Physicochemical Characteristics, Antinutritional factor and functional properties of Tamarind fruit pulp and seeds powder

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Abstract

Tamarind is native to tropical Africa, especially in Sudan. Tamarind tree produces eatable, unit like natural product which are utilized widely in cooking styles all over the country. Different purposes incorporate customary medications and metal shines. The present study aimed to chemical composition, antinutrients and functional properties of Tamarind fruit (*Tamarindus indica L*) pulp and whole seeds grown in Sudan. Samples of tamarind fruit were collected from north Kordofan state local market (El-Obaid City), season 2014 -2015. The nutritional value of tamarind fruit pulp and whole seeds was evaluated using chemical methods The chemical analysis indicated an increase of moisture content of fruit pulp (FP) (12.73%) as compared with seeds powder (SP) (7.98%). The other chemical components of (FP) and (SP) were as follows: the ash content 4.33% and 2.16%, protein content: 6.42% and 7.90%, fat content 0.80% and 3.82%, fibber content 3.41% and 22.25% Moreover, the antinutritional factors such tannin, phytate and poly phenol content (%) of (FP) and (SP) were found to be 0.172% and 0.01% for tannin, 0.01795% and 0.082 % for phytate and 1.252% and 1.432% for poly phenol respectively. (FP) and (SP) contained 1150 and 140 PPM of potassium and 90 and 20 PPM of iron respectively, as the highest and lowest minerals respectively. The (FP) functional proprieties of tamarinds fruit pulp show that tamarind pulp had ability to bind to water and make viscous porridge, and had high emulsification activity, and poor foaming capacity.

Keywords: Tamarind, Sudan, functional properties, minerals, antinutritional, medicinal, proximate

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1. Introduction

Tamarind (*Tamarindus indica L.*) is an exotic fruit from the Fabaceae family that thrives in semi-tropical regions with low rainfall, conditions that promote optimal fruit development. Although originally native to Madagascar, tamarind has spread worldwide due to its easy adaptability and efficient seed propagation, The fruit is structurally divided into four main parts: Peel – Dark brown or gray with longitudinal and horizontal cracks. Fibers – Branched, woody structures that cling to the pulp. Edible pulp – Brown, with a sweet or acidic taste. Seeds – Oval, shiny, and dark brown, enclosed within the endocarp (Azad, 2018).

According to Abubakari and Muhammad (2013). The tamarind tree was brought to India long ago and adapted there, to the point where it is frequently claimed to be indigenous to that country. Some scientist went on to say that it probably came from Asia. The Arabs and Persians called it "Tamar Hindi" (Indian date), from the dried pulp's date-like appearance and traded it, giving it both its common name and its generic name. Sadly, the particular name "indica" also perpetuates the myth that it is Indian in origin. There is only one species (indica) in the genus Tamarindus because its taxon is monotypic (Chimsah *et al*., 2020) According to El-Siddig (2006) tamarind is primarily valued for its fruit, particularly its pulp, which is utilized for numerous domestic and industrial applications. Tamarind is primarily grown by smallholder farmers in Africa, where it is not widely grown. The fruit are obtained either from semi-domesticated individual tamarind trees that have been preserved, protected, or planted by farmers (Diallo *et al*., 2008) or from wild natural populations of tamarinds (Bourou *et al*., 2012).

Tamarind pulp is widely used in the preparation of various food products. Additionally, it serves as a raw material for manufacturing several industrial products, such as tamarind juice concentrate, tamarind pulp powder, tartaric acid, pectin, tartrates, and alcohol (Wal *et al*., 2024). While the nutritional composition of tamarind fruit pulp varies depending on geographical conditions (Reis *et al*., 2016), the nutritional profile, antioxidant content, and antinutritional factors of tamarind grown in Sudan have not yet been investigated.

Tamarind pulp, which makes up about 30–50% of the fruit, has long been used as a spice in Asian cuisine, thanks to its content of reducing sugars and tartaric acid that create a distinct blend of sweet and sour flavours (Rao & Mathew, 2012). Various tamarind-based products are available on the market, including juice, syrup, frozen pulp, dehydrated fruit, jellies, and sweets. Industrial processing of tamarind ensures its availability throughout the year, even in regions where it is not grown. However, this process generates a significant amount of by-products, as 11–30% of the fruit consists of peel and 25–40% consists of seeds (Martins *et al*., 2020)

Tamarind by-products are often utilized in animal feed or discarded into the environment (de Souza *et al*., 2018). Research shows that these by-products contain significant nutritional value, offering carbohydrates, proteins, vitamins, and minerals. Additionally, they are rich in bioactive compounds, including phenolics, polysaccharides, polyphenols, alkaloids, and fatty acids (Sivakumar and Karuppaiyan, 2020). The bioactive elements found in tamarind seeds exhibit properties such as antioxidant, anti-diarrheal, and anti-inflammatory effects (Gupta, 2017). Meanwhile, the peel has been linked to antioxidant and cytotoxic activities (Ngwewondo *et al*., 2018)

The objective of the present study was to determine the physicochemical characteristics, antinutritional factor, mineral content and functional properties of Tamarind fruit pulp and seeds kernels.

2. Materials and methods

2.1. Preparation of Samples

Tamarind (Tamarindus indica L.) fruit sample were obtained from north Kordofan state local market (El-Obaid City), season 2014 -2015, and then transported into sacks to the Food Laboratory, Department of Food Science and Technology, University of Khartoum, Shambat, Sudan. The tamarind samples were cleaned to removed any foreign material. For chemical analysis, the seeds were separated from the pulp .

2.2. Proximate analysis of Tamarind pulp and seeds kernels

Analysis of proximate composition was carried out on the samples of tamarind fruit pulp and seeds kernels to determine the contents of crude protein, crude fat, crude fiber, moisture content, crude oil, ash and total carbohydrate according to (AOAC, 2006) methods. The total carbohydrate was obtained by calculation as the difference between the sum of the other major ingredients, moisture, ash, crude fiber, crude protein and fat from 100, i.e. Total carbohydrate content = 100-(% moisture + % crude protein + % crude fiber + % crude fat + % ash).

2.3. Determination of Functional properties of tamarinds fruit pulp

2.3.1. Water Holding capacity (WHC)

It was determined according to Hansen, (1978). One gram of tamarind samples was accurately weighed in a Petri-dish, and then transferred to desiccators (half -filled with distilled water) and incubated for: 24, 48, 69, 120 and 144 hours, the Petri-dish with samples were then reweighed and finally expressed as percentage as follows.

$$WHC(\%) = \frac{W_2}{W_1} \times 100$$

Where
WHC = Water Holding Capacity.
W_1= Weight of the added water.
W_2 = Weight of formulation.

3.2.2. Determination of Emulsifying Stability

It was determined according to (Kinsella, 1979). Tamarind solution (20% concentration) was mixed with oil (Sunflower oil) at ratio of 80:20 W/W respectively; they were mixed using a blender for one minute. The mixture was then diluted to the ratio of 1:1000 and it was read at 520 nm. The second reading was taken after one hour. Emulsifying stability was calculated as follows:

$$E.S = \frac{first\ reading}{reading\ after\ 1hour}$$

Where:
E.S = Emulsifying stability.

3.2.3. Determination of Foaming properties

The foaming capacity (FC) was assessed using the procedure described by Kabirullah and Wills, (1982).This involved blending 30 ml of sample (1%) for 2 min at 25˚C. The mixture was poured into 100 ml measuring cylinder and the foam volume was recorded after 30
sec. Foaming capacity (FC) was calculated as percentage using the formula :-

$$FC(\%) = \frac{volume\ after\ whipping - volume\ before\ whipping}{volume\ before\ whipping} \times 100$$

2.4. Antinutritional factors determination

Tannin content of dried, ground tamarinds (FP) and (SP) was determined according to Price *et al.* (1978), Phytate was determined according to the method of (Wheeler & Ferrel R, 1971). The method as described by Price *et al.* (1978) was used to determine Total Polyphenols

2.5. Determination of minerals content

The determination of the tamarind pulp and seed mineral contents were carried out using X-ray fluorescence spectrometer (XRF). Described by Székely *et al*. (2014). The used equipment is a brand Pan analytical, Axios max 4.0 kw, XRF device. The X-ray fluorescence spectrometry as an instrumental analytical method is able to determine elemental composition of solid and fluid samples from minimal prepared sample size.

The sample was treated by ignition in a muffle furnace until it turned gray-white. A 10-gram portion was then weighed and thoroughly mixed with cellulosic material. The sample was transferred into an aluminum disc and compressed to a minimum volume using a pressure machine before examination.

In the course of the process the sample is shot by the X-ray thus the atoms within the sample were became excited, so typical characteristic radiation for particular elements is emitted. Energy (wavelength) of these characteristic radiations changes element by element and this fact is considered as the bottom line of the qualitative element analysis. The intensity of characteristic radiation of the element is commeasurable to its concentration which permits the qualitative analysis.

2.6. Statistical analyses

Replicate of each sample was analysed using statistical system, the analysis of variance was performed to examine the significant effect in all parameters, Least Significant Difference test (LSD test), was used to separate the means (Peterson, 1985).

3. Results and discussion

3.1. Chemical Composition of Tamarind Fruit Pulp and Seed Powder

The chemical composition of the tamarind fruit pulp is shown in Table (1). The average value of moisture, fat, ash, crude fiber, crude protein and carbohydrate content for tamarind (FP) content was 12.73%; 0.80%; 4.33%; 3.41%; 6.42% and 62.31% respectively. Higher and lower values for chemical composition of different varieties of tamarind (FP) were reported by FAO (1970), the moisture content of tamarind (FP) ranges from 15 – 47%, fat content in the range of 0.90 – 1.00%, protein content in the range 14.00 – 3.40%, fiber content and carbohydrate content 62.50%.

These findings were comparable to results of Coronel (1991) and Feungchan *et al*. (1996) who stated that the average value of moisture, fat, ash, crude fiber, crude protein and carbohydrate content for (FP) content was 17.8 - 35.8%; 0.6%; 2.6-3.9%; 2.9%; 2 - 3% and 41.1- 61.4% respectively, and Abdelrahman (2011) stated that the tamarind fruit pulp varieties grown in Sudan, average value of moisture, ash, crude fiber, crude protein and carbohydrate were 14.09%; 2.98%; 3.90%; 73.83% respectively, and (Eltom, 2006) reported that the composition of tamarind fruit pulp grown in Darfur and kordofan were 15.2 - 6.1 % for moisture content, 2.4 – 3.5 % for ash content, 4.5– 3.2% for crude protein, 5.95 – 4.2 % for crude fiber, 0.15 - 0.08% for fat content and 71.8 – 82.29 % for total carbohydrate.

The average value of tamarind (SP) content were 7.98% for moisture, 3.82% for fat, 2.16% for ash, 22.25% for crude fiber, 7.90% for crude protein and 55.89% for carbohydrate content. These findings similar to Morad *et al*. (1978); Ishola *et al*. (1990); Bhattacharya *et al*. (1994) whose reported that the composition of tamarind seed were 9.4 -11.3% for moisture, 1.60 – 4.2 % for ash, 13.3 – 26.9% for crude protein, 4.5 -16.2 for crude fat, 7.4 – 8.8% for crude fiber and 50.0 – 57.0% for total carbohydrate content.

Table 1. Chemical composition and antinutritional factors of tamarinds fruit pulp and seed powder (per 100 g)

	Fruit pulp %	Seed powder %
Moisture %	12.73	7.98
Fat %	0.80	3.82
Ash %	4.33	2.16
Fiber %	3.41	22.25
Protein %	6.42	7.90
Carbohydrate%	62.31	55.89
Tannin (ppm)	0.172	0.01
Phytate (ppm)	0.01795	0.082
Poly phenol (ppm)	1.252	1.432

Higher and lower values for the chemical composition of different varieties of tamarind fruit pulp and seed powder, values mentioned above were reported to be attributed to climatic condition differences and genetic variation.

3.2. Antinutritional factors of tamarind fruit pulp and Seed Powder

As shown in Table (1), the content of tamarind (FP) from antinutritional factor, the tannin, phytate and poly phenol were 0.172 %, 0.01795 % and 1.252 % respectively, these findings agree with (Eltom, 2006) who state that the tamarind varieties grown in Darfur and kordofan has content of tannin, phytate and poly phenol were 0.270 - 0.150 %, 0.027 - 0.029 % and 1.080 - 0.920 % respectively. These results are lower than those obtained by Meillon (1974); Parvez *et al*. (2003). They found the tannin content of tamarind fruit pulp was 0.6%. (Ishola *et al*., 1990). Report that the tamarind pulp does not contain any detectable amounts of phytic acid. The content of tamarind (SP) from antinutritional factor, the tannin, phytate and poly phenol were 0.01%, 0.082% and 1.432 % respectively.

3.3. Functional proprieties of tamarinds fruit pulp

3.3.1. Water Holding Capacity (WHC)

Water Holding capacity represents the ability of a product to associate with water under conditions where water is limiting, like in dough (Giami and Bekebain, 1992). The results were presented in table (2) (54.49 %) were similar to that found in guar gum by findings of (Eldirany, 2009) who stated that water holding capacity for four guar genotypes range between 58.84 and 81.67%, suggest that tamarind pulp had ability to bind to water and make viscous porridge.

3.3.2. Emulsifying Stability

Emulsifier are classified as a group of surface-active agents that can stabilize a dispersion of two liquids such as water and oil, which are essential for emulsion formation and stabilization to occur, (Kinsella, 1979). Tamarind pulp gives improved dispersivness and emulsification although it appears that this emulsification activity. As shown in table (2). The results (1.18 ES) indicate that tamarind pulp had higher emulsification activity, this result were higher than that found in guar gum by findings of (Eldirany, 2009) who stated that emulsifying stability for four guar genotypes range between 0.86 and 1.06 ES, suggest that tamarind pulp had ability to use as emulsifier agent

3.3.3. Foaming Capacity

Foam is a colloid of many gas bubbles trapped in a liquