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Full Length Research Paper

Chemical, physico-chemical and sensory properties of soy-plantain flour

V. F. Abioye*, B. I. O. Ade-Omowaye, G. O. Babarinde and M. K. Adesigbin

Department of Food Science and Engineering, Ladoke Akintola University of Technology, P. M. B. 4000, Ogbomoso, Oyo State, Nigeria.

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In recent years, research efforts in the developing countries have focused on the improvement of protein quality of food products due to mass malnutrition. Plantains are invaluable source of carbohydrate, comparable in nutritive value to yam or potato and are useful as a variant on the usual staple foods. It is consumed mainly in Nigeria as snacks and it is gradually finding applications in weaning food formulation and composite flour preparations. This study therefore aimed at evaluating the effect of soy flour fortification on chemical, physicochemical properties and consumer acceptability of plantain flour for probable industrial uses. The plantain- soy mixes were prepared from green matured plantain and defatted soybean. Substituted plantain flour with soy flour at varying proportions (100:0; 90:10; 80:20; 70:30; 60:40) was evaluated for proximate composition and physico-chemical properties. Reconstituted thick paste "amala" prepared from all the flour samples were evaluated for consumer acceptability. The proximate composition of the flour samples showed an increase of about 23 to 85 % in protein content, 148 to 840% in fat content, 3 to 7% in ash contents while the carbohydrate decreased from 3 to 12% depending on the level of substitution. The bulk density (BD), swelling power (SP) and solubility (Sol) of the flour samples decreased while the water absorption capacity (WAC) increased on soy substitution. The pasting viscosity analysis showed that soy flour addition decreased the peak viscosity of the flour. The sensory evaluation of the reconstituted plantain thick paste indicated a sharp difference at 5% probability level in all quality attributes between 0 to 10% and 20 to 40% substitution, while that of 10% soy flour reconstituted thick paste "amala" was more preferred.

Key words: Plantain flour, soy flour, plantain-soy mixes, reconstituted thick paste, plantain.

INTRODUCTION

Nigeria is faced with the problem of malnutrition due to deficiency of protein and calories. The protein-calories sources of vegetable origin have been proposed as a solution to this problem. In Nigeria and many African countries, plantains (*Musa paradisiaca*) are used as an inexpensive source of calories (Akubor et al., 2003). It is an important starchy staple and commercial crop in the West and Central Africa where fifty percent of the world's plantain crop is produced (Swennen, 1990).

Cassava, plantain and sweet potato are among the major starchy crops which are used in many tropical countries (FAO, 1990). According to FAO (2009), over 2.3 million metric tons of plantains are produced in Nigeria annually. However, about 35 to 60% post harvest losses had been reported and attributed to lack of storage facilities and inappropriate technologies for food processing.

Plantain is a popular dietary staple due to its versatility and good nutritional value. It is starchy, less sweet variety of banana that can be used either ripe or unripe, they are invaluable source of carbohydrate, comparable in nutritive value to yam or potato and are useful as a variant on the usual staple foods. It is consumed mainly in Nigeria as snacks in form of chips, dodo ikire e.t.c.

*Corresponding author. E-mail: gbolafunmi2k2@yahoo.com.

Unripe plantain is traditionally processed into flour in Nigeria and in other west and central African countries (Ukhum and Ukpebor, 1991). The flour produced is mixed with boiling water to prepare an elastic pastry ("amala" in Nigeria and foufou or fufu in Cameroon) which is eaten with various sauces. It is however gradually finding applications in weaning food formulation and composite flour preparations (Olaoye et al., 2006; Otegbayo et al., 2002; Mepba et al., 2007; Ogazi et al., 1996). It is recommended to produce plantain flour from green fruits, since it has high starch content of about 35% on wet weight basis (Simmond, 1976).

