Changes in the Nutritional Quality of Fermented Cassava Tuber Meal

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A comparative analytical investigation on major nutrient contents based on the proximate analysis, gross energy, and mineral and amino acid compositions in fresh and fermented cassava tuber meals was carried out. The traditional fermentation of grated cassava used in the production of gari and meal of retted cassava in many parts of West Africa resulted in a decrease in the protein content by about 45%. Although the tuber meal is poor in minerals, the traditional fermentation method causes an ~69% decrease in the phosphorus content, a 65% decrease in magnesium, a 76% decrease in potassium, and a 50% decrease in the sodium content. Fermentation also causes substantial reduction in the absolute quantity of the amino acids. Traditional fermentation causes a decrease in the chemical score of the tuber protein by about 3% and also accounted for an ~2% reduction in the biological value of the tuber meal.

Cassava tuber meal is used as a major source of energy supply in diets of people in many tropical third world countries especially in West Africa. The most popular processed forms of the cassava meal as human feedstuffs in Nigeria are meal of retted cassava (fufu) and Gari (Onwueme, 1978). The meals undergo certain degree of fermentation process during gari and fufu productions (Collard and Levi, 1959; Collard, 1963; Akinrele, 1964). Also, some microorganisms have been isolated and identified in connection with the fermentation process during gari production (Okafor, 1977; Collard, 1963).

The chemical composition based on the proximate analysis of the finished gari product has been reported (Oke, 1966; Oyenuga, 1968). But a comparative study on the nutritional changes in relation to the gross energy, proteins, and amino acid and mineral compositions in the fermented product does not seem to have been reported. Such results are useful in the assessment of the nutritive value of gari and meal of retted cassava (fufu). This paper reports the results of the comparative analytical investigations on major nutrient contents based on the gross energy, proximate analysis, and amino acid and mineral compositions in the fresh and fermented cassava tuber meals.

MATERIALS AND METHODS

Fermentation of Cassava Tuber Meal. Cassava tubers were purchased from a local market around the University of Port Harcourt. The tubers were peeled, washed, and grated. Samples were removed and dried in an oven at 60 °C for 24 h as dried fresh material (unfermented). Then the bulk of the grated material was transferred into a fermentor and covered with water for 4 days. After this period, the meal was transfered into cloth bags, tied, and subjected to heavy pressure for 24 h to remove most of the water. The resulting material was then dried in an oven at 60 °C for 24 h as fermented product. This method duplicates the household fermentation process for meal of retted cassava—fufu (Onwueme, 1978). A similar method is usually adopted for fermentation of corn for Nigerian Agidi (Umoh and Fields, 1981).

Chemical Analysis. The proximate analysis was carried out as described in Association of Official Analytical Chemists (1975). Mineral content was determined after wet digestion of appropriate samples with perchloric and nitric acids. Sodium and potassium by flame photometer, calcium, magnesium, and trace elements by atomic absorption spectrophotometry in the Analytical Service Laboratory of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Phosphorus was by the method as described (O'Neill and Webb, 1970). Amino acids were determined after acid digestion by automatic amino acid analyser and gross energy by adiabatic bomb calorimetry all at the Department of Chemical and Physical Analysis of Rowett Research Institute, Aberdeen, Scotland. Cysteine and methionine were determined chromatographically after oxidation with performic acid. Tryptophan was not determined.

From the analytical data, the chemical score and biological value were calculated by the method proposed by Block and Mitchell (1946), with reference to the corresponding amino acid of the FAO/WHO (1973) reference pattern.

Table I. Nutrient Composition of Cassava Tuber Meal and Its Fermented Product

nutrients, % dry matter	unfermented tuber meal	fermented tuber meal
dry matter, % dry matter	29.88 ± 0.44	28.76 ± 0.30
organic matter, % dry matter	94.98 ± 0.20	95.04 ± 0.25
crude fiber, % dry matter	0.56 ± 0.21	0.56 ± 0.20
crude protein ($N \times 6.25$), % dry matter	1.7 ± 0.10	0.94 ± 0.14
ether extract, % dry matter	0.48 ± 0.02	0.66 ± 0.02
nitrogen free extract, % dry matter	92.24 ± 0.12	92.88 ± 0.11
total ash, % dry matter	5.02 ± 0.50	4.56 ± 0.48
gross energy, kcal/g	4.13 ± 0.01	4.22 ± 0.01

