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Nutritional Evaluation and Physiochemical Properties of Boiled and Fried Tree Locust

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Abstract: The proximate composition and the levels of antinutritional factors, protein digestibility, minerals extractability and physiochemical properties of boiled and fried locust flour consumed in Sudan were determined. Results showed that during processing the proximate composition fluctuated for both samples with a maximum protein content of 67.75% and 66.24% for fried and boiled locust flour, respectively. Fried locust flour contained significantly ($p \leq 0.05$) high tannin content (9.00 mg/100g) compared to boil one which contained only 5.8 mg/100g. Phytic acid content was found to be significantly ($p \leq 0.05$) high in boiled locust flour (350 mg/100g) compared to fried locust (293.33 mg/100g). Processing of locust greatly reduced the protein digestibility. In general, results of total and extractable minerals as well as physicochemical properties of both boiled and fried locust slightly similar with few exceptions.

Key words: Locust, boiled, frying, roasting, antinutritional factors, protein digestibility, mineral extractability

Introduction

The acute imbalance between the increase in the rate of population growth and the world food production has led to the present shortage of protein supply and the spread of malnutrition. Available possibilities of bridging the gap between present and future food production level and consumption are the exploitation of new non-conventional food resources and the enrichment of the poor quality foodstuffs. The use of insect as food for man is very common in Africa, Asia, Middle East and Latin America. In Sudan boiled and fried tree locust are the favorable dishes in the western states. The adult of hemiptera, isoptera and orthoptera are usually eaten and the larvae of the coleoptera and lipidoptera also can be consumed (Huis, 1996). Insects are the most successful group of animals constituting about 76% of known species of animals (Yoloye, 1988). Insects affect man either as destroyers of man's valuable materials and crops or as sources of his nutrients. Goodman (1989) reported that chitin, an important insect component, can significantly reduce serum cholesterol and serve as a haemostatic agent for tissue repairs and for accelerating healing of burns and wound. The cultural practice of entomophagy is an old and well-established custom in non-industrialized regions of the world (Sutton, 1988). The high cost of animal protein, which is beyond the reach of the poor has greatly encouraged entomophagy. Insects are valuable sources of animal protein for Zambia's rural population since meat from domesticated and wild animals are scarce (Mwizenge, 1993). An increase in the world supply of animal proteins through mass production of insects can largely eliminate the malnutrition problem and also decrease the pressure on other protein sources. Studies in Nigeria have shown that entomophagy has contributed significantly to the reduction in protein deficiencies in the country (Fasoranti and Ajiboye, 1993). The objective of this study is to investigate the nutritional value and physiochemical properties of processed tree locust to ascertain their suitability as a food.

Materials and Methods

Materials and sample preparation: Two samples of boiled and fried tree locusts (*Anacridium melanorhodon*) were obtained from Mayo local market, Khartoum, Sudan. Both boiled and fried locusts were first cleaned, freed from foreign matter, separated inedible parts and milled in a laboratory miller to pass a 0.4 mm screen and then defatted. Refined Groundnut oil was brought from Bittar Co.ltd, Khartoum. Sudan. Unless otherwise stated all chemicals used in this study were of reagent grade.

Proximate analysis: The proximate (moisture, ash, ether extract, fibre and crude protein) analyses of all samples were done using the method reported by AOAC (1984). Carbohydrate (NFE) content was estimated by difference.

***In vitro* protein digestibility (IVPD) determination:** *In vitro* protein digestibility of samples was measured according to the method of Saunders *et al.* (1973). About 250 mg sample was suspended in 15 mL of 0.1 N HCl containing 1.5 mg pepsin (1:10,000) in a 100 mL conical

flask. The mixture was incubated at 37°C for 3 hours. The mixture was then neutralized with 0.5 N NaOH and treated with 4 mg pancreatin (Grade VI porcine) in 7.5 mL of 0.2 M phosphate buffer (pH 8.0) containing 0.005 M sodium azide. The mixture was incubated at 37°C for 24 hours. About 10 mL of 10% trichloroacetic acid (TCA) were added to the mixture to stop the reaction. The mixture was then centrifuged at 5000 rpm for 5 minutes. About 5 mL of the aliquots from the supernatant were pipetted and analyzed for nitrogen content (AOAC, 1984). Protein digestibility was determined according to the equation:

$$\text{Protein digestibility \%} = \frac{\text{N in supernatant-enzyme N}}{\text{N in sample}} \times 100$$

