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Chemical composition and fatty acid profiles of cereals in Nigeria

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Proximate composition, mineral and fatty acid contents of the major cereal grains (sorghum, millet, maize and rice) all cultivated in Iree, Oyo State, Nigeria, have been investigated. The water, oil, ash, protein and carbohydrate contents were in the ranges 9·4–11·0%, 0·3–4·9%, 0·8–2·6%, 6·5–10·9% and 70·7–82·4%, respectively.

Potassium, phosphorus and magnesium were the richest minerals, concentrations varying from 325–450 mg/100 g for potassium, through 180–390 mg/100 g for phosphorus to 60–195 mg/100 g sample for magnesium. Calcium, sodium, manganese, iron, copper and zinc had much lower concentrations.

Stearic, oleic and linoleic were the most abundant fatty acids in every sample. All the cereal grains had high degrees of unsaturation (between 75·8% and 86·4%) and high quantities of essential fatty acids. Sorghum had the highest protein and essential fatty acid contents.

INTRODUCTION

Cereals, including rice (*Oryza sativa*, L), maize (*Zea mays*, L), guinea corn (*Sorghum bicolor*, L) and millet (*Pennisetum typhoides*, Stapf & Hubbard) constitute a major class of staple food in Nigeria and other tropical countries. Along with tubers, they are a major source of carbohydrate, the people's major source of energy. Hence, in Nigeria the cereals are widely cultivated with sorghum and millet mainly in the north and the middle-belt, rice in the north and some southern areas and maize (which requires more rain than the others) in the southern rainy parts of Nigeria.

Differences may occur in the chemical composition and fatty acid profiles of agricultural products due to changes in soil and climate among other factors (Oyenuga, 1968; Fashakin & Ojo, 1988; Olaofe & Sanni, 1988). However, it is vital to have an adequate knowledge of the chemical composition of food for the sake of the health, well-being and safety of the consumer.

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Oyenuga (1968) has reported the chemical composition and mineral contents of foodstuffs produced around Ibadan, Nigeria, while Olaofe and Sanni (1988) reported the mineral contents of some agricultural products including maize and sorghum grown around Ilorin, Nigeria. The present study examines the proximate composition, mineral contents and fatty acid profiles of the major cereals all grown in Iree, near Osogbo, Nigeria, and looks at variation in composition between different species from the same location. There has been no previous report on the chemical composition of cereal grains grown in the Osogbo area of Nigeria. The results of this study will hopefully aid the food composition table in Nigeria.

MATERIALS AND METHODS

Sample collection and preparation

The cereal grains were collected from the agricultural farm of The Polytechnic campus, Iree, Oyo State, Nigeria. Portions (1 kg) of each sample were blended

(National food grinder, model MK 308, Japan) and kept in an air-tight bottle in a deep freezer until taken for analysis.

Proximate analysis

Moisture content was determined by drying to constant weight at 105°C in an air oven, ash content by ignition at 550°C in a muffle furnace, oil content by Soxhlet extraction with hexane (8 h), protein by the Kjeldahl method, and crude fibre by the acid and alkaline digestion methods, all described by Lees (1975). The carbohydrate content was estimated by difference, subtracting the sum of water, protein, fat, crude fibre and ash percentages from one hundred.

Minerals

Minerals were determined by digesting the ash with 3 M hydrochloric acid and using the atomic absorption spectrophotometer for calcium, copper, magnesium, manganese and zinc and the flame photometer for potassium and sodium. Phosphorus was determined using a Technicon Autoanalyzer (AA 11) (International Institute of Tropical Agriculture, Ibadan, Nigeria).

Fatty acid analysis

An aliquot of the oil extract was esterified with boron trifluoride–methanol (BF_3–methanol) reagent (Meltcalfe & Schmitz, 1961). The fatty acid methyl esters so prepared were then chromatographed using 10% DEGS on Chromosorb W HP packed in glass column (200 cm × 4 mm i.d.) on a Varian 3700 GC equipped with a flame ionization detector (FID). Injector, detector and column temperatures were 220, 270 and 190°C isothermal, respectively, and nitrogen, hydrogen and air were flowing at 30, 25 and 300 ml/min, respectively. Identification of the methyl esters was done by comparing the retention times of the sample esters with those of standards under the same operating conditions.

The peak area was measured by triangulation and the relative proportions of the individual compound obtained by determining the partial area in relation to total area.

RESULTS AND DISCUSSION

Proximate composition

Table 1 shows the proximate compositions of the cereals. The ash content varied between 0·8% in rice and 2·6% in sorghum. The low value for rice could be attributed to the removal of the bran, the ash content being an indication of the level of inorganics in the sample. The oil content varied from 0·3% in rice to 4·9% in maize. The wide gap between the very low oil content of rice and those of other cereals may be due also to the removal of the bran as this contains about 7·6% oil (Oyenuga, 1968).

Table 1. Proximate composition of the cereals[a]

	Water (%)	Oil (%)	Ash (%)	Protein (N × 6·25) (%)	Crude fibre (%)	Carbohydrate (%)
Sorghum	10·1	3·9	2·6	10·9	1·83	70·7
Millet	11·0	3·2	1·9	7·9	1·10	74·9
Maize	9·6	4·9	2·3	7·4	1·72	74·1
Rice	9·4	0·3	0·8	6·5	0·63	82·4

[a] Average of two determinations.

The protein content was highest in sorghum (10·9%) and lowest in rice (6·5%). Although protein supplies from cereals are low and need to be supplemented with other protein-supplying diets, sorghum serves as the highest protein source of all the cereal samples. This favours babies of the low-income mothers in Nigeria who are fed on sorghum palp (*ogi baba*) in preference to maizes (*ogi*). The carbohydrate content varied from 70·7% in sorghum to 82·4% in rice, roughly inversely proportional to their protein contents.