RESULTS AND DISCUSSION

There are many reports on the use of microorganisms to convert cassava into microbial protein in a solid-state fermentation process (Brook et al., 1969; Nestel and Graham, 1977). There seems to be little or no information on the chemical analysis of the traditional fermentation of grated cassava used in the production of meal of retted cassava in many parts of West Africa and Ferinha do mandioca in Brazil. Results of the nutritional changes in the traditional fermented grated cassava are presented in Table I. There was an ~3.8% loss of dry matter in the fermented meal that could be attributed to solubilization during fermentation. The results also indicate a decrease in the protein content of about 45% in the fermented meal. This is contrary to the solid-state fermentation involving the use of special microorganisms such as *Rhizopus* and

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Table II. Mineral Composition of Cassava Tuber Meal and Its Fermented Product

minerals	unfermented tuber meal	fermented tuber meal
phosphorus, % dry matter	0.100	0.031
calcium, % dry matter	0.032	0.029
magnesium, % dry matter	0.063	0.015
potassium, % dry matter	0.557	0.106
sodium, ppm	233.1	117.0
zinc, ppm	13.9	14.3

Table III. Changes in the Amino Acid Content of Cassava Tuber Meal and Its Fermented Product

	composition, g/kg of dry matter	
amino acids	unfermented meal	fermented meal
asparagine	1.33	0.68
threonine	0.64	0.38
serine	0.57	0.34
glutamic acid	1.98	0.89
glycine	0.58	0.34
alanine	0.94	0.51
cysteine	0.07	0.04
valine	0.69	0.39
methionine	0.11	0.05
isoleucine	0.59	0.32
leucine	0.88	0.49
tyrosine	0.36	0.22
phenylalanine	0.55	0.30
histidine	0.34	0.16
lysine	0.87	0.47
arginine	0.58	0.34
proline	0.52	0.28

Table IV. Amino Acid Composition of Cassava Tuber Meal and Its Fermented Product

	composition, g/16 g of nitrogen	
amino acids	unfermented meal	fermented meal
asparagine	7.96	7.20
threonine	3.82	4.08
serine	3.44	3.63
glutamic acid	11.87	9.50
glycine	3.46	3.64
alanine	5.62	5.40
cysteine	0.428	0.42
valine	4.11	4.11
methionine	0.63	0.54
isoleucine	3.55	3.41
leucine	5.30	5.23
tyrosine	2.17	2.39
phenylalanine	3.32	3.17
histidine	2.03	1.72
lysine	5.19	5.05
arginine	3.49	3.58
proline	3.09	3.00

Aspergillus species (Reade and Gregory, 1975; Gregory et al., 1976, 1977) and the concomitant addition of supplemental nitrogen that the microorganisms convert to protein nitrogen. Information on the microbial association with the traditional fermentation implicated bacteria and yeast (Collard and Levi, 1959; Collard, 1963; Akinrele, 1964; Okafor, 1977). A great number of these microorganisms in the traditional fermenting product without externally added nitrogen could result in the decrease of the cassava protein.

The results on the mineral composition (Table II), show that although the tuber meal is very low in mineral contents, they were considerably reduced after fermentation. Fermentation caused ~69% decrease in the phosphorus content, a 65% decrease in magnesium, a 76% decrease in potassium, and a 50% decrease in the sodium content. The decrease in the calcium content was relatively very small, about 9.4%. Nutritionally significant levels of Mn, Fe, and Cu were not detected in cassava tuber meal, and this is consistent with findings reported elsewhere (Nestel and Graham, 1977). The results also indicate that mineral elements constituted only about 15% of the total ash in the unfermented meal and about 4% of the fermented meal. The total ash content is not a reflection of the level of mineral content. This shows that the products of this fermentation require adequate supplementation with minerals to meet the body requirement in an event of an all-cassava meal.

Changes in the amino acid composition in the fermented meal are presented in Table III. The various individual amino acids were adequately represented except the sulfur amino acids (methionine and cystine). As the amino acid contents were expressed on a basis of g/kg of dry matter, there were substantial decreases in the various individual amino acids in the fermented meal. But the composition as determined and expressed on a basis of g/16 g of N (Table IV) seemed not to be affected by fermentation. When the quality of the proteins was evaluated in terms of the chemical scores and biological values, calculations based on the methods of Block and Mitchell (1946) with the FAO/WHO (1973) amino acid reference pattern (Table V), the chemical score for the unfermented meal was about 30% and for the fermented meal 27%. The primary limiting amino acids were the sulfur amino acids, although tryptophan was not evaluated. This is in agreement with the extensively reported essential amino acid pattern in cassava proteins (Nestel and Graham, 1977). It could be seen that traditional fermentation caused a reduction in the chemical score of the tuber protein by about 3%. The biological values of 58 and 56% were obtained for the unfermented and fermented meal, respectively. Fermentation accounted for an ~2% reduction in the biological value of the tuber meal.