Determination of tannins content: Quantitative estimation of tannin for each sample was carried out using the modified vanillin-HCl in methanol method as described by Price *et al.* (1978). A standard curve was prepared expressing the results as catechin equivalents, i.e. amount of catechin (mg per ml) which gives a colour intensity equivalent to that given by tannin after correcting for blank.

Phytic acid determination: Phytic acid content was determined by the method described by Wheeler and Ferrel (1971) using 2.0 gm of a dried sample. A standard curve was prepared expressing the results as Fe $(NO_3)_3$ equivalent.

Total minerals determination: Minerals were extracted from the samples by the dry ashing method that described by Chapman and Pratt (1961). The amount of iron, zinc, manganese and Cobalt were determined using Atomic Absorption Spectroscopy (Perkin-Elmer 2380). Ammonium Vandate was used to determine phosphorus along with Ammonium Molybdate method of Chapman and Pratt (1982). Calcium and was determined by titration method that described by Chapman and Pratt (1961). Sodium and potassium were determined by flame photometer (CORNIG EEL) according to AOAC (1984).

HCl extractability of mineral: The HCl extractability of minerals was performed according to Chauhan and Mahjan (1988) method. About 1.0 g was extracted using 10 mL of 0.03N HCl with shaking at 37°C for 3 h. The clear extract obtained was dried at 100°C and then placed in a muffle furnace at 550°C for 4 h. Thereafter, the samples were cooled and about 5 mL of 5N HCl were added and boiled gently for 10 min and then cooled, diluted to 100 mL with distilled water. Minerals were determined as described above.

Water and fat absorption capacity: Water Absorption Capacity (WAC) of the samples was measured by the centrifugation method of Sosulski (1962). Fat Absorption Capacity (FAC) of the defatted samples was measured by the method described by Lin *et al.* (1974).

Bulk density: The bulk density of the samples was determined by the method described by Wang and Kinsella (1976).

Dispersibility: The dispersibility of the samples at selected pH levels (3, 7 and 10) was measured according to the method of Kulkarni and Ingle (1991).

Statistical analysis: Each sample was analyzed in triplicate and the values were then averaged. Data were assessed by the analysis of variance (ANOVA) as described by Duncan' multiple range test with a probability $p \leq 0.05$.

Results and Discussion

Proximate composition of tree locust flour: Two samples of locust (boiled and fried) were used in this study. Boiling of locust usually practiced to preserve it before frying. The results of the proximate composition of the samples tree locust flour are shown in Table 1. The moisture content was quite low and was found to be 5.47 and 7.47% for fried and boiled locust, respectively which may be advantageous in view of the samples' shelf life. The result showed that both fried and boiled tree locust flour are quite rich in protein (67.75% and 66.24%). The result obtained for protein is higher than that reported by Omotoso (2006) for larva of *Cirina ford*. Thus, locust flora could contribute significantly to the recommended human daily protein requirement of 23%~56% stipulated by NRC (1980). The ash content of boiled locust was 5.53% and after frying it was 6.02% which is lower than that obtained for termites (*Trinervitermes germinatus*) reported by Ajakaiye and Bawo (1990). Both fried and boiled locust flour and contained higher amount of oil and expected to interfere with other parameters determination, therefore, the samples were defatted and the remaining oil was found to be 5.25% for both samples, respectively. The value reported for fried locust was higher than that obtained for *Cirina ford* reported by Omotoso (2006). Fats are essential in diets as they increase the palatability of foods by absorbing and retaining their flavours and help in the transport of nutritionally essential fat-soluble vitamins (Omotoso, 2006). Crude fiber was quite high for boiled locust (8.38%) compared to that of fried one. However, the amount of carbohydrate obtained for fried locust was slightly similar to that of boiled locust.

