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DEVELOPMENT AND QUALITY EVALUATION OF FORTIFIED 'AMALA'

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Abstract. White yam was fortified with cassava and plantain flours to develop a traditional food called 'amala'. The fortified amala were subjected to organoleptic and chemical evaluations. Results showed that the protein and water absorption capacity of the fortified amala increased significantly. The panelists found yam fortified with plantain more acceptable. The samples stored in the refrigerator produced low pH values, remained fresh and maintained their attractive organoleptic attributes for a longer period than those stored at the room temperature.

Key words: development, quality, fortified, 'amala', plantain, cassava, yam

INTRODUCTION

'Amala' is a common food item in Nigeria and some other West African countries. 'Amala' is a menu that can be taken anytime of the day with stew, vegetables or other types of soup, which differ with taste. It is processed from root and tuber crops like yams, cassava and these may be fortified with other food items like soya, plant and wheat, just to mention a few. Root and tuber crops are the staple foods in many tropical countries of the world, varieties may differ greatly in nutritional quality.

The knowledge of nutritional quality of foods in a country is of great value in identifying and solving nutritional and health problems of the population. In Nigeria, there are data on the nutrient composition and nutritional qualities of foodstuffs eaten by the people but the data in most cases are fragmentary and scattered over the literature. There is the need to compile the available data in form of food composition tables for use in Nigeria [Eka 1998].

Research has been carried out on fortification of Nigerian foods with the aim of enriching them. Recently, Ogi and adun have been fortified with soybean protein, rich weaning foods have also been produced [Odetokun and Oladimeji 1996]. The aim of this study was to develop and evaluate the quality of fortified amala.

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In Southwest part of Nigeria yam flour is usually fortified with cassava and plantain to produce 'amala', but there is the dearth of information on the nutritive value of this food. Therefore the aim of this work is to develop and evaluate the quality of the fortified amala with a view of adding to nutritional knowledge.

MATERIALS AND METHODS

The yam (*Discorea alata*), cassava (*Manihot utilisima*) and plantain (*Musa parasidiaca*) flours were purchased from Akure market in Ondo State, Nigeria. The flours were sieved in a 2 mm wire mesh to remove impurities and stored in dry container at an ambient temperature. Yam flour was fortified with cassava and plantain (ratio 1:1). The samples were labelled thus: Cassava flour (CF_1), plantain flour (PF_2), yam flour (YF_3), yam fortified with cassava (YCF_4) and yam fortified with plantain (YPF_5). 'Amala' was prepared by adding flour into 250 cm^3 of boiled water, stirred thoroughly, (to avoid lumps) with a wooden spoon and cooked for 25 min to form soft dough. It was removed from fire and served [Uwaegbute et al. 1995].

Chemical analysis to determine proximate composition of all samples was carried out by standard methods. Protein was determined by the micro-Kjeldahl method [AOAC 1990], fat by soxhlet extraction, and moisture by oven dying. Ash was determined by incineration [AOAC 1990], carbohydrate was calculated by difference. The analysis of total energy was calculated according to the method reported for cricket [Abulude 2004]. Total phosphorus (P), phytate P, phytate, and phytate (percentage of total P) were determined using the methods reported for vegetables [Abulude 2001 a]. Organoleptic test of amala was done with a consumer panel of 10 men and women using a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). Methods used by Obajolu et al. [1995] for pH changes on locust bean were followed by the determination of pH changes of amala stored in the room and refrigerator. Results were statistically analysed.

RESULTS AND DISCUSSION

The chemical characteristics such as moisture, ash, crude fat, crude protein and fiber contents, varied significantly due to the difference in sample varieties (Table 1). The moisture content varied from 0.45-13.11%, ash content from 1.84-3.87%, crude protein 10.65-22.36%, crude fat from 6.95-14.83% fibre from 0.12-0.46% and carbohydrate from 54.83-72.46%. Gross energy 348.38-416.43%. The results tallies with the findings of Abulude [2004 b] on raw and processed rice and results of Rehman et al. [2004] on the moisture, ash and fibre contents of whole wheat and patent flours. According to Adeyeye and Ayejuyo [1994], the low moisture content of the samples would hinder the growth of micro-organisms and the storage life would be high. The protein content of the unfortified samples ranged between 10.65-12.10%, but these values increased to 15.11-22.36% when they were fortified. The mixture of yam and plantain gave the highest carbohydrate value of 72.46%. This would provide the much-needed energy to adults who are peasant farmers, most especially in the Southwest of Nigeria. The nutrient composition of the fortified samples is in agreement with the recommended allowance for consumers [FAO/WHO 1973].

Table 1. Proximate composition of flours, % DM
Tabela 1. Skład podstawowy mąki, % s.m.

