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Effects of Stepwise Dietary Processing on the Nutritional Value of the Seeds of *Treculia africana*

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ABSTRACT

The Nigerian cooked testa-free seeds (afon) *of* Treculia africana *were prepared in the laboratory by the traditional technique from raw seeds of* T. africana *and the nutritional consequences of such cooking assessed. Cooking considerably improved the nutritional value of the raw seeds. The protein efficiency ratio was almost trebled (0·7 to 1·9) while the true digestibility and net protein utilisation were significantly increased—from 85·0 to 93·3 and from 41·6 to 69·2, respectively. The biological value of the seeds was greatly improved, from 48·9 to 74·2.*

INTRODUCTION

The amounts of nutrients present in food at the time of consumption depend on the way in which the raw materials are treated during preparation of the food.

Some studies of the apparent losses of nutrients under controlled conditions of cooking and processing of individual foods have been reported in advanced countries (Bender, 1966). In Nigeria, this type of information is still lacking. The fruit of *Treculia africana* is used as a food in many parts of Africa. It is often called African breadfruit because it is

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large and contains edible seeds. *T. africana* is usually found in forests and near streams. It is sometimes planted.

Consumption of the cooked, testa-free seeds of *T. africana* may reduce the relatively high incidence of malnutrition in the developing areas of the world. The present study was undertaken to investigate the effect of heat processing on the nutritional qualities of the seeds of *T. africana*.

EXPERIMENTAL PROCEDURE

Materials

Fruit of Treculia africana

Fruits of the plant, *Treculia africana*, used for this study were collected from the same tree in Ishara-Remo, Ogun State of Nigeria.

Many large fresh fruits were collected and taken to the laboratory.

Raw seeds

The raw, unprocessed seeds were obtained from the fruits described above. The fruits were placed in water in large containers. After five days, the seeds embedded in the spongy pulp of the fruits were extracted and washed thoroughly with water.

Preparation of the parboiled seeds

The raw, unprocessed seeds were boiled in water for 15 min. The boiling water was discarded and the boiled seeds allowed to cool. The boiled seeds were dried in the sun for two days, after which the seed coats were cracked with the aid of small stones, thus exposing the white cotyledons. These were then boiled in water for a further 10 min. The boiling water was again discarded and the white cotyledons allowed to cool. These are now termed parboiled seeds.

Preparation of the cooked testa-free seeds

The cooked testa-free seeds were prepared by further boiling of the parboiled seeds in water (until the boiling water almost dried up). The soft seeds were then broken up into small pieces and ground into a paste.

Milling of the samples

The dried raw seed samples, parboiled seeds and cooked testa-free seeds (*afon*) were milled separately into powdery form and then stored in sealed cellophane bags kept in a freezer at −20 °C until required.

Experimental animals

Fifty male albino rats of the Wistar strain, weaned at 23–24 days, were obtained from the Veterinary Science Department, University of Ibadan, and reared on a commercial stock diet (Pfizer Livestock Feeds Ltd., Nigeria) until they were 30–31 days old and weighed 50–60 g. The rats, which were disease free, were weighed to the nearest 0·1 g, and allocated, on the basis of weight and litter origin, to five groups of ten rats each. The rats were individually housed in a battery of wire cages with facilities for separate faecal and urinary collection.

Composition of the diets

The composition of the diets is shown in Table 1. The milled samples of the raw seeds, the parboiled seeds and the cooked testa-free seeds (*afon*) and casein, respectively, were added to the test diets and control ration, at the expense of maize starch, to give 10 g as crude protein per 100 g of diet. The diets were each initially mixed in a 10-litre plastic bucket and then in a 'Kenwood Chef' domestic food mixer for 20 min. Homogeneity of the diets was checked by determining the nitrogen content of each diet in duplicate immediately after mixing and in the middle of the experimental period.

Composition of salt mixture

Sodium chloride (NaCl), 50 g; calcium phosphate ($Ca_3(PO_4)_2$), 400 g; ferrous citrate ($FeC_6H_5O_7 . 3H_2O$), 35 g; magnesium sulphate ($MgSO_4 . 7H_2O$), 80 g; anhydrous sodium hydrogen phosphate (NaH_2PO_4), 105 g; potassium chloride (KCl), 250 g; potassium iodide (KI), 1·0 g; manganese sulphate ($MnSO_4 . 4H_2O$), 0·2 g and sodium fluoride (NaF), 0·4 g.