Antinutrional factors and protein digestibility of tree locust flour: Table 2 shows the antinutritional factors content and protein digestibility of locust flour. The level of tannin for both boiled (5.80 mg/100g) and fried (9.00 mg/100g) locust flour was very low. Results obtained for

Table 1: Proximate composition (%) of processed locust

Samples	Moisture	Crude Protein	Crude Fibre	Crude Ash	Ether extract	Carbohydrate (NFE)
Locust flour:						
Boiled	7.47 (±0.210)[a]	66.24 (±0.02)[a]	8.38 (±0.02)[a]	5.53 (±0.38)[b]	5.25 (±0.18)[a]	7.13 (±0.51)[c]
Fried	5.47 (±0.06)[b]	67.75 (±0.03)[a]	7.32 (±0.12)[a]	6.02 (±0.18)[b]	5.25 (±0.27)[a]	8.19 (±0.56)[c]

Values are means (±SD) of triplicate samples. Values having different superscript letters in a column differ significantly at $p \leq 0.05$

Table 2: Antitinutritional factors content (mg/100g) and protein content and digestibility (%) of processed locust

	Protein		Antinutritional factors	
Samples	Content	Digestibility	Tannin	Phytic acid
Locust flour:				
Boiled	66.24 (±0.02)[a]	49.89 (±0.74)[c]	5.80 (±0.46)[d]	350.00 (±43.59)[a]
Fried	67.75 (±0.06)[a]	41.13 (±0.42)[d]	9.00 (±2.56)[c]	293.33 (±72.34)[b]

Values are means (±SD) of triplicate samples. Values having different superscript letters in a column differ significantly at $p \leq 0.05$

Table 3: Minerals content (mg/100g) and HCl extractability (%) of processed locust

	Locust flour			
	Boiled		Fried	
Minerals	Total	Extractable	Total	Extractable
Ca	19.23 (±0.10)[c]	53	19.41 (±0.13)[c]	65
K	35.69 (±0.17)[d]	33	44.36 (±0.10)[c]	44
Na	6.32 (±0.06)[c]	84	3.43 (±0.38)[d]	69
P	4.43 (±0.03)[c]	35	3.53 (±0.03)[c]	35
Fe	12.31 (±0.07)[c]	2	12.20 (±0.17)[c]	3
Mg	0.83 (±0.05)[c]	25	0.56 (±0.01)[c]	13
Zn	2.80 (±0.01)[c]	30	2.95 (±0.09)[c]	33
Co	0.36 (±0.01)[c]	46	0.11 (±0.02)[c]	57

Values are means (±SD) of triplicate samples. Values having different superscript letters in a row are differ significantly at $p \leq 0.05$

locust were lower than those reported by Adeduntan (2005) for the edible insects, who obtained a range of 25-105 mg/100 g and higher than those reported by Enujiugha and Ayodele-Oni (2003) who was unable to detect any amount of it in *C. forda*. It was clear that frying of locust increased tannin content this increment may be due to the facts that frying may cause tannin to migrate to the surface of the sample. Phytic acid content of boiled and fried locust flour was 350.00 and 293.33 mg/100g, respectively. The values obtained in this study agree with those observed by Adeduntan (2005) who reported a range of 110.02-315.90 mg/100 g for edible insects. The results obtained indicated that frying significantly ($p \leq 0.05$) reduced phytic acid content. The *in vitro* protein digestibility (IVPD) of boiled and fried tree locust flour was 49.89 and 41.13%, respectively. It was clear that frying of locust significantly ($p \leq 0.05$) reduced the IVPD of the protein. The lower values of IVPD for locust samples will be attributed to phytate which complexed with proteins and render them unavailable. Moreover, the negative effect of cooking on the IVPD could be due to the formation of disulphide bond in the protein (Oria *et al.*, 1995) together with an increase in fiber content or due to possible loss in available lysine (Bressani *et al.*, 1984).

Total and extractable minerals of tree locust flour: Table 3 shows total and extractable minerals of tree locust flour. Ca content of both boiled and fried locust was found to be 19.23 and 19.41 mg/100g and out of this amount about 53 and 65% was found to be extractable, for boiled and fried samples, respectively. Results obtained for locust were lower than that of *Rhynchophorus phoenicis* larva (54.6 mg/100g) reported by Morah *et al.* (1998). Results obtained for K for boiled and fried locust flour are similar to that obtained for Ca. Although both fried and boiled locust flour contained lower amount of Na, the extractable amount was found to be very high (84 and 69%) for boiled and fried flour. Results obtained for Na for locust were lower than those reported by Morah *et al.* (1998). Phosphorous content of both locust flours was very low, but their extractability was more or less similar for both samples. Iron (Fe), Mn, Zn and Co contents and extractability were found to be higher for boiled compared to fried locust flour with few exceptions. Results obtained indicated that locust flour were very poor in total and extractable minerals. However, reduction in total minerals of processed locust may be attributed to washing out of the mineral during boiling and reduction in extractability is likely to be due to complexation with other food constituents as well as antinutrients.

Table 4: Physiochemical property of boiled and fried locust flour

	Locust flour	
Physiochemical property	Fried	Boiled
Fat absorption capacity (ml/100 g)	1.30 (±0.06)[c]	1.00 (±0.10)[c]
Water absorption capacity (ml/100 g)	2.47 (±0.23)[c]	2.93 (±0.12)[c]
Bulk density (g/ml)	1.82 (±0.03)[b]	1.50 (±0.20)[b]
Dispersibility (%)		
pH 3	61.00 (±1.73)[b]	61.00 (±1.73)[b]
pH 7	65.57 (±1.96)[b]	64.43 (±1.96)[b]
pH 10	55.23 (±1.75)[c]	60.33 (±0.58)[b]

Values are means (±SD) of triplicate samples. Values having different superscript letters in a row are differ significantly at $p \leq 0.05$

Physicochemical properties of tree locust: Fat Absorption Capacity (FAC) was 1.0 ml/g for boiled locust and slightly increased to 1.3 ml/g after frying. Oil absorption capacity may determine whether the protein will perform well as meat extenders (Circle and Smith, 1972) and also it is important since oil acts as flavour retainer and increases the palatability of foods (Kinsella, 1976). Water Absorption Capacity (WAC) values of boiled and fried locust flour were found to be 2.93 ml/g and 2.47 ml/g, respectively. Results obtained indicated that processing of locust slightly reduced WAC. The increase in WAC could be caused by the dissociation of proteins that might occur as a result of heating and denaturation and could be minimized by short-period treatment (Abbey and Ibeh, 1987). The degree of WAC is considered to be useful as an indication of performance in several food formulations, especially those involving dough handling (Circle and Smith, 1972). The Bulk Density (BD) of boiled and fried locust was 1.5 and 1.82 g/ml, respectively. Results obtained for BD showed that processing of both samples slightly increased it. Higher bulk density is desirable since it helps to reduce the paste thickness which is an important factor in convalescent and child feeding (Padmashree *et al*., 1987). As shown in Table 4 both boiled and freid locust flour had high dispersibility at pH 7 compared to other pH values. It was reported that higher dispersibility enhances emulsifying and foaming properties of proteins, which was observed during bread making, macaroni and cookies (Kinsella, 1979).

In conclusion, the results obtained in this study indicated that both locust samples are rich sources of nutrients. Therefore, they can be consumed as food or as supplementary ingredients especially in Africa and Asia to alleviate the problem of nutrient/protein malnutrition. Further work is needed to evaluate the nutritional value by using *in vivo* tests.

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