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Functional and Pasting Properties of Wheat/ Three-leaved Yam *(Dioscorea dumentorum*) composite flour blend.

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The study investigated the functional, pasting and chemical properties of wheat/three-leaved yam (TLY)*(Dioscorea dumentorum*) composite flour blends. Wheat flour was collected from Port-Harcourt Flour Mill, while flour from three-leaved yam was produced using standard procedures. The flour samples were blended into different proportions of 100%wheat and 100% three-leaved yam(TLY) flour, wheat/TLY blends of 90:10, 80:20, 70:30,60:40 and 50:50. The pasting properties of flour blends were significantly different ($p<0.05$) from that of the 100% wheat flour. Peak viscosity, trough and break down values of blends decreased with increase in substitution, ranging from 84.67 -95.88 RVU, 48.17-59.86 RVU and 20.0-45.70 RVU respectively. Final and set back viscosities of flour blends increased with increase in substitution, ranging from 132.67 -173.92 RVU and 82.5 – 122.42 RVU respectively. Time and temperature to attain peak viscosity ranged from 5.8 -6.2min and 49.3 - 49.7℃. Functional properties increased with substitution and ranged from 8.20 -10.90%, 71.30 -94.84% for swelling power and water absorption capacity respectively. While dispersibility decreased with substitution and ranged from 50-72%. Solubility and color indices showed no significant ($p>0.05$) difference between the 100% wheat and three –leaved yam flour. Results of chemical analysis showed that substitution had a significant effect ($p<0.05$) for all the parameters analysed except sugar content. Moisture, amylopectin ash and fat contents increased with increase in substitution and ranged from 7.36-11.42%, 66.27-76.79%, 0.65-3.01% and 1.42-4.8% respectively. The present study showed that compositing the popular wheat flour with locally available under-utilized root crop like three-leaved yam flour is desirable in terms of functional, pasting and chemical characteristics.

Keyword: composite flour, wheat, three-leaved yam., functional, pasting, properties.

INTRODUCTION

Flour is a powder which is made by grinding cereal grains, other seeds or roots like cassava (Wikipedia, the free encyclopedia). Wheat flour is generally the main ingredient for bread and baked products, making the availability of adequate supplies of flour a major economic and political issue at various times. In many parts of Africa and particularly Nigeria, advancing prosperity and urbanization, coupled with tremendous increase in population in recent years have lead to the increase in consumption of wheat based products especially biscuit and bread. Wheat flour for this purpose is usually imported resulting in huge burden on the external reserves of our nation. However continuous search for wheat supplements have led researchers to evaluate the utilization of other food sources within the environment as substitutes to complement wheat flour.

Three leaved yam (TLY) is one of the 600 species of the yam family (Onuegbu *et al.,* 2011). It originated in tropical Africa and occurs in both wild and cultivated forms, but its cultivation is still restricted. *Dioscorea dumetorum* has not been widely studied as other yam species, not withstanding that it grows readily on various soils, the yield being 3-7 times that of other widely grown yam species (Treche and Guion 1979). The trifoliate yam have been neglected in attempts to process roots and tubers into more durable and value added form. This is because of the severe hardening that develops post harvest due to bruising and makes the tuber difficult to cook.

A greater part of these tubers are consumed by boiling and eating with fresh palm oil. Therefore compositing wheat flour with locally available, underutilized root crop such as *Dioscorea dumetorum* may be found desirable in reducing wheat importation in many developing countries such as Nigeria. However, there is little information on three leaved yam composite flour. The aim of this work was to determine the functional, pasting and chemical properties of wheat/TLY composite flour blends.

MATERIALS AND METHODS

Materials: Virgin wheat flour was collected from Port Harcourt flour mill, while TLY was collected from a farmer in Obio Akpor Local Government Area of Rivers State. Other laboratory materials and chemicals were collected from the analytical laboratory of the Rivers State University of Science and Technology, Nkpolu, Port Harcourt.

Sample Preparation: The trifoliate yam was washed, peeled, cut in to thin slices and soaked in 0.1% sodium metabisulphide solution for 15 minutes to prevent enzymic browning. The slices were further drained and oven dried at 50℃ for 24 hours. Dried slices were milled in a dry milling machine, sieved through a 50mm mesh size and packed in an air tight polyethylene bag and stored for further analysis. The composite blends were constituted and coded in the following proportions of wheat/TLY flour. Sample WH=100% wheat, TLY=100% Three leaved yam, AWT=90:10, BWT= 80:20, CWT=70:30, DWT=60:40 and EWT=50:50 blends of wheat/TLY flour respectively.

