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Proximate, Mineral, Amino Acid and Fatty Acid Compositions of Maize Tuwo-Cirina Forda Flour Blends

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ABSTRACT

The proximate, mineral, amino acid and fatty acid compositions of maize tuwo-cirina forda flour blends in the ratio 90:10, 80:20, 70:30 and 100:0w/w were investigated using standard method processing technique. Data obtained indicated that addition of cirina forda flour to maize tuwo flour increased the protein content at all level of addition (7.56±0.02-35.06±0.01%) and fat content (3.45±0.01-8.79±0.01%) of the blends respectively, while the carbohydrate content of the blend was significantly lower to that of the control sample (MCF4). Addition of cirina forda to maize tuwo flour also increased the mineral compositions of the blends where the most abundant mineral element was Sodium (17.86±0.01-23.17±0.02mg/100g) and Phosphorus (0.01mg/100g) being the least mineral element. There was a significant increase ($p<0.05$) in the amino acid compositions of the flour blends with glutamic acid (1.67±0.01-2.17±0.02mg/100 crude protein) having the highest and tryptophan (0.14±0.01-0.17±0.01mg/100g crude protein) the least. The most abundant fatty acid of the blends was palmitic acid (16.29±0.02-26.35±0.02%) while the least fatty acid was behenic acid (1.53±0.01-2.14±0.01%).
The findings in this study therefore confirms the endless possibilities of protein enrichment of maize tuwo with cirina forda flour blends for the production of complementary food as a potentially effective strategy for enhancing the protein energy balance, particularly in developing countries.

INTRODUCTION

Protein malnutrition is a major public health problem in developing world; diets in these parts are predominantly starchy (Aberoumand and Deokule, 2009). Maize (Zea Mays) as a source of starch is the third most important cereal in the world after rice and wheat. Its utilization includes food uses, for industrial processing as a raw material and for animal feed formulation (Kent and Evers, 1994). However, utilization of maize for food production is the most common in developing countries as against industrial usage in the developed countries (Mejia, 2005). Maize is a major source of dietary energy for low income consumer in many parts of tropical Africa, including major urban areas (Ngoddy, 1985). Maize tuwo is one of the food products that can be obtained from maize in Nigeria. It is essentially a food gel or dumpling which is stiff, has a yield value and can be moulded into shapes (Muller, 1970). However, the utilization of tuwo and maize generally is limited by its extremely low protein content and so the consumption of its products has been implicated in malnutrition. The low protein intake in Africa has been attributed to the increasing high cost of animal protein (Osho, 2003). Insects and other related invertebrates have served as food for people for thousands of years all over the planet. Insects commonly consumed include: Locust, termites, grasshoppers, weevils and various caterpillars (Ene, 1963). Today insect eating is rare in the developed world, but remains a popular food in many developing regions of central and south America, Africa and Asia. In fact, insects are preferred to meat in some of these regions. Different studies have shown that edible insects contain appreciable amount of protein (Olaofe *et al.*, 1998; Ramos-Elourdy *et al.*, 1997; Fashoranti and Ajiboye, 1993). Cirina forda is one of the most widely eaten insects in the southern Nigeria (Fashoranti and Ajiboye, 1993). The larva of this insect is a delicacy served as snacks or taken with carbohydrate food in Nigeria (Anthonio and Isom, 1992). Cirina forda is a pest of shear butter tree, its larvae resemble silk worm caterpillars except that they do not spin cocoons instead they dig into the soil at the base of the host tree to pulpate, hence they are called “Konni wole” in the South western part of Nigeria. The larva of these insects is processed into dried form which is widely marketed and consumed as essential ingredients in vegetable soup. (Fasoranti and Ajiboye, 1993).

Investigations have been carried out to improve the protein content of tuwo using plant sources (Oyewole and Aibor, 1992). Okeiyi and Futrell (1983) reported that these had resulted in product of variable organoleptic properties and poor digestibility, attributed to the low solubility of the plant protein. There is limited information on the influence of Cirina forda as insect protein source on the nutritional composition of maize Tuwo. The present work therefore determines the influence of different levels of substituting cirina forda flour into Tuwo (Traditional maize dumpling), on the proximate, mineral, amino and fatty acid compositions of maize tuwo.

MATERIALS AND METHODS

White maize seeds (Zea mays) used for this study were obtained from the Department of Agricultural Technology farm of the Polytechnic Ibadan, Saki Campus Oyo State, Nigeria.
Dry larvae of Cirina forda were purchased from Sango market Saki, Oyo State Nigeria.

