CHEMICAL STUDIES ON SOME NIGERIAN CEREALS[1]

O. L. OKE[2]

ABSTRACT

This paper reports on the chemical composition of three Nigerian cereals, maize (*Zea mays*), grain sorghum (*Sorghum spp.*), and rice (*Oryza sativa*). Sorghum is the richest in crude protein (13.0%) and crude fiber (2.9%), maize in caloric value (409.7 cal.), ether extract (4.1%), and ash (3.7%), and rice in carbohydrate (85.7%). In general the mineral content of rice is lowest while that of maize and sorghum follows the same trend. The same thing applies for oxalic and phytic acids. The similarity in chemical composition of maize to sorghum shows that sorghum could replace maize (and vice versa) without significantly changing the nutritive value of the diet.

Little is available in the literature on the chemical composition of Nigerian cereals, and yet cereals furnish the major part of the protein in human diets in Nigeria. Usually the cereals are boiled and eaten with soup and meat (rice for example) or else they are fermented and sieved and the starchy granules are made into a thick paste with boiling water and used as breakfast porridge (maize and sorghum). Cereals are second only to tuber products as a source of food in Nigeria.

We discuss here preliminary work on the nutritive values of some Nigerian cereals. Proximate analysis, mineral composition, and determinations of oxalic, hydrocyanic, and phytic acid are reported.

Materials and Methods

In this study maize, sorghum, and rice were used. The materials were obtained from the local market, dried at 100°C. overnight, and finely ground.

Crude protein, crude fiber, ash, ether extract, and hydrocyanic acid were determined according to AOAC *Methods of Analysis* (1), potassium by flame photometry, other minerals spectrographically by use of a photoelectric spectrometer, oxalic acid by the method of Dye (2), and phytic acid by the method of McCance and Widdowson (3).

Results

Slight variations were observed among the determinations of oxalic, hydrocyanic, and phytic acids. Table I shows a typical proximate analysis of the cereals. Table II gives the distribution of the

[1]Manuscript received October 13, 1964.
[2]Lecturer, Chemistry Department, University of Ife, Nigeria.

major inorganic constituents, Table III the minor inorganic constituents, and Table IV shows the oxalic, hydrocyanic, and phytic acid contents. All determinations are based on percentage of dry matter.

TABLE I

PROXIMATE ANALYSIS OF SOME NIGERIAN CEREALS[a]

SAMPLE	DRY MATTER	CRUDE PROTEIN	ETHER EXTRACT	CRUDE FIBER	CARBOHYDRATE	ASH	CALORIES
	%	%	%	%	%	%	*per 100 g.*
Maize	90.4	11.8	4.1	1.3	82.6	3.7	409.7
Sorghum	88.4	13.0	3.3	2.9	76.2	2.6	394.1
Rice	94.4	7.9	0.21	0.19	85.7	1.4	394.9

[a] All values expressed as percent of dry matter.

TABLE II

MINERAL STATUS OF SOME NIGERIAN CEREALS. MAJOR ELEMENTS

SAMPLE	NITROGEN	PHOSPHORUS	POTASSIUM	CALCIUM	MAGNESIUM
	%	%	%	%	%
Maize	1.88	0.41	0.38	0.10	0.12
Sorghum	2.08	0.46	0.36	0.05	0.15
Rice	1.26	0.14	0.17	0.05	0.00

TABLE III

MINERAL STATUS OF SOME NIGERIAN CEREALS. MINOR ELEMENTS

SAMPLE	SODIUM	MANGANESE	IRON	COPPER	BORON	ZINC	MOLYBDENUM	ALUMINUM
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Maize	79	19	34	11.0	4.8	54	0.9	23
Sorghum	52	22	34	10.2	3.3	4.4	0.6	30
Rice	110	16	15	6.0	2.2	26	0.7	6.2