Methods: Proximate analysis of flour samples were determined by the AOAC (1990). Starch damage was determined by the method described by Mc-Dermortt (1980), while amylose and color were determined by the methods of Williams *et a*l., (1970) and Francis (1998) respectively.
Dispersibility of flour blends were determined using the method described by Kulkarni *et al.,* (1991), swelling power and solubility by the methods of Takashi and Sieb (1988) while water absorption capacity was determined by the method of Sosulski (1962). Pasting properties were determined using the Rapid Visco-analyzer (RVA Model), Newport Scientific Warriewood, Australia).

Statistical Analysis: Differences between means were assessed by analysis of variance and means separated by Duncan's Multiple range test according to the method of steel and Torrie (1980).

RESULTS AND DISCUSSION

FUNCTIONAL PROPERTIES OF WHEAT/TLY FLOUR BLENDS.

Table I shows the functional properties of wheat/TLY yam flour blends. Water absorption capacity for the flour blends ranged from 71.30-186.29% with sample AWT as the least and TLY as the [i]highest while solubility ranged from 12.64-15.25%. Both parameters increased with increase in substitution. Water absorption capacity is the ability of flour particles to entrap large amount of water such that exudation is prevented. Niba *et al.,* (2001) described water absorption capacity as an important processing parameter that has implications for viscosity. Furthermore, water absorption capacity is important in bulking and consistency, while the increase in solubility would result from the shortening of the chain length of the starch molecules with a corresponding weakening of the hydrogen bonds holding the granules together (Sapade and Grys 1991). Solubility according to Hari *et al.,* (1989) reflects the extent of intermolecular cross bonding within the granule. Solubility result in the present study falls within that reported by Onuegbu *et al.,* (2011) for TLY, ranging from 5. 36 -15.10%

Swelling power ranged from 7.00-10.90% with wheat as the least and blend EWT as the highest. Safo-Kantanka *et al.,* (1991) stated that the swelling power of a starch based food is an indication of the strength of the hydrogen bonding between the granules. Richard *et al.,* (1991) further described swelling power as a factor of the ratio of amylose to amylopectin, the characteristics of each fraction in terms 0f molecular weight/distribution, degreed/length of branding and conformation. The ratio of swelling power to water absorption capacity is an indication of the reconstitution ability.

Color Indices for flour blends ranged from 86.17-86.93%, with TLY having the least and AWT having the highest. The values for color of the flour blends were higher than the color of the 100% samples. This could be associated to the effect of blending. The color in the present study indicates whiteness which is an important criterion for flour quality. Moorthy (1985) reported that the color of starch will determine its clarity when cooked and that clarity depends on the associative bonds between the starch molecules in the granules. Dispersibility values ranged from 67-72% with sample CWT(70:30) having the least and sample AWT(90:10) the highest. The percentage dispersibility gives an indication of water absorption capacity. In the present study, the dispersibility decreased with an increase in substitution. Fifty percent (50%) value and above could be seen as high and therefore mean that the higher the dispersibility, the better the flour's ability to reconstitute in water to give a fine and consistent paste.

Functional properties showed a significant (P>0.05) difference in all parameters evaluated between the samples and treatments.

TABLE 1 FUNCTIONAL PROPERTIES (%) OF WHEAT/THREE-LEAVED YAM COMPOSITE FLOUR BLENDS

Sample Code	WAC	Swelling Power	Solubility	Colour	Dispersibility
WH	81.41[d]	7.00[e]	12.64[c]	86.39[c]	68.00[b]
TLY	186.29[a]	10.81[a]	15.25[a]	86.17[c]	50 00[d]
AWT	71.30[g]	8.19[d]	13.65[b]	86.93[a]	71.00[a]
BWT	75.56[f]	9.95[c]	13.73[b]	86.45[b]	72.00[a]
CWT	78.95[e]	9.79[c]	13.47[b]	86.63[b]	67.00[b]
DWT	88.16[c]	10.27[b]	13.62[b]	86.47[b]	60.00[c]
EWT	94.84[b]	10.90[a]	13.24[b]	86.38[c]	60.00[c]

Means on the same column bearing the same superscript are not significantly different (P>0.05).

