 -15.

Adebowale A. A, Sanni, L.O., and Fadahunsi E.I (2010) Functional and pasting characteristics of cassava sweet patato starch blends pro 11th ISTRC Congo 4-8 October.

Akpata M. I and Akubo, P.I (1999). Chemical Composition and Selected Functional Properties of sweet orange (Citrus Sinensis) Seed Flour. Plant Food Hum. Nutri. 54:353 – 362 doi.

Aremu, M.O., Olaofe, O. and Akintayo, E.T. 2007. Functional properties of some Nigerian varieties of legume seed flours and flour concentration effect on foaming and gelation properties. Journal of Food Technology 5 (2): 109-115

Babu, A.S.andParimaravalli (2012). Functional and chemical properties of starch isolated from tubers international. Journal of Agricultural and Food Science ISSN 2249-8516.

Dendy D.A.V (1993). Review of composite flour technology in the context of Tanzania, a paper presented A the workshop entitled “Soghum and Millets marketing and utilization held at Acrusha, Tanzania 3 -5 May 1993.

Diop, P.H. (1998). Storage and processing of roots and tuber in thetropics, Calverley

Egbedike, C.N, Ozo, N.O, Ikegwu, O.J, Odo, M. O and Okoprie, P. A (2016) Effect of rice bran substitution on the physicochemical properties of water yam flour. Asian Journal of Agricultural Food Science. Vol 4:246 – 257.

Eltayeb, M., Ali, A.O., Abou-Arab, A.A. and AbuSalem, F.M. 2011. Chemical composition and functional properties of flour and protein isolate extracted from Bambara groundnut (Vigna subterranean), African Journal of Food Science 5: 82-90.

Iwe, M.O. and Ngoddy, P.O (1998) Proximate composition and some functional properties of extrusion cooked soybean and sweet potato blends. *Plant Foods for Human Nutrition* **55**:159 – 168.

Leach, H. Mc Cowen, L.D. and Thomas, S. (1959). Structure of starch granule: swelling and solubility patterns of various starches. Cereal chem**36**:534 – 544.

Malomo, O, Ogunmoyela, O.A.B, Adakoyeni O.O., Oluwajoba, S.O., Sobanwa, M.O., (2012). Rheological and functional properties of By-proundo yam flour. *International Journal Food Science and Nutrition*Eng**2**(6):101 -107. Dol:10:5923/J Food 20120206.01.

Milligan, E.D., Amlie, J.H., Reyes, J., Garcia A. and Mayer, B. (1981). Processing for Production of edible soy flour. *Journal American Oil Chemistry Social* 58:331.

Moorthy S.N. and Ramanujam T. (1986) variation in properties of starch in cassava varieties in relation to age of the crop starch/starke 38:5861.

National Academy of Science (1979). Tropical legumes: Resources for the future, pp 27- 32. Washington, DC

Niba, L.L. Bokonga, M.M., Jackson, E.L., Schlimme, D.S. and Li, B.W. (2001). Physicochemical properties and starch granular characteristics of flour from various manihotesculenta (cassava) genotyoes. *Journal of Food Science* **67**(5):1701 – 1705.

Nneoma ,E.O, Ngozi, U and Enyidiya,E(2012) Production and evaluation of biscuits from African yam bean and wheat flours. Food science and quality management VOL7pp22 -29

Noor Aziah, A.A and Komathi, C.A. (2009) Acceptability attributes of crackers made from different types of composite flour. *International Food Research Journal***16**:479 -482.

Nwabueze, T.U. Glory, A. and Anoruoh,G.A (2009) Evaluation of flour and extruded noodles from eight cassava mosaic disease (CMD) resistant varieties food bioprocess technology, DOI 1001007/511947 -009.

Nwokolo E (1987) A nutritional assessment of African yam bean: Sphenosrylis steno- carpa (Hochst ex A. Rich) Harms. J Sci Food Agric41 : 123-1 29.

Oke, M.O., Awonorin S.O and Workneh, T.S. (2013) effect of varieties on physiochemical and pasting characteristics of water yam flours and starches. *African Journal of Biotechnology* vol. **12** (11) pp. 1250 – 1256.

Okigbo B.N., Duke, J.A and Reed, C.F. (1977) Sphenosrylisstenocarpa (Hochst ex A. Rich) Harms, Tropical Grain Legume Bulletin 10: 4-7.

Onwurafor, E. U.,Onweluzo, J.C. and Uzodinma, E.O. (2016). Chemical properties of ferumented maize – mungbean melt complementary foods fortified with vegetable and crayfish powder –proceedings of the 40^{th} conference of NIFST 24^{th} – 26^{th} October 2016 pp 157 Coronation Hall, Government House, Kano, Kano State.

Padmashree, T.S. Vijayalakshmi, L and Puttara J.S. Effect of traditional processing on the functional properties of cowpea. *Journal of Food Science Technology* 24:221 – 225.

Shittu, T., Raji., A.O and Sanni, L.O. (2007) Bread from composite cassava –wheat flour in: effect of baking time and temperature on some physical properties of bread loaf. Food research international 40:280 – 290.

Siddiq M., Maser M., Rari; R, Dotan JD, Butt, Ms. (2009). Effect of defatted maize germ addition on the functional and textural properties of wheat flour. *International Journal Food Properties***12**:860 – 870.