The oil contents agreed fairly well but the protein and carbohydrate contents were lower than those reported by Oyenuga (1968). The ash contents also agreed fairly well with those reported by Oyenuga (1968) but were higher than those reported (for maize and sorghum) by Olaofe and Sanni (1988) (Table 2).

Table 2. Some literature data on proximate composition and minerals of cereals in Nigeria

	Sorghum		Millet	Maize		Rice
	(a)	(b)	(a)	(a)	(b)	(a)
Moisture (%)	—	15·3	—	—	10·2	—
Oil (%)	3·25	—	4·99	4·09	—	0·14
Ash (%)	2·36	1·9	1·09	3·13	1·9	0·38
Protein (%)	15·03	—	9·02	10·65	—	12·51
Carbohydrate (%)	79·12	—	83·86	83·88	—	90·18
Calcium (mg/100 g)	23·0	8·3	50·0	6·0	2·2	12·0
Magnesium (mg/100 g)	230	747	180	160	377	119
Potassium (mg/100 g)	370	644	310	400	757	342
Sodium (mg/100 g)	20	23	10·0	50·0	3·5	78·0
Manganese (mg/100 g)	27	4·7	14·0	6·83	2·1	10·1
Iron (mg/100 g)	0·37	12·7	9·0	2·5	5·3	2·0
Copper (mg/100 g)	7·0	1·3	5·0	4·49	0·8	3·6
Zinc (mg/100 g)	—	6·2	—	—	3·8	—
Phosphorus (mg/100 g)	71·0	—	358	300	—	290

(a) Oyenuga (1968); (b) Olaofe & Sanni (1988).
—, No data.

Table 3. Minerals of the cereals (mg/100 g)[a]

	Calcium (Ca)	Magnesium (Mg)	Potassium (K)	Sodium (Na)	Manganese (Mn)	Iron (Fe)	Copper (Cu)	Zinc (Zn)	Phosphorus (P)
Sorghum	24·3	195·0	405·0	15·0	1·8	10·8	0·3	2·0	278·0
Millet	60·0	115·5	450·0	27·0	1·4	30·9	0·6	2·3	297·0
Maize	39·0	105·0	360·0	15·0	0·9	8·1	6·2	1·7	180·0
Rice	51·0	60·0	325·0	15·0	1·1	24·3	0·3	0·9	390·0

[a] Average of two determinations.

Minerals

Table 3 lists the minerals of the cereals. In agreement with plant food products, potassium was the most abundant mineral in all the cereal samples. This ranged fron 325 mg/100 g in rice to 450 mg/100 g sample in millet. Phosphorus was the second most abundant mineral, varying from 180 mg/100 g in maize to 390 mg/100 g sample in rice. Magnesium was the next most abundant mineral, with the highest value in sorghum (195 mg/100 g sample) and the lowest in rice (60 mg/100 g sample). Calcium and iron contents were lower than those of potassium, phosphorus and magnesium. Manganese (0·8–1·8 mg/100 g), copper (0·3–6·2 mg/100 g) and zinc levels were the lowest of all the minerals in all the samples.

Values for potassium agreed fairly well with those reported by Oyenuga (1968), but were lower than those (for maize and sorghum) reported by Olaofe and Sanni (1988). Phosphorus, calcium and iron contents were higher but magnesium contents were lower than reported by Oyenuga (1968), while magnesium contents fell lower than those reported (for sorghum and maize) by Olaofe and Sanni (1988) (Table 2).

The variations in proximate composition and minerals of the cereals between this location and other places in Nigeria may be due to variation in soil type and/or weather conditions.

Fatty acid composition

Table 4 shows the fatty acid composition of the cereal oils. Palmitic, oleic and linoleic acids (C16:0, C18:1 and C18:2, respectively) were the three most abundant fatty acids in all the cereal samples. This is the case with most plant seed oils (Girgis & Turner, 1972; Raie & Latif Iqbal, 1983; Grampone, 1988; Ajewole & Adeyeye, 1991). Stearic acid (C18:0) was in low quantities in all samples (1·6–2·7%). Lauric (C12:0) and myristic (C14:0) acids were found in low but measurable quantities in millet and rice, while there were traces of myristic acid in sorghum. Linolenic acid (C18:3) was present in reasonable quantities (2·2–7·1%) in rice, millet and sorghum, but none in maize. Palmitoleic acid (C16:1) was present in a very small quantity in rice only.

All the samples showed very high levels of unsaturation ranging from 75% in millet to 86·4% in sorghum. The essential fatty acid contents were also high, ranging from 39% in rice to 58% in sorghum. Except for low oil contents, the cereals are good sources of essential fatty acids. The highest contents of essential fatty acids and protein in sorghum make it more nutritious than the other cereals in this study.

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Table 4. Fatty acid composition of the cereal oils (% total fatty acids)

	C12:0	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:0	Unsaturation	EFA
Sorghum	—	t	10·9	—	2·7	28·4	50·9	7·11	—	86·4	58·0
Millet	0·3	0·4	21·0	—	1·6	23·9	48·7	3·2	0·9	75·8	51·9
Maize	—	—	18·3	—	1·7	33·7	46·3	—	—	80·0	46·3
Rice	0·1	0·2	14·7	0·4	2·0	43·7	36·8	2·2	—	82·9	39·0

EFA, Essential fatty acids (C18:2; C18:3).
t, Trace (less than 0·1%).

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