In recent years, research efforts in the developing countries have focused on the improvement of protein quality of cereals and tuber Crops. Various degrees of success has been reported in this area such as fortification of maize with soybean (soy-ogi), cassava with soy flour (cassava -soy flour), fermented yam flour supplemented with soy flour (yam -soy mixture) for "amala", a popular west African food (Adeyemi et al., 1991; Akingbala et al., 1995). Ogazi et al. (1996) reported that feeding mainly on plantain cannot meet up with the daily protein requirement, therefore protein supplementation is essential.

Soybean (*Glycine max*) is a cheap source of quality protein that is superior to all other plant foods because it has good balance of the essential amino acids and it contains a reasonable amount of methionine lacking in plantain, making it a good supplement for plantain (Ogazi et al., 1996). The reconstituted paste from plantain flour is gaining importance among the people in Nigeria therefore supplementing it with soybean has the potential of providing a relatively cheap protein source for low income earners in the country. However incorporating soy-flour into plantain flour may change the physicochemical properties of the flour as well as acceptability of the paste (amala).

Hence this work was aimed at determining the effect of soy flour additions on the chemical and physico-chemical properties of plantain flour for probable uses in industries and also to evaluate the consumer acceptability of the reconstituted thick paste, a common food in Nigeria.

MATERIALS AND METHODS

Green matured plantain and soybeans used for this study were obtained from a local market in the Southwestern part of Nigeria.

Preparation of plantain and soybean flour

The method of Ogazi (1984) was used to prepare the plantain flour. Green matured plantain fruits were washed to remove adhering soil particles, peeled and sliced into thin thickness of about 2 cm. soaked in 0.03% of sodium metabisulphite for 20 min and dried in the cabinet dryer at 60℃ for 24 h. The dried plantain slices were milled into flour using a hammer mill and sieved through 250 µm aperture sieve. The flour was packed and sealed in polyethylene bags until analyzed. Soybean seed was processed into defatted flour using the method described by Ogazi et al. (1996).

Preparation of various flour blends

Flour blends containing varying proportions of soy flour (0 to 40%) together with plantain flour were prepared by mixing required amounts of respective flours.

Chemical analysis

The samples obtained from different mixtures of soy and plantain flour were analyzed for moisture, ash, crude fibre, protein (N*6.25), crude fat and the carbohydrate determined by difference according to the method described by AOAC (1990). Selected minerals including iron, phosphorus and calcium were extracted from dry-ashed samples and determined by atomic absorption spectrophotometer (AOAC, 1990) (Table 2).

Physical and physico-chemical properties

The bulk density of the samples was determined by the method of Okaka et al. (1991). The swelling power and solubility was determined by the method described by Tester and Morrison (1990). The method described by Lawal et al. (2005) was employed in determining the water absorption capacity of the samples. The titratable acidity and the pH of all the samples were determined using the method described by AOAC (1990). Pasting characteristics were determined with a Rapid Visco Analyzer (RVA) (ModelRVA 3D+, Newport Scientific Australia) as described by Ikegwu et al. (2009).

Sensory evaluation

The five samples obtained from the different fractions of plantain – soy mixes were made into thick gruels using about 50 g of flour and 15 ml of boiling water. The samples were rated on the following quality attributes; palatability, texture, colour, taste and overall acceptability using 7 point hedonic scale. The scores obtained were subjected to analysis of variance at 5 % level of significance and means separated using Duncan Multiple Range Test.

RESULTS, DISCUSSION AND CONCLUSION

Chemical composition

There was no significant difference in the moisture contents of the mixture samples which ranged between 9.65 to 9.80% (Table 1). The protein and fat contents increased with increasing level of soy flour substitution indicating nutrients enhancement with soy flour substitution ranging from 2.54 and 0.45 (0% soy flour substitution) to 8.40 and 7.05 (40% soy flour substitution) respectively. This could obviously be due to the significant quantity of protein in soy bean seeds (Olaoye et al., 2006). This high protein content in plantain soy mixes will be of nutritional importance in most developing countries, Nigeria inclusive where many people can hardly afford high proteinous foods because of the costs.