TABLE 1
Composition of the Diets (Campbell, 1963)
(Percentage dry weight basis)

Ingredients	*Basal diet*	*Control diet (Casein)*	*Raw seeds*	*Parboiled seeds*	*Cooked testa-free seeds*
Maize starch	80	70	70	70	70
Cottonseed oil	10	10	10	10	10
The milled seeds of *T. africana* (as protein—N × 6·25)	—	—	10 (milled raw seeds)	10 (milled parboiled seeds)	10 (milled cooked seeds)
Casein (as protein—N × 6·25)	—	10	—	—	—
Mineral mixture	4	4	4	4	4
Vitamin mixture	1	1	1	1	1
Cellulose powder	5	5	5	5	5

Composition of the vitamin mixture

Vitamin A, 4000 IU; vitamin D (calciferol), 2000 IU; vitamin E (tocopherol acetate), 280 mg; vitamin K (monaphthone), 2 mg; thiamin, 30 mg; riboflavin, 30 mg; pyridoxine, 8 mg; calcium-D-panthothenate, 100 mg; nicotinic acid, 100 mg; vitamin B_{12}, 50 mg; choline, 1000 mg; pteroyglutamic acid, 1·0 mg, biotin, 0·2 mg; inositol, 220 mg and *p*-aminobenzoic acid, 75 mg. (Riboflavin and pteroylglutamic acid were added last.)

One group of rats was given the nitrogen free basal diet (diet 1), the second group was placed on the casein control diet (diet 2) and the remaining three groups were allocated to the test rations, as shown in Table 1. All diets and water were offered *ad libitum*. Throughout the experimental period, the animal house temperature varied between 27 °C and 29 °C with a mean at 28 °C.

The weights of the animals were recorded every other day throughout the experiment. The first 3 days were regarded as an acclimatisation period during which no records were kept of food consumption and no collection of faeces was made. Collection of faeces was made daily for the last 28 days of the feeding experiment. The faeces of individual rats were pooled, dried at 75 °C for 3 days and ground to a powder, for faecal nitrogen determination. Daily records of food consumption were kept for the last 28 days of the experiment.

For the determination of digestibility, nitrogen was determined on the dried ground faecal samples of each rat by the semi-micro distillation apparatus of Markham (1942). The true digestibility (TD) was calculated by the balance sheet method of Mitchell (1923–1924).

For the determination of the protein efficiency ratio (PER), net protein utilisation (NPU) and biological value (BV), the rats in each group were weighed to the nearest 0·1 g on the last 28 days of the 31-day dietary treatment and killed with chloroform. The food intake in the last 28-day period was measured and this value and the determined crude protein content of the diet were used to calculate the amount of protein consumed during the test. The PER was calculated from these results using the formula given by the United States National Academy of Sciences/ National Research Council (1963). The carcasses of the rats were dried in a hot air circulation oven at 85 °C, after incisions were made into the skull, thoracic and body cavities. The dried carcasses were digested for nitrogen determinations by a modified method of Rippon (1959), the

modification being that it was not found necessary to autoclave the carcass slurry. Complete disintegration occurred when the carcass was first pounded in a porcelain mortar and treated with 100 ml of concentrated sulphuric acid, followed by 100 ml of distilled water. The resultant dark brown solution was made up to 250 ml and 25 ml duplicate portions were taken for determination. The NPU values were calculated using the original equation of Miller & Bender (1955). The BV was computed by dividing NPU by TD (Bender & Haizelden, 1957).

The energy value was determined with a ballistic bomb calorimeter described by Miller & Payne (1959).

RESULTS AND DISCUSSION

Table 2 shows the nutritive values of the raw seeds, the parboiled seeds and the cooked testa-free seeds (*afon*) with the standard deviations. The figures were analysed statistically, using Student's *t* test.

It can be shown from the results that cooking considerably increased the biological value, net protein utilisation and protein efficiency ratio of the raw seeds. The NPU of the raw seeds (41·6) was considerably less than that of the parboiled seeds and this resulted in a very low BV of 48·9 %. Using the diet consisting of the parboiled seeds, there was a significant improvement in BV (66·7) and NPU (60·2) while the PER was also increased (1·7). However, the cooked testa-free seeds (*afon*) were shown to be superior to both the parboiled and raw seeds. The digestibility of *afon* was greatly improved (93·3), while the NPU (69·2) and BV (74·2) were significantly higher than those of either the parboiled or raw seeds. Cooking almost trebled the PER of the raw seeds (0·7 to 1·9).

