FULL LENGTH RESEARCH ARTICLE

PROXIMATE AND MINERAL COMPOSITION OF *TAMARINDUS INDICA* LINN 1753 SEEDS

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ABSTRACT
Physical parameters and nutrient contents of the whole seeds and seed nuts of *Tamarindus indica* L. 1753 were determined. Crude protein was between 21.25–22.20%, carbohydrate ranged from 8.9-17.10%, crude fibre was 2.33–3.82 %, crude lipid 6.94-11.43 %, in seed nuts and whole seeds respectively. Moisture contents were higher in the seed nuts 19.90 %. Removal of the seed coat increased the mineral elements in the seeds. Sodium to Potassium ratio (Na/K) was 0.1 and 0.09 while Calcium to Phosphorus ratio (Ca/P) was 0.39-1.24, with calorie values of 210.90 and 122.41 kcal/100g for whole seeds and seed nuts respectively. The length of pod (LOP) was 7.30 ± 1.31 cm (*n=50*), breadth of pod (BOP) was 3.05 ± 1.20 cm. *T. indica* seed nuts were found to be potential sources of mineral elements while the whole seeds were richer in other proximate components with the exception of moisture and ash contents.

Keywords: *Tamarindus indica,* proximate composition, mineral composition, whole seed, seed nuts

INTRODUCTION
The importance of wild plants in the diets of people in developing world is in the increase because the countries continues to suffer from drought and other weather related calamities, which tend to decrease the yields of their traditional grain staples such as millet, maize, and sorghum (Glew *et al.* 1997). Since the 1980's, 13 of 41 African countries have experienced a decline in the yields of cereals, and 15 saw decline for tubers and root crops (Paarlberg 1996). Other reasons includes the tightening of the world grain markets resulting in the depleting of the world grain reserves which are now approaching their lowest levels as well as the fierce competition between human and livestock for the same food or land on which the food is grown. The high cost of producing and maintaining livestock, which are priority source for balanced diets in the developing world also constitute a major problem. Ayres (1999) estimated that to produce 1 kg of feedlot beef requires 7 kg of feed grain, which takes 7,000 kg of water to grow and further stated that as more water is used for raising livestock at the expense of crop cultivation, millions of wells will run dry. Some parts of Africa are already running freshwater deficits. These reasons validate the proposition to investigate and document the potentials of some wild seeds for use as food for man or livestock, particularly at this time when more efficient ways of feeding the human population are needed.

The tamarind is grown throughout the tropics as an ornamental tree and an important legume (Bhattacharya *et al.* 1994). It is widely distributed in Nigeria across the different ecological zones (Keay & Onochie 1964). The plant originated from Africa and was introduced long ago into India, and not vice versa as is often believed (Duke *et al.* 1981; Morton 1987).

The aim of this work was to investigate the nutrient contents of *Tamarindus indica* Linn seeds to raise its public and nutritional potential for human and livestock.

MATERIALS AND METHODS
Fruits of *Tamarind indica* were collected in Zaria, Kaduna state Nigeria between the months of November and January and subjected to the following:

Physical measurement and sample preparation: The length of pod (LOP), the breath of pod (BOP), the number of seeds per pod (NOSPP), and the weight of the seeds (WTOS) were measured. The fruits were soaked to soften in water and the pulp washed to remove the seeds. These were divided into two, one set to dry under the sun while the other was soaked for 14 days to remove the seed coats and obtain the seed nuts. The seed nuts were then dried under the sun after which both the dried seeds and seed nuts were finely ground and sieved into fine powders and stored separately in screw tight sample containers until required for analysis.

Proximate analyses: The proximate analyses for moisture, dry matter, ash, organic matter, lipid (fat) content and crude fibre were carried out in triplicates according to the methods described by AOAC (1984). Nitrogen was determined by the micro-kjedahl method as modified by Cocon & Diane (1973) and the nitrogen content was converted to protein by multiplying by 6.25 (Jeanette 1987). Carbohydrate was determined by the Manual Clegg Anthrone method as described by Osborne & Voogt (1978). All proximate results were expressed as percentage of sample analysed.

Estimation of energy value: The sample calorific value was estimated (in kcal/g) by multiplying the percentages of crude protein, crude lipid and carbohydrate with the recommended factors (2.44, 8.37 and 3.57 respectively) as proposed by Martin and Coolidge (1978).