The increase in protein content is similar to some other research study in which soy flour was used in supplementation, such as in soy- maize for "agidi"; wheat-soy plantain in bread (Olaoye et al., 2006). The fat,

Table 1. Proximate composition of soy- plantain flour mixes.

Sample	MC	Protein	Fat	Ash	Fibre	CHO (By Diff)
A	9.65±0.03	4.54±0.02	0.75±0.01	1.96±0.01	1.83±0.02	83.1±0.10
B	9.70 ±0.04	5.60±0.01	1.86±0.02	2.02±0.02	1.92±0.01	80.82±0.13
C	9.80±0.03	6.40±0.02	4.88±0.01	2.12±0.01	1.86±0.02	76.8±0.12
D	9.74± 0.03	7.13±0.01	5.98±0.02	1.98±0.01	1.90±0.02	75.17±0.13
E	9.68± 0.04	8.40±0.02	7.05±0.01	2.10±0.01	1.84±0.01	72.77±0.15

Sample: A: 100% plantain flour, B: 90% plantain flour and 10% soy flour, C: 80% plantain flour and 20% soy flour, D: 70% plantain flour and 30% soy flour, E: 60% plantain flour and 40% soy flour.

Table 2. Mineral content of soy-plantain mixes.

Sample	Iron	Phosphorus	Calcium
A	0.24	33.43	6.55
B	0.25	31.10	7.12
C	0.27	29.45	6.82
D	0.28	27.65	6.70
E	0.31	26.22	5.89

Sample: A : 100% plantain flour, B: 90% plantain flour and 10% soy flour, C:80% plantain flour and 20% soy flour, D: 70% plantain flour and 30% soy flour, E: 60% plantain flour and 40% soy flour.

Table 3. Functional properties of soy plantain mixes.

Sample	B.D (g/cm^3)	WAC (%)	pH	T.A (%)	SP (g/g)	SOL (g/100g)
A	0.46	80.05	5.50	0.25	8.22	7.35
B	0.45	82.46	5.62	0.33	7.96	6.83
C	0.45	83.55	5.08	0.36	7.86	6.73
D	0.43	84.27	5.75	0.29	7.56	6.67
E	0.42	86.50	5.60	0.24	7.48	6.31

Sample: A : 100% plantain flour, B: 90% plantain flour and 10% soy flour, C: 80% plantain flour and 20% soy flour, D: 70% plantain flour and 30% soy flour, E: 60% plantain flour and 40% soy flour. BD, Bulk density; T.A, titratable acidity; WAC, water absorption capacity; SP, swelling power; SOL, solubility.

ash, iron and fiber contents also (Table 2) assumed the same trend as the protein content also, due to the same reason while the carbohydrate decreased with increasing level of soy flour substitution supporting the claims of Akpapunam (1997). The phosphorus decreased with increase in soy flour substitution probably due to the fact that soybean is not a good source of phosphorus while calcium did not follow a particular trend. Recent report suggests that phytic acid contained in soybeans interferes with the availability of calcium (Salunkhen, 1992).

Functional properties

The functional properties determine the application and use of food material for various food products (Table 3). The bulk density values were found to be between 0.42 to 0.46 g/cm^3, it decreased with increasing level of soy flour substitution with 100% plantain flour being denser than all other substituted samples. The bulk density is generally affected by the particle size and the density of the flour and it is very important in determining the packaging requirement, material handling and application in wet processing in the food industry, indicating a lesser package requirement with increase in soy flour substitution (Adebowale et al., 2008).

Water holding capacity of plantain-soy flours increased with soy flour substitution due to increase in protein content, addition of soy flour to plantain flour confers high water binding capacity to plantain flour which in turn improves the reconstitution ability and textural ability obtainable from the plantain flour (Adebowale et al., 2008).The swelling capacity decreased with soy flour substitution. The titrable acidity and pH (Table 3) did not follow a particular trend. The solubility decreased with

Table 4. Pasting characteristic of soy plantain mixes.