Flour Mąka	Ash Popiół	Moisture Woda	Protein Białko	Fat Tłuszcz	Fibre Włókno	CHO Węglowo-dany	Energy Energia kcal
CF_1	3.44	11.55	11.08	8.93	0.14	66.55	390.89
YF_2	3.87	10.45	10.65	14.83	0.12	60.09	416.43
YF_3	2.99	13.11	12.10	9.47	0.19	62.15	386.27
YF_4	1.84	12.10	22.36	8.74	0.14	54.8	348.38
YF_5	3.54	12.10	15.11	6.65	0.16	62.44	369.24
Mean Średnia	3.11	11.86	14.26	9.72	0.20	61.21	382.24
Std error Błąd standardowy	0.8	1.00	4.9	3.1	0.1	4.3	25.4
CV, % Współczynnik wariancji, %	24.73	8.18	34.02	3.23	56.27	6.97	6.64

Table 2 depicts total P, phytate P, phytate and phytate P expressed as percentage. The phytate content ranged from 461.5-532.5 mg·100 g^{-1}. These values were lower than those reported for vegetables [Abulude 2001 a], mushrooms [Abulude 2001 c] and lupin seeds [Trugo et al. 1993]. The levels of phytate were comparable to levels reported for some foods of major consumption in Nigeria [Adeyeye et al. 2000]. The total P was highest in cassava and lowest in plantain. These values were not in agreement with the concentrations found for soybean, cowpea and legumes [Ologhobo and Fetuga 1984]. Phytate P expressed as percentage of total P ranged between 91.6 and 96.7%. Phytate

Table 2. Total phosphorus (P), phytate P, phytate (mg 100 g^{-1} DM) and phytate (% of total P)
Tabela 2. Zawartość fosforu całkowitego (P), fosforu fitynowego, fitynianów (mg 100 g^{-1} s.m.) oraz fitynianów (% fosforu całkowitego)

Flour Mąka	Phytate Fityniany mg 100 g^{-1}	Total P Fosfor całkowity mg 100 g^{-1}	Phytate P Fosfor fitynowy mg 100 g^{-1}	Phytate P as % of total P % całkowitego P
CF_1	532.5	150	145	96.7
PF_2	479.3	135	125	92.6
YF_3	504.1	142	130	91.6
YCF_4	521.9	147	142	96.6
YPF_5	461.5	136	130	95.6
Mean Średnia	499.86	142	134.4	94.62
Std error Błąd standardowy	29.43	6.6	8.6	2.4
CV, % Współczynnik wariancji, %	5.89	4.65	6.41	2.50

has often been considered as an anti-nutrient due to its enormous potential for forming complexes with cations and proteins places. Where animal production is intense, large amount of phytate P are excreted in the manure and contribute significantly to the eutrophication of surface waters [Marounck et al. 2000]. Phytate has been shown to play a role in preventing colorectal carcinomia, hypercholestrolaemia and renal calculi. Phytate content varies considerably depending on the environmental conditions, maturation and processing procedures.

The results obtained for some functional properties are shown in Table 3. Water absorption capacity (WAC) ranged between 205% in cassava flour and 310% in yam fortified with plantain flour. These values were much higher than values reported for cowpea seed [Abulude 2001 a], locust bean seeds [Adeyeye et al. 2002] and kolanut seeds [Abulude 2004 c]. WAC is considered a critical function of protein in viscous food then these samples could be used for viscous food formulations. The least gelation capacity for the samples was 8% as shown in Table 3. This value was in agreement with values earlier reported for African yam bean [Adeyeye and Aye 1998] and raw and precooked taro [Fagbemi and Olaofe 2000]. Where gelation ability is needed, all these samples may be useful. The oil absorption capacity (OAC) is lower than that obtained for cricket [Abulude 2004 a] and *Adenopus breviflorus* benth flour [Oshodi 1992]. OAC is important, as oil acts as a flavour retainer and improves the mouth feel of foods [Kinsella 1979], so the samples both fortified and unfortified would be good in this respect. This study showed that the foaming capacity of the samples (Table 3) ranged between 24--36%, this is quite high when compared with values reported in the literature. Consequently, these samples would be attractive for product where foaming is important [Kinsella 1979].

Table 3. Some functional properties of flours, %
Tabela 3. Wybrane właściwości funkcjonalne mąk, %

Flour Mąka	WAC	OAC	FC	LGC
CF_1	205	102	25	8
PF_2	228	95	36	8
YF_3	210	92	24	8
YCF_4	240	98	31	8
YPF_5	301	96	33	8
Mean Średnia	236.8	96.6	29.8	8
Std error Błąd standardowy	38.5	3.7	5.2	0
CV, % Współczynnik wariancji, %	16.27	3.85	17.34	0

WAC – Water Absorption Capacity, OAC – Oil Absorption Capacity, FC – Foaming Capacity, LGC – Least Gelation Capacity.

WAC – zdolność absorpcji wody, OAC – zdolność absorpcji tłuszczu, FC – wydajność pienienia, LGC – zdolność żelowania.