Preparation of maize Tuwo flour

Ten kilogram of maize grain used was first tempered with water followed by decortification of the grains on a locally fabricated decorticator. This machine removes the germs and hulls of the grains. The decorticated grains (maize grits) were then ground into flour using a locally fabricated plate mill. The maize flour finally obtained was sieved using a sieve with 300mm aperture and then kept in air- tight polythene bags until needed.

Preparation of Cirma forda flour

C. forda purchased were oven dried at 40^{O}C for 1h in the laboratory, the dried samples were ground into powder with the laboratory electric blender and kept in air- tight polythene bags until required.

Mix formulation

The maize tuwo and cirina forda flour were homogenously prepared as maize- cirina forda blends in proportions of 90:10; 80:20; 70:30 and 100:0% as control.

Determination of the proximate composition of maize tuwo – cirina forda blends

The proximate compositions of the blends were determined as follows: the moisture content was determined by using the oven drying method as described by AOAC (1990). Fat content was determined using the procedure of AOAC (1990) and n-hexane as solvent. The crude protein content was determined using macro kjeldahl method as reported by kirk *et al.* (1991). The gram nitrogen obtained was multiplied by 6.25 to obtain the crude protein. The total ash was determined as described by Kirk *et al.* (1991). The crude fibre was determined according to the procedure of AOAC (1990). The carbohydrate was calculated by difference and the energy value in Kcal using Atwater factor.

Determination of mineral compositions of the blends

The method described by Association of Official Analytical Chemists (AOAC) (2005) was used for mineral analysis. The samples were ashed at 550°C. The ash was boiled with 10ml of 20% hydrochloric acid in a beaker and then filtered into a 100ml standard flask. This was made up to the mark with deionized water. The minerals were determined from the resulting solution. Sodium (Na) and potassium were determined using the standard flame emission photometer. Nacl and Kcl were used as standards (AOAC, 2005). Phosphorus (P) was determined calorimecally using the spectronic 20 (Gallenkamp, UK) (Kirk and sawyer, 1991) with KH_2PO_4 as the standard. Calcium (Ca), Magnesium (Mg) and Iron (Fe) were determined using Atomic Absorption Spectrophotometer (AAS model SP9). All values were expressed in mg/100g.

Determination of amino acids profile of the blends

Amino acid compositions of the sample were measured on hydrolysates using amino acid analyzer (Sykam-S7130) based on high performance liquid chromatography techniques. Sample hydrolysates were prepared following the method of (Glew *et al*. (2005). Two hundred milligrams of samples were taken in hydrolysis tube. Then 5ml 6NHCl were added to sample in the tube, tightly closed and incubated at 110°C for 24hrs. After incubation period, the solution was filtered and 200 mL of the filterate were evaporated to dryness at 140°C for an hour. Each hydrolysate after dryness was diluted with one milliliter of 0.12N, pH 2.2 citrate buffers. A liquid of 150 ml of sample hydrolysate was injected in a cation separation column at 130°C. ninhydrine solution and an eluent buffer (The buffer system contained solvent A, pH 3.45 and solvent B, pH 10.85) were delivered simultaneously into a high temperature reactor coil (16 m length) at a flow rate of 0.7ml/min. The buffer/ninhydrine mixture was heated in the reactor at 130°C for 2 minutes to accelerate chemical reaction of amino acids with ninhydrine. The products of the reaction mixture were detected at wavelength 590nm and 440nm on a dual channel photometer. The amino acids composition was calculated from the areas of standards obtained from the integrator and expressed as percentage of the total protein.

Determination of the fatty acids of the blends

Fatty acid compositions of the blends were analyzed using gas – liquid chromatography (with omega-wax capillary supelco, USA). The lipid classes were separated by thin layer chromatography on silica gel G 60 (Merek, Darmstadt), using n-hexane/ethyl ether/acetic acid (73/25/2/v/v/v) as developing solvent. The fatty acids of phosphohpids and triglycerides were transformed with sodium methylate into methylesters.