Sample	Peak viscosity	Trough	Break down (RVU)	Final viscosity	Set back	Peak time (min)	Pasting Temp (°C)
A	330.25	243.00	87.25	399.33	156.33	5.56	89.20
B	267.50	203.33	64.17	370.42	147.09	5.60	92.00
C	196.58	163.33	33.25	299.67	136.34	5.83	89.88
D	185.25	162.75	22.50	282.25	119.50	5.48	91.50
E	93.75	88.50	5.25	123.83	35.33	5.52	92.40

Sample: A, 100% plantain flour; B, 90% plantain flour: 10% soy flour; C: 80% plantain flour: 20% soy flour; D: 70% plantain flour: 30% soy flour; E, 60% plantain flour: 40% soy flour. Peak viscosity = maximum viscosity developed during or after the heating portion of the test; Trough = minimum viscosity after the peak normally occurring after the commencement of the sample cooling; Breakdown = peak viscosity minus trough viscosity Final viscosity = viscosity at the end of the test; set back = final viscosity minus peak viscosity. Peak time (min) = Time at which the peak viscosity occurred.

Table 5. Mean score of sensory evaluation of reconstituted paste “amala”

Quality attribute	A	B	C	D	E
Palatability	6.77^a	5.89^a	3.89^b	3.67^b	3.67^b
Texture	6.56^a	6.11^a	4.33^b	4.33^b	4.22^b
Taste	6.56^a	5.56^a	3.67^b	3.67^b	3.22^b
Colour	6.67^a	6.11^a	5.11^b	4.11^b	3.89^b
Overall acceptability	6.56^a	5.89^a	4.67^b	4.22^b	3.56^b

Sample with the same number of superscript are not scientifically different at 5 % probability level. Samples: A: 100% plantain flour, B: 90% plantain flour and 10% soy flour, C: 80% plantain flour and 20% soy flour, D: 70% plantain flour and 30% soy flour, E: 60% plantain flour and 40% soy flour.

soy flour substitution, a factor of soybean attributes. The result of the pasting characteristics indicates that the addition of soy flour reduced the peak viscosity. The relatively low peak viscosity affected by soy flour addition is indicative that the flour may be suited for products requiring low gel strength and elasticity (Table 4)

The trough which is the minimum viscosity value measures the ability of paste to withstand breakdown during cooling ranged between 88.5 and 243RVU. The final viscosity decreased with increase in soy flour substitution, it indicates the ability of the material to form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear stress during stirring. The set back values decreased with increase in soy four substition level, indicating the higher the substitution level, the more the retrogradation level during cooling and the higher the staling of the products made from the flour. The peak time which is an indication of the cooking time ranged between 5.48 to 5.83 min. The pasting temperature gives an indication of the gelatinization time during processing, it increased with soy flour substitution (Adeyemi and Idowu, 1990).

Sensory evaluation

The samples with 0 and 10% soy flour substitution had no significant difference at 5% probability level while the mixes with 20, 30 and 40% soy flour substitution levels had no significant difference in all the qualities evaluated but there was a sharp difference between those with 0 and 10% substitution and 20 to 40% substitution levels (Table 5). This observation suggests that plantain flour could be substituted with 10 % soy flour yielding product with acceptable sensory characteristics.

Conclusion

Substitution of plantain flour with soy flour at levels of 10 to 40 % resulted in notable increase in protein content, which could be nutritionally advantageous to Nigeria, where many people can hardly afford high proteinous foods because of the costs. Some of the functional properties of the plantain-soy mixes obtained could be an advantage in industrial uses, such as the bulk density and water holding capacity. The 10% soy flour substitution was generally accepted by the panelist probably due to the insignificance effect on the sensory attributes with that of the plain plantain flour. Though the 40 % substituted plantain flour had a better nutritional quality, the two factors can be combined to obtain an acceptable and nutritious reconstituted paste “amala”.

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