Key:

WH = 100% wheat flour
TLY = 100% Three-leaved yam flour
AWT = 90% wheat, 10% TLY
BWT = 80% Wheat, 20% TLY
CWT = 70% Wheat, 30% TLY
DWT = 60% Wheat, 40% TLY
EWT = 50% Wheat, 50% TLY

PASTING PROPERTIES OF WHEAT/ TLY FLOUR BLENDS .

Pasting properties are the most commonly assessed set of quality characteristics probably because the methods are well established and have been proven to be a reliable predictor of flour quality.

Table II shows the pasting properties of wheat/TLY flour blends. The peak viscosity of blends ranged from 79.58RVU-128.25RVU with sample WH (100% wheat) having the least and TLY the highest value. The peak viscosity of the blends were higher than 100% wheat but less than 100%TLY flour. This is expected because of the difference in origin of the plants (cereal and tuber). Peak viscosity is indicative of the strength of pastes, which are formed from gelatinization during processing in food applications. It also reflects the extent of granule swelling (Liang and King 2003).

Trough values ranged from 48.17RVU-71.42RVU while breakdown viscosities ranged from 10.58RVU-56.83RVU. Trough and breakdown viscosity values decreased with an increase in substitution. Breakdown viscosities reflects the stability of the paste during processing. Final and set back viscosities ranged from 125.42RVU-173.92RVU and 56.42RVU-122.42RVU respectively. These viscosities increased with an increase in substitution and blend values higher than 100% wheat and TLY flour in both cases. Final viscosity indicates at 50^{o}C the stability of the cooked paste. In agreement with the above statement Niba *et al.,* (2001) stated that final viscosities are important in determining ability of the sample material to form a gel during processing while Set back viscosity indicates gel stability and potential for retrogradation (Niba *et al*., 2001., Liang and King 2003).

Generally, time to attain peak viscosity ranged from 5.80min-6.97min while pasting temperature ranged from 49-30-49.70^{o}C. The attainment of the pasting temperature is essential in ensuring swelling, gelatinization and subsequent gel formation during processing. The pasting temperature (PT) is the temperature at which the viscosity starts to rise (Swinkels, 1985, Liang and King, 2003). Lower pasting temperature as shown in the present study indicates faster swelling.

There were significant differences (P<0.05) in all the pasting properties of the flour blends. This may be predominantly as a result of the substitution of TLY for wheat.

TABLE 11: PASTING PROPERTIES (RVU) OF WHEAT/ THREE-LEAVED YAM COMPOSITE FLOUR BLENDS

Samples	Peak Viscosity(PV) (RVU)	Trough viscosity(TV) (RVU)	Break down Viscosity(BV) (RVU)	Final Viscosity(FV) (RVU)	Setback Viscosity(SV) (RVU)	Pasting Time (Min)	Pasting Temp $^{\circ}C$
WH	128.25^{a}	71.42^{a}	56.83^{a}	146.17^{d}	74.75^{f}	6.97^{a}	49.50^{a}
TLY	79.58^{f}	69.00^{b}	10.88^{g}	125.42^{f}	56.42^{g}	5.87^{b}	49.30^{a}
AWT	95.88^{b}	59.86^{c}	45.70^{b}	132.67^{e}	82.50^{e}	5.80^{b}	49.40^{a}
BWT	85.33^{e}	56.83^{d}	37.17^{c}	159.75^{c}	97.58^{d}	5.80^{b}	49.70^{a}
CWT	84.67^{e}	51.50^{e}	33.17^{d}	173.92^{a}	111.58^{c}	5.83^{b}	49.40^{a}
DWT	87.33^{d}	48.17^{g}	30.50^{e}	173.75^{a}	116.92^{b}	5.90^{b}	49.30^{a}
EWT	89.92^{c}	50.33^{f}	20.00^{f}	166.50^{b}	122.42^{a}	6.19^{a}	49.50^{a}

Means on the same column bearing the same superscript are not significantly different (P>0.05).

Key:

WH = 100% wheat flour
TLY = 100% Three-leaved yam flour
AWT = 90% wheat, 10% TLY
BWT = 80% Wheat, 20% TLY
CWT = 70% Wheat, 30% TLY
DWT = 60% Wheat, 40% TLY
EWT = 50% Wheat, 50% TLY

CHEMICAL COMPOSITION OF WHEAT/TLY FLOUR BLENDS.