Statistical analysis

The procedure was triplicate and the mean data recorded. The data were analyzed using SPSS version 16.00. The mean and standard error of means (SEM) of the triplicate analyses were calculated. The analysis of variance (ANOVA) was performed to determine significant differences between the means (p< 005), while the means were separated using the new Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The proximate composition of the maize tuwo- cirina forda flour blends were presented in Table 1. The moisture content of the blends ranged from 10.67±0.02-10.82±0.04%. The lower moisture observed in this study is an indication of longer shelf life of the blends and this agreed with the findings of Olitino *et al*. (2007). The protein content of the sample differed significantly (p<0.05) with MCF1 having the highest protein content (47.14±0.02%). The difference was observed because the protein content of the blends increased with addition of cirina forda flour. However, cirina forda have been reported to be a good source of protein (Ramos-Elorduy *et al*., 1997). The value obtained was higher than the value for the blends of maize tuwo flour with tilapia fish 16% (Fasasi, 2005), maize tuwo flour with bambara groundnut 10% (Wang and Daun, 2000) and maize flour with soyabean flour 18% (Sefa-Dedeh *et al*., 2002). The energy value of the blends ranged from 358.97±0.03-381.83±0.02% which was higher than those reported for maize flour with full fat fluted pumpkin flour (Giami *et al*., 2000), hence making the sample to be classified as energy dense food which can be incorporated to improve the nutritional quality of weaning food.

The mineral compositions of the maize tuwo-cirina forda flour blends are shown Table 2. The mineral contents of the sample were comparatively higher than the control sample (MCF4). For instance, Calcium, Iron, Sodium, Zinc and Magnessium were significantly higher than the control sample. This finding showed that maize tuwo-cirina forda flour is a good source of these essential minerals, particularly Iron and Zinc which are of public health significant. Heavy metals like Copper, Aluminium, Nickel and Manganese were not detected in the samples; and this further enhanced the nutritional value of the sample, hence its utilization as food or in any cereal-based meal products would not have any detrimental effects on the consumers. The ratios of Sodium to Potassium Na/K and Calcium to Phosphorus (Ca/P) were shown in Table 2. Na/K ratio is of great importance for prevention of high blood pressure. Na/K ratio less than one is recommended, hence maize tuwo flour would probably reduce the risk of high blood pressure (NRC, 1989). Diets rich in protein and Phosphorus may promote the loss of Calcium in the urine (Shills and Young, 1988); this had led to the concept of the Ca/P ratio. Adeyeye and Fagboun (2005) reported that a Ca: P ratio above two (twice as much as

Calcium and Phosphorus) helps increase the absorption of calcium in the small intestine. Food is therefore considered “good” if the ratio is above one and “poor” if the ratio is less than 0.5 (Nieman *et al*., 1992).

Table 3 showed the amino acid compositions of maize tuwo-cirina forda flour blends. The predominant amino acid was glutamic acid (1.67±0.01-2.17±0.02mg/100gcp) while the least amino acid was tryptophan (0.14±0.01-0.17±0.01mg/100gcp). In this study, the values obtained for the amino acids content of the samples are comparable to their corresponding protein content and this implies that the amount of non-protein nitrogenous materials in this blends is insignificant (Wung and Cheung, 2000) Amino acids are important components for healing and protein synthesis processes; any deficiency in these essential amino acids will hinder the recovery process (Zuraini *et al*., 2006). According to Witte *et al*. (2002), glycine together with other essential amino acids such as alanine, arginine and phenylalanine form a polypeptide that will promote growth and tissue healing.

The fatty acid compositions of the blends are shown in Table 4. The results showed that a significant difference (p<0.05) existed in the amino acid contents of the blends. The most abundant fatty acid was palmitic acid (16.29±0.02-24.77±0.01%) while behenic acid was the least (1.53±0.01-2.14±0.01%). In this present study, the finding showed that addition of cirina forda flour to maize tuwo flour improved the fatty acid contents of the maize flour. Quite a number of studies have reported that high polyunsaturated fatty acids level in dietary intake are desirable because of their potential health benefits (Bonvehi and Coll, 1993; Cunnane *et al*., 1993; Zwarts *et al*., 1999). With the current emphasis on lowering consumption of saturated fats, minimizing or eliminating trans fat, and increasing polyunsaturated and monounsaturated fats intake, the consumption of maize tuwo-cirina forda flour blends would improve the integrity of cardiovascular system.