Fortified and unfortified amala samples were subjected to sensory evaluation for colour, taste, odour, texture and overall acceptability. The results are shown in Table 4. Although all the samples were accepted, the yam flour fortified with plantain was the most acceptable. The high score was considered to be due to its excellent texture as reported by panelists. Fortified yam with cassava was less preferred. Major complaints by the panelist were on the taste and the aroma of the food.

pH values obtained for the amala samples stored at room temperature and in the refrigerator are shown in Tables 5 and 6. There was a significant drop in the pH of both the fortified and unfortified samples. This indicated fermentation process. The pH values obtained for the samples stored at ambient temperature throughout the 14 days storage

Table 4. Organoleptic evaluation of 'amala'
Tabela 4. Wyniki oceny organoleptycznej

Flour Mąka	Colour Barwa	Taste Smak	Odour Zapach	Texture Tekstura	Overall acceptability Ogólna akceptowalność
CF_1	7.0	6.8	6.0	6.2	6.5
PF_2	5.2	7.3	6.0	6.2	6.6
YF_3	7.5	7.0	6.5	6.5	6.3
YCF_4	7.0	5.1	5.1	6.8	6.0
YPF_5	7.2	7.4	6.2	7.6	7.4
Mean Średnia	6.78	6.72	5.96	6.76	6.56
Std error Błąd standardowy	0.9	0.9	0.9	0.6	0.5
CV, % Współczynnik wariancji, %	13.37	13.94	8.77	8.73	7.97

Table 5. Change in pH of 'amala' during storage at room temperature
Tabela 5. Zmiany wartości pH 'amali' podczas przechowywania w temperaturze pokojowej

Flour Mąka	Days after preparation – Dni po produkcji						
	1	2	3	4	5	7	14
CF_1	6.7	6.0	6.0	6.0	6.1	6.9	9.4
PF_2	6.8	6.5	6.5	6.2	6.2	6.9	9.4
YF_3	7.0	7.0	6.8	6.8	6.3	6.0	9.1
YCF_4	7.4	7.0	7.0	6.9	6.4	6.4	9.6
YPF_5	6.8	6.6	6.6	6.4	6.0	6.0	6.6
Mean Średnia	6.94	6.62	6.58	6.46	6.2	6.44	9.42
Std error Błąd standardowy	0.3	0.4	0.4	0.4	0.2	0.5	0.2
CV, % Współczynnik wariancji, %	4.02	6.27	6.08	5.96	2.55	7.00	2.18

Table 6. Change in pH of 'amala' during storage in refrigerator
Table 6. Zmiany wartości pH 'amali' podczas przechowywania w warunkach chłodniczych

Flour Mąka	Days after preparation – Dni po produkcji						
	1	2	3	4	5	7	14
CF_1	6.6	6.0	6.0	6.0	6.0	6.3	6.4
PF_2	6.8	6.3	6.3	6.2	6.1	6.0	6.0
YF_3	6.9	6.8	6.3	6.3	6.1	5.8	5.8
YCF_4	7.2	6.8	6.7	6.9	6.7	6.0	6.0
YPF_5	6.3	6.0	6.0	6.0	6.0	5.7	5.0
Mean Średnia	6.76	6.38	6.26	6.28	6.18	5.96	5.86
Std error Błąd standardowy	0.3	0.4	0.3	0.4	0.3	0.2	0.5
CV, % Współczynnik wariancji, %	4.97	6.31	4.60	5.89	4.77	3.86	9.32

were between 6.0 and 9.6. The decrease in pH were apparent after the second day of storage and these trends continued until the samples were completely spoiled (day 5), but pH later increased to 9.6 by day 14 which might be due to prolonged storage. This pH was suitable for the production of microorganisms, which may be hazardous when consumed.

In contrast, the unfortified and fortified samples stored in the refrigerator produced low pH values. The samples remained fresh and maintained their attractive organoleptic attributes.

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MODYFIKACJA I OCENA JAKOŚCI WZBOGACONEJ POTRAWY 'AMALA'

Streszczenie. Mąka z białego ziemniaka (Discorea) była mieszana z mąką z manioku i owocu podobnego do banana (plantain) dla wzbogacenia tradycyjnej potrawy zwanej 'amala'. Wzbogacona 'amala' była przedmiotem oceny organoleptycznej i analiz che-

micznych. Wyniki tych analiz wskazują na istotny wzrost zawartości białka oraz wodochłonności w żywności wzbogaconej. Poprawie uległa również jej jakość sensoryczna (akceptowalność). Próby przechowywane w warunkach chłodniczych odznaczały się niższymi wartościami pH i lepszą jakością sensoryczną w porównaniu z próbami przechowywanymi w temperaturze pokojowej.

Słowa kluczowe: postęp, jakość, wzbogacenie, 'amala', plantain, maniok, słodki ziemniak

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