Table 111 shows the chemical properties of the wheat/TLY blends, and 100% wheat and TLY flour. Amylose content ranged from 23.21-33.74% with EWT(50:50) blend having the least value. The amylose content of raw materials is an important factor with regard to the end use properties of various products such as noddles (Sievert and Lausanne 1993). The high amylase content reported in this study may be due to the fact that blends are still in their raw form, as further processing will reduce amylose content. In agreement with the above statement, Raja and Ramakrishma (1990) reported that heat treatment caused a reduction in amylose content of starch based products. While amylopectin ranged from 66.27-76.79%. Amylose decreased with an increase in amylopectin, meaning that one is a function of the other and both properties are important in food preparation and development. Fat content ranged from 1.42-4.80% with 100% wheat flour having the least and 100%TLY having the highest. Substitution increased the fat content of the blends.

Protein content ranged from 10.54-12.63% with 100% TLY flour having the least and sample DWT(60:40) having the highest. . Moisture content ranged from 7.36%-11.42%. This is in agreement with the findings of Onuegbu *et al.*,(2011) who reported moisture content of 11.92-15.52%. Compositing increased the moisture content of the blends, yet they fall within the range recommended for a good shelf life of flour. Ash content ranged from 0.64-3.01%. 100% wheat flour had the least ash while 100% TLY had the highest. Ash content of the blends increased with an increase in substitution. The amount of inorganic constituent present as measured by the ash content conveys an impression of the quality of metal ions bound to the raw material (FAO,1977). Sugar content ranged from 3.17-8.38% with 100% TLY flour having the highest. Compositing made no difference in the sugar content between the 100% wheat flour and the blends.

Starch content and the degree of starch damage ranged from 58.75%-68.85% and 1.14-1.52% respectively, with sample EWT (50:50) having the highest starch content and the least starch damage. All chemical properties except sugar content showed a significant difference (p>0.05) among the flour blends. The extent of starch damage may have been as a result of processing during milling (Cell exposure).

TABLE 111: CHEMICAL PROPERTIES (%) OF WHEAT/THREE-LEAVED YAM COMPOSITE FLOUR BLENDS

Sample code	Moisture content	Amylose	Amylopectin	Protein	Sugar	Starch	Ash	Fat	Starch damage
WH	7.36^{e}	29.27^{b}	70.74^{e}	11.84^{b}	3.71^{b}	68.74^{a}	0.65^{e}	1.42^{d}	1.52^{a}
TLY	11.42^{a}	33.74^{a}	66.27^{f}	10.54^{d}	8.38^{a}	64.51^{b}	3.01^{a}	4.8^{a}	1.24^{b}
AWT	10.54^{c}	25.62^{c}	74.39^{d}	11.85^{b}	3.17^{b}	58.72^{e}	0.92^{d}	2.02^{c}	1.42^{c}
BWT	10.88^{b}	23.21^{f}	76.79^{a}	10.79^{d}	3.41^{b}	60.76^{d}	1.12^{d}	2.26^{c}	1.21
CWT	9.96^{d}	24.74^{d}	75.26^{c}	11.58^{b}	3.55^{b}	62.13^{c}	1.34^{c}		1.47
								2.82^{c}	
DWT	9.42^{e}	23.86^{e}	76.15^{b}	12.63^{a}	3.47^{b}	65.12^{b}	1.55^{c}	3.29^{b}	1.27^{b}
EWT	9.23^{e}	23.82^{e}	76.18^{ab}	11.09^{c}	3.55^{b}	68.85^{a}	1.83^{b}	3.75^{b}	1.14^{b}

Means on the same column bearing the same superscript are not significantly different (P>0.05).

Key:

WH	=	100% wheat flour
TLY	=	100% Three-leaved yam flour
AWT	=	90% wheat, 10% TLY
BWT	=	80% Wheat, 20% TLY
CWT	=	70% Wheat, 30% TLY
DWT	=	60% Wheat, 40% TLY
EWT	=	50% Wheat, 50% TLY

CONCLUSION

The study showed that different blends of wheat/ TLY flour improved chemical properties like ash and fat, while protein did not reduce as would have been the case, since a tuber was substituting a cereal. The high protein content observed in the present study will aid to reduce the incidences of protein energy malnutrition (PEM), thereby making TLY an ideal substitute for wheat and at the same time help to reduce the issue of wheat importation. The results of this study has also provided additional information about the functional, pasting and chemical properties of wheat/TLY composite flour blends. Different levels of substitution of TLY for wheat have significantly resulted in changing and improving the profile of the flour blends, especially in their functional, pasting and chemical properties. These changes will bring about better opportunities for improved industrial uses.

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