Table 1: Proximate composition (%) of maize tuwo-cirina forda blends

Nutrient/Sample	MCF1	MCF2	MCF3	MCF4
Moisture	10.67^{ab}±0.01	10.36^{b}±0.02	10.82^{a}±0.04	10.76^{ab}±0.02
Crude protein	47.14^{a}±0.02	35.06^{b}±0.01	20.96^{c}±0.01	7.56^{d}±0.02
Crude fat	8.35^{b}±0.02	8.14^{c}±0.01	8.79^{c}±0.01	3.45^{d}±0.01
Total ash	2.75^{a}±0.01	2.65^{b}±0.01	2.34^{c}±0.01	2.08^{d}±0.01
Crude fibre	2.51^{a}±0.02	2.44^{ab}±0.01	2.38^{b}±0.01	1.97^{c}±0.01
Carbohydrate	28.52^{c}±0.03	41.35^{d}±0.01	54.72^{b}±0.03	74.42^{a}±0.04
Energy(Kcal)	377.79^{c}±0.03	378.90^{b}±0.03	381.83^{a}±0.02	358.97^{d}±0.03

MCF1: 90% maize tuwo flour:10% cirina forda flour; MCF2: 80% maize tuwo flour: 20% cirina forda flour; MCF3: 70% maize tuwo flour:30% cirina forda flour; MCF4: 100% maize tuwo flour:0% cirina forda flour.
Values are means of triplicate determination.

Means bearing different superscripts in the same row differed (p< 0.05).

Table 2: Mineral compositions (mg/100g) of maize tuwo-cirina forda blends

Minerals/sample	MCF1	MCF2	MCF3	MCF4
Calcium	1.07^{c}±0.01	1.18^{a}±0.01	1.13^{b}±0.01	1.00^{d}±0.01
Phosphorus	0.01^{a}±0.01	0.01^{b}±0.02	0.01^{b}±0.02	0.01^{a}±0.01
Iron	0.64^{c}±0.01	0.94^{a}±0.01	0.68^{b}±0.02	0.24^{d}±0.01
Sodium	23.17^{a}±0.02	19.24^{c}±0.01	20.17^{b}±0.01	17.86^{d}±0.01
Zinc	1.13^{a}±0.01	1.09^{b}±0.01	1.09^{b}±0.01	1.05^{c}±0.01
Potassium	0.02^{c}±0.02	0.02^{d}±0.02	0.02^{b}±0.02	0.02^{a}±0.02
Magnessium	18.10^{a}±0.01	16.31^{b}±0.02	16.16^{c}±0.01	15.15^{d}±0.01
Na/K	0.11^{b}±0.00	0.11^{b}±0.00	0.12^{a}±0.01	0.12^{a}±0.00
Ca/P	0.01^{a}±0.00	0.01^{a}±0.00	0.01^{a}±0.00	0.01^{a}±0.00
Lead	-	-	-	-
Copper	-	-	-	-
Aluminium	-	-	-	-
Nickel	-	-	-	-
Manganese	-	-	-	-

MCF1: 90% maize tuwo flour: 10% cirina forda flour; MCF2: 80% maize tuwo flour: 20% cirina forda flour; MCF3: 70% maize tuwo flour: 30% cirina forda flour; MCF4: 100% maize tuwo flour: 0% cirina forda flour. (-): not detected.
Values are means of triplicate determination.

Means bearing different superscripts in the same row differed ($p < 0.05$).

Table 3: Amino acid compositions (mg/100g crude protein) of maize tuwo-cirina forda blends