TABLE IV

OXALIC, HYDROCYANIC, AND PHYTIC ACID CONTENTS OF SOME NIGERIAN CEREALS

SAMPLE	OXALIC ACID	HYDROCYANIC ACID	PHYTIC ACID PHOSPHORUS	
	%	*mg. %*	*mg. %*	*% of original P*
Maize	2.6	1.5	150	37
Sorghum	2.8	1.5	130	30
Rice	2.2	0.0	80	59

Discussion

Table I shows that the crude protein contents of Nigerian maize and sorghum, 11.8 and 13.0% respectively, are higher than the figures of 10.0 and 9.1% for United States maize and sorghum given by Martin and Leonard (4). Since an average adult could consume about 200 g. dry matter, as found experimentally by the author, it can be in-

ferred that a large proportion of an individual protein requirement could be met by these cereals, subject to full complements of the essential amino acids and a sufficiently high rate of intake. The crude protein content of Nigerian rice is, however, lower than the American (7.9 and 12.4% respectively). The main difference between Nigerian and American maize is the ash content (3.7 and 1.4% respectively). The corresponding figures for sorghum are 2.6 and 2.1%. The important dietary constituents of the ash are calcium, phosphorus, and iron. Rice is low in phosphorus (0.14%), but the phosphorus and iron contents of maize and sorghum are very similar (0.41%, 34 p.p.m., and 0.46%, 34 p.p.m., respectively).

The Ca:P ratio for maize, sorghum, and rice is 1:4, 1:9, and 1:3 respectively. The satisfactory ratio for balanced foodstuffs is 1:2.

The other minor elements are included for comparison. Apart from the high content of zinc in maize (54 p.p.m. in maize and 4.4 p.p.m. in sorghum), the other elements show a similar trend in both maize and sorghum. In general the figures for rice are lower than for maize and sorghum. This is most pronounced with magnesium (0.00% compared with 0.12 and 0.15% in maize and sorghum, respectively).

Maize and sorghum show similar protein, phosphorus, and magnesium contents: maize is higher in ash, calcium, and ether-extractable substances, and sorghum has a crude fiber content nearly twice that of maize. Bressani and Rios (5) and Bressani and Mertz (6) showed that the levels of the essential amino acids of maize and sorghum are very similar, and that they are both deficient in lysine and tryptophan.

It is generally accepted that under certain conditions dietary calcium is precipitated in the intestine and this reduces calcium availability, restricts growth, and even causes rickets. Oxalic and phytic acids are presumed responsible for this. Furthermore, the loss of calcium by excretion as calcium oxalate takes place through the kidneys. The crystals of calcium oxalate are deposited in the uriniferous tubules as granules or stones, leading to oxaluria.

Hence, calcium determinations on foodstuffs are of little significance from the nutritional point of view unless taken in conjunction with oxalic or phytic acid determinations, or both.

The oxalic acid contents of the cereals range from 2.2 to 2.8%.

Maize contains the highest amount of phytic acid phosphorus; rice contains the lowest. Phytic acid, besides interfering with calcium absorption, does not permit complete utilization of the phosphorus it contains. McCance and Widdowson (3) showed with diets of Hovis

bread, blackberries, and 2 g. phytic acid on three different people that about 36 to 63% of the phytic acid was excreted unchanged in the feces and they concluded that about half of the phytic acid phosphorus taken was unavailable. Thus, the total phosphorus content may be a wholly incorrect guide to the available phosphorus.

Cyanogenesis has been extensively studied in many plants, chiefly because of the possible toxic effect that the hydrocyanic acid produced could have on livestock. Hydrocyanic acid occurs in combination with sugars as insoluble, nontoxic compounds known as cyanogenetic glycosides. Rice is free from hydrocyanic acid and maize and sorghum contain only traces (1.5 mg.% each).

The above results indicate that sorghum could replace maize in the diet without appreciable effect on nutrition. It is interesting to note that sorghum, which is extensively cultivated in the northern parts of Nigeria, is popular only in the north, and that maize is cultivated mainly in the southern part and is also more popular in the south. The methods of preparation of both for food in the north and south are very similar.

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