Table V. Essential Amino Acid Level and Chemical Scores

	essential amino acid composition, g/16 g of N			chemical scores, %	
amino acids	FAO/WHO (1973) ref pattern	unfermented meal	fermented meal	unfermented meal	fermented meal
isoleucine	4.0	3.55	3.41	89	85
leucine	7.0	5.30	5.23	76	75
lysine	5.5	5.19	5.05	94	92
methionine + cysteine	3.5	1.05	0.96	30	27
phenylalanine + tyrosine	6.0	5.49	5.56	92	93
threonine	4.0	3.82	4.08	96	102
valine	5.0	4.11	4.11	82	82

Registry No. Phosphorus, 7723-14-0; calcium, 7440-70-2; magnesium, 7439-95-4; potassium, 7440-09-7; sodium, 7440-23-5; zinc, 7440-66-6.

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Analysis of Sweet Potato (*Ipomoea batatas*) from the Highlands of Papua New Guinea: Relevance to the Incidence of *Enteritis necroticans*

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Analyses have been made for crude protein, amino acids, and trypsin inhibitor content of 21 cultivars of sweet potato collected from two regions of the highlands of Papua New Guinea, one (Upper Mendi region) of high incidence of *Enteritis necroticans* (EN) and the other (Erave region) of low incidence of EN. The incidence of EN occurs in populations that are reported to be low in protein; hence, the analysis of the staple food (sweet potato) *may* give a clue to the difference between the two regions. No significant differences were found in the crude protein content, amino acid scores, or trypsin inhibitor contents between the sweet potatoes from the two regions. The range of crude protein content is 0.5–2 g of protein/100 g of fresh sweet potato; the S-containing amino acids (cystine plus methionine) are limiting in 65% of cases, followed by lysine (23%), leucine (6%), and other amino acids. The average chemical score is 0.6. The trypsin inhibitor content varies greatly over a 67-fold range. No significant correlation (r = 0.057) is found between trypsin inhibitor and crude protein.

Enteritis necroticans (EN) is endemic to the Highlands of Papua New Guinea (P.N.G.), where until recently it was the main cause of death of children over 1 year of age (Lawrence et al., 1979a). The disease is caused by *Clostridium perfringens* type C present in the gut, which produces protein toxins (particulary the β-toxin) that damage the intestinal wall. The diet in the Highlands is very low in protein with sweet potato as the staple food; very occasionally there occurs a high-protein meal or feast. The occurrence of EN normally follows the consumption of high-protein food, usually pig meat, hence the local name "pig-bel" for EN. It is postulated that this causes rapid growth of *C. perfringens* type C, which is either contaminating the meat or already present in the gut (Millar, 1983), with the production of β-toxin, that causes necrosis of the intestinal wall (Lawrence, 1979; Lawrence and Walker, 1976). An effective vaccine has been developed that is in use in the Highlands (Lawrence et al., 1979b), but its ultimate efficacy is limited by its restricted delivery to the population at risk (Lawrence et al., 1979c). It is estimated that at best only about 50% of children will receive full vaccination. Severely protein deficient diets in monkeys (Gyr et al., 1975) are known to cause a diminution of exocrine pancreatic function, hence a lowered concentration of proteases in the gut and a consequent reduction in the attack of β-toxin by trypsin and chymotrypsin. Furthermore, the presence of appreciable levels of trypsin inhibitor in sweet potatoes (Sugiura et al., 1973; Sumathi and Pattabiraman, 1975; Lin and Chen, 1980) that constitute the major component of the diet of the Highland people may retard the tryptic breakdown of the necrotising β-toxin produced by *C. perfringens* type C (Lawrence, 1979).

In this paper we report the analysis for crude protein, amino acids, and trypsin inhibitor of 21 representative varieties of sweet potato from two regions of the Highlands of P.N.G.; in one region there is a high incidence of EN and in the other region there is a low incidence of the disease. The objective is to establish if the difference in

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