Amino acids	MCF1	MCF2	MCF3	MCF4
Non essential amino acids				
Alanine	$0.79^{a}\pm0.01$	$0.84^{a}\pm0.02$	$0.70^{a}\pm0.01$	$0.70^{a}\pm0.01$
Aspartic acid	$1.12^{c}\pm0.01$	$1.26^{b}\pm0.01$	$1.24^{a}\pm0.01$	$1.09^{c}\pm0.01$
Serine	$0.73^{b}\pm0.01$	$0.82^{a}\pm0.01$	$0.66^{c}\pm0.01$	$0.40^{d}\pm0.01$
Glutamic acid	$2.05^{b}\pm0.02$	$2.17^{a}\pm0.02$	$2.16^{a}\pm0.01$	$1.67^{c}\pm0.01$
Total	4.69	5.09	4.76	3.86
Conditionally essential amino acids				
Proline	$0.71^{b}\pm0.02$	$0.77^{a}\pm0.02$	$0.64^{b}\pm0.01$	$0.47^{c}\pm0.01$
Glycine	$0.45^{a}\pm0.02$	$0.49^{a}\pm0.02$	$0.48^{a}\pm0.01$	$0.36^{b}\pm0.01$
Arginine	$0.65^{b}\pm0.02$	$0.75^{a}\pm0.01$	$0.79^{a}\pm0.01$	$0.59^{c}\pm0.01$
Tyrosine	$0.44^{b}\pm0.01$	$0.55^{a}\pm0.01$	$0.45^{b}\pm0.01$	$0.35^{c}\pm0.01$
Total	2.25	2.56	2.36	1.77
Essential amino acids				
Lysine	$0.53^{b}\pm0.01$	$0.63^{a}\pm0.01$	$0.59^{a}\pm0.01$	$0.47^{c}\pm0.01$
Valine	$0.84^{a}\pm0.01$	$0.87^{a}\pm0.01$	$0.88^{a}\pm0.01$	$0.75^{b}\pm0.01$
Methionine	$0.46^{c}\pm0.01$	$0.52^{a}\pm0.01$	$0.48^{b}\pm0.01$	$0.44^{c}\pm0.01$
Phenylalanine	$0.64^{c}\pm0.01$	$0.72^{b}\pm0.01$	$0.79^{a}\pm0.01$	$0.54^{d}\pm0.02$
Histidine	$0.27^{b}\pm0.01$	$0.34^{a}\pm0.01$	$0.30^{a}\pm0.01$	$0.27^{b}\pm0.01$
Tryptophan	$0.15^{a}\pm0.01$	$0.17^{a}\pm0.01$	$0.15^{a}\pm0.01$	$0.14^{a}\pm0.01$
Leucine	$1.19^{b}\pm0.01$	$0.99^{b}\pm0.01$	$1.24^{a}\pm0.01$	$0.77^{c}\pm0.01$
Total	4.08	4.35	4.43	3.38

MCF1: 90% maize tuwo flour: 10% cirina forda flour; MCF2: 80% maize tuwo flour: 20% cirina forda flour; MCF3: 70% maize tuwo flour:30% cirina forda flour; MCF4: 100% maize tuwo flour:0% cirina forda flour.
Values are means of triplicate determination.

Means bearing different superscripts in the same row differed ($p < 0.05$).

Table 4: Fatty acids composition (% of total fatty acid) of maize tuwo-cirina forda blends

Fatty acids	MCF1	MCF2	MCF3	MCF4
Saturated fatty acids (SFA)				
Stearic acid	$15.23^{c}\pm0.01$	$16.06^{a}\pm0.02$	$15.79^{b}\pm0.01$	$15.06^{d}\pm0.02$
Palmitic acid	$18.64^{c}\pm0.01$	$26.35^{a}\pm0.02$	$25.60^{b}\pm0.03$	$16.29^{d}\pm0.02$
Behenic acid	$1.93^{b}\pm0.01$	$1.89^{c}\pm0.01$	$2.14^{a}\pm0.01$	$1.53^{a}\pm0.01$
Total	35.80	44.30	43.53	32.88
Polyunsaturated fatty acids (PUFA)				
Linolenic acid	$20.23^{c}\pm0.01$	$24.77^{a}\pm0.01$	$24.17^{b}\pm0.01$	$15.67^{d}\pm0.01$
Linoleic acid	$13.15^{a}\pm0.01$	$12.86^{b}\pm0.01$	$12.57^{c}\pm0.01$	$12.45^{d}\pm0.01$
Total	33.38	36.63	36.64	27.12
Monosaturated fatty acids (MUFA)				
Oleic acid	$17.15^{a}\pm0.01$	$16.23^{c}\pm0.01$	$16.95^{b}\pm0.01$	$14.79^{b}\pm0.01$
Total	17.15	16.23	16.95	14.79
P:S	0.93	0.83	0.84	0.82

MCF1: 90% maize tuwo flour: 10% cirina forda flour; MCF2: 80% maize tuwo flour: 20% cirina forda flour; MCF3: 70% maize tuwo flour: 30% cirina forda flour; MCF4: 100% maize tuwo flour: 0% cirina forda flour.

Values are means of triplicate determination.
Means bearing different superscripts in the same row differed ($p < 0.05$).

CONCLUSION

The results from this study has shown that supplementing maize flour with cirina forda flour considerably improved the protein, minerals, amino acid and fatty acid contents of the blends. In view of this, the blends may be used as traditional breakfast meal (ogi) or in the formulation of complementary foods.

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