Mineral elements analysis: Sodium (Na) and Potassium (K) were determined using the standard flame emission photometer. NaCl and KCl were used as the standards (AOAC 1984). Phosphorus was determined calorimetrically using the spectronic 20 (Gallenkamp, UK) as described by Pearson (1976) with KH_2PO_4 as the standard. Calcium (Ca), Magnesium (Mg) and Iron (Fe) were determined using Atomic Absorption Spectrophotometer (AAS Model SP9). All values were expressed in mg/100g.

RESULTS

Results of physical measurements of the pods and seeds shows that the mean LOP was 7.30 ± 1.31 cm (*n=50*), while the mean BOP was 3.05 ± 1.20 cm (*n=50*).

Table 1 presents the results for proximate analyses of *T. indica* whole seeds and seed nuts. The highest proximate component was organic matter with the range of 90.49-92.65 % in seed nuts and whole seeds. Dry matter contents were also high in both seed nuts and whole seeds (80.10-88.25 %). Moisture content in the seed nuts was 19.90 ± 0.1 %, higher than 11.75 ± 0.25 % recorded in whole seeds.

TABLE 1: PROXIMATE COMPOSITION OF WHOLE SEEDS AND SEED NUTS OF *T. INDICA* (%DRY MATTER BASIS) AND CALORIE (Kcal/100g)

Parameter	Whole seeds*	Seed nuts*
Moisture %	11.75± 0.25	19.90± 0.1
Dry matter %	88.25± 0.25	80.1± 0.1
Ash content %	7.35 ± 0.55	9.51 ± 0.01
Organic matter %	92.65 ± 0.55	90.49 ± 0.02
Carbohydrates %	17.10 ± 0.1	8.9 ± 0.9
Crude lipid %	11.43 0± 0.07	6.94 ± 0.06
Crude fibre %	3.82 ± 0.005	2.33 ± 0.02
Crude protein %	22.20 ± 0.55	21.25 ± 0.01
Calorie value (kcal/100g)	210.90	122.41

* Mean ± Standard Deviation of three replicates.

The values for crude protein recorded were 22.20 ± 0.55 % for whole seeds and 21.25 ± 0.01 % for seed nuts. The crude lipid in seed nuts was 6.94 ± 0.06 %, lower than in whole seeds (11.43 ± 0.07 %).

The analysis of carbohydrate contents gave values of 17.10 ± 0.1% in whole seed and 8.9 ± 0.9 % in seed nuts. In terms of energy yield expressed in kcal/100g, more calories (210 kcal/100g) occurred in the whole seeds than the seed nuts (122.41 kcal/100g), agreeing with values earlier reported by Ega (1986) on her studies with *T. indica* and *Parkia spp* seeds.

The mineral composition of *T. indica* whole seeds and seed nuts is shown in Table 2.

TABLE 2: MINERAL COMPOSITION IN Mg/100g OF *T. INDICA* WHOLE SEEDS AND SEED NUTS

Mineral (mg/100g)	Whole seeds*	Seed nuts*
Sodium (Na)	2.1 ± 0.05	3.8 ± 0.05
Potassium (K)	21.0± 0.02	41.0 ± 0.01
Calcium (Ca)	10.0 ± 0.05	31.0 ± 0.02
Magnesium (Mg)	15.0 ± 0.05	13.2 ± 0.01
Iron (Fe)	75..9 ± 0.09	102.40 ± 0.1
Phosphorous (P)	25.5± 0.05	25.0± 0.02
Na/K	0.1	0.09
Ca/P	0.39	1.24

* Mean ± Standard Deviation of three replicates.
Na/K = Sodium to Potassium ratio.
Ca/P = Calcium to Phosphorus ratio

The highest mineral element was iron with values of 75.39 ± 0.09 mg/100g in whole seeds and 102.40 ± 0.1 mg/100g in the seed nuts. Whole seeds and seed nuts of *T. indica* contained the same amount of phosphorus (25.0 ± 0.05 mg/100g). However, the calcium contents of whole seeds were lower (10.0 ± 0.05 mg/100g) than that of the seed nuts (31.0 ± 0.02 mg/100g). The results of Sodium to Potassium (Na/K) ratio and that of Calcium to Phosphorus (Ca/P) are shown in Table 2.

DISCUSSIONS

The results of the physical measurements of the whole nuts and seeds of *T. indica* gave comparable values that fall within the range obtained by Dalziel (1948) and Duke *et al.* (1981).

The high proximate component observed in seed nuts and whole seeds during the present study as well as high dry matter contents were lower than the 31.60 % obtained by Ekop (2007) for *Gnetum africanum* Welw. 1930 (Afang) seeds and Okeoma (1984) for fermented locust beans. Ash contents which is an indicator for mineral elements for whole seeds (7.35 ± 0.55 %) was lower than in seed nuts (9.51 ± 0.01 %), an indication that the seed nuts contains high amounts of some mineral elements. These values were higher than the range of 3.2-4.6 g/100g reported in Nigerian underutilised legume flours (Aremu *et al.* 2006) and 1.8-7.2 % in 104 legume seeds (Prakash *et al.* 2001).

The lower values for crude protein recorded during the present investigation were in agreement with those reported by Ega (1986) and within the range of 20-37% reported by Glew *et al.* (1997) for indigenous plants of Burkina Faso, but lower than those reported for *Acacia mellifera* (Vahl) Benth 1796, *Bauhinina triandra* Roxb. 1832, *Lathyrus odoratus* Linn 1788 and soybean (Prakash *et al.* 2001), hence showing that *T. indica* will not be a very good source of plant protein on its own unless incorporated with other protein sources or feeds in case of livestock.

The value of the crude lipid in *T. indica* seed nuts was 6.94 ± 0.06 %, lower than in whole seeds (11.43 ± 0.07 %). Generally, these values were lower than the range of 22.8–23.5 % reported in soya beans (Salunkhe *et al.* 1985), 27.1% for *dinyan kwakwa* (Glew *et al.* 2005) and 75 mg/g for *T. indica* seeds reported in Glew *et al.* (1997). The high values reported by Glew *et al.* (1997) could be because they use a different method of solvent extraction and lipid analysis using GC/MS. These values were within the range reported by Ega (1986) which confirmed that whole seeds of legumes are richer than the seed nuts in lipid contents.

The analysis of carbohydrate contents in *T. indica* indicated a low value in seed nut than in whole seed. These values are much lower than carbohydrates value of 87.62 ± 004 % in *G. africanun* seeds (Ekop 2007) but within range reported for legumes reported by Parkash *et al.* (2001), suggesting that the seeds of *T. indica* are poor sources for carbohydrates on their own compared to other food sources like vegetables.

Fibre is an important part of diet, which decreases serum cholesterol levels, risk of coronary heart disease, hypertension, diabetes, colon and breast cancer (Ishida *et al.* 2000). Values for crude fibre were within the range reported for legumes by Prakash *et al.* (2001) and for Nigerian underutilised legumes (Aremu *et al.* 2006). However, the values are below the RDA for fibre in children and lactating mothers, which are 19-25, and 29% respectively (Ishida *et al.* 2000).

Iron was the highest mineral element in T. indica both in whole seed and seed nut, an indication that it could serve as a good source of iron, since daily requirement is 1.00 mg/100g (Bothwell *et al.* 1989 quoted by Ishida *et al.* 2000). Adeyeye & Otokiti (1999) described iron as an essential trace element for haemoglobin formation, normal functioning of the central nervous system the oxidation of carbohydrates, proteins and fats.

These values for phosphorus and calcium in whole seed and seed where within the range reported for edible wild plants (Glew *et al.* 2005). Earlier reports (Fleck 1976), revealed that calcium, magnesium, phosphorus, manganese in conjunction with vitamins A, C, D, and protein are involved in bone formation. Because of the similarities of the results, it is therefore possible for *T. indica* to serve as a rich source for minerals involved in bone formation.

The Na/K ratio in the body is important because it helps in controlling high blood pressure. Na/K ratio of less than one is recommended, hence the whole seeds and seed nuts of *T. indica* could be useful in lowering blood pressure, which comparing favourably with flours of some Nigerian underutilised legumes (Aremu *et al.* 2006). The concept of Ca/P ratio was introduced by Shills and Young (1988). It takes into cognisance that modern diets, which are rich in animal proteins and phosphorus, promote the loss of calcium in urine. If the Ca/P ratio is low high amount of calcium may be loss in urine, resulting in a decrease of the calcium levels in bones. Nieman *et al.* (1992) considered a food source good if the Ca/P ratio is above 1 and poor if the ratio is less than 0.5. The seeds nuts of *T. indica* happen to be good food source (Ca/P ratio= 1.24) for minerals used in bone formation, while the whole seeds (Ca/P ratio = 0.39) as bad food source in terms minerals used in bone formation.

The results obtained in this study suggest that the removal of seed coat decreases the organic matter content, carbohydrates, crude fibre, crude protein and the calorie values, while it served to increase the moisture contents and ash content, thus increasing the mineral contents of the seeds. Overall, *T. indica* seeds could be incorporated as food sources for human and livestock after investigating their antinutritional components and possibly removing or reducing them like in some other commonly used legumes.

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