The results in Table 2 also show that cooking increased the protein (feed) intake of the rats significantly. The lower value observed for the gain in body weight of the rats on the raw seeds might be due to the presence of some growth-inhibiting factors, which have not been identified. However, these are heat-labile and feeding of cooked testa-free seeds brought about considerable gain in the rats' body weight. Hence, the presence of these antinutritional factors in the raw seeds may not pose a problem when they are used for human consumption.

The lower NPU value for the raw seeds (41·6) in the rats (Table 2) might be due to the presence of an unavailable protein fraction in the seeds. Cooking might have increased the availability of the entire protein

TABLE 2

The Total Protein Consumed, Net Body Weight Gain, PER, TD, BV, NPU and NDP cals Per cent of the Rats Fed on the Raw, Unprocessed Seeds; Parboiled Seeds; the Cooked Testa-Free Seeds (*afon*) and the Control Diet (Casein)

Diet	*Total protein consumed* (*g*)	*Net body weight gain* (*g*)	*PER*	*TD*	*BV*	*NPU*	*NDP cals per cent*
Casein (control diet)	29·4 ± 1·6	70·6 ± 0·8	2·4 ± 0·1	95·3 ± 1·1	77·6 ± 2·1	73·9 ± 1·4	8·1 ± 0·2
Raw, unprocessed seeds	25·0 ± 0·4	17·5 ± 0·5	0·7 ± 0·0	85·0 ± 1·4	48·9 ± 1·7	41·6 ± 1·0	4·2 ± 0·3
Parboiled seeds	26·2 ± 0·5	44·6 ± 2·4	1·7 ± 0·3	90·2 ± 1·6	66·7 ± 1·2	60·2 ± 1·3	3·9 ± 0·5
Cooked testa-free seeds (*afon*)	29·3 ± 0·2	55·7 ± 1·4	1·9 ± 0·1	93·3 ± 2·3	74·2 ± 1·1	69·2 ± 0·8	4·5 ± 0·3

Each figure represents the mean value of ten rats together with the standard error.
PER, Protein efficiency ratio.
TD, True digestibility.
BV, Biological value.
NPU, Net protein utilisation.
NDP cals per cent, Net dietary protein calories per cent.

TABLE 3

Comparison of the NDP Cals Per cent of the Unprocessed Seeds, the Parboiled Seeds, the Cooked Testa-Free Seeds and the Control Diet as Determined by Rat Assay Method with the Recommended Scale of Allowance of Miller (1963) and the FAO (1965)

Subject	*Age*	*Recommended allowance of NDP cals per cent Miller (1963) FAO (1965)*	*Raw seeds*	*Parboiled seeds*	*Diets*	
					Cooked testa-free seeds	*Control diet*
Infant	0–3 months	8·3				8·01
	3–9 months	8·0				
Toddler	9 months–3 years	7·8				
Child	3–9 years	5·9				
Adolescent	—	8·4				
Adult	—	4·8	4·23	3·94	4·48	
Pregnant woman (second and third trimester)	—	7·0				
Lactating mother	—	9·5				
Mixed household community	—	6·5				

moiety, as indicated by the higher values obtained for the cooked testa-free seeds (69·2). Oyenuga (1968) and Owusu-Domfeh *et al.* (1970) have shown most raw legumes are poorly utilised and that cooking improves such utilisation.

The NDP cals per cent of the raw seeds, the parboiled seeds and the cooked testa-free seeds, as assayed with the healthy growing rats, were compared with the recommended allowances of Miller (1963) and the FAO (1965) as indicated in Table 3. It can be shown that the cooked testa-free seeds with the highest value ($4{\cdot}5 \pm 0{\cdot}3$) can satisfy the needs of an adult person when consumed in large quantities. Cooking also increased the NDP cals per cent of the raw seeds.

These studies certainly indicate that cooking improved the nutritional value of the raw seeds and brought about a significant gain in body weight of the rats. However, the utilisation of the seeds is limited by the tedious, time- and energy-consuming processes required for their preparation. The prolonged cooking time required for adequate palatability and destruction of anti-nutrients is a major constraint to the utilisation of the seeds. Bressani *et al.* (1963) reported a minimum cooking time of 2 h at atmospheric pressure for the processing of dry beans (*Phaseolus vulgaris*). The raw seeds of *T. africana* take about 3 h to cook (Lawal, 1979). There is, therefore, a need for the development of improved technologies for the processing of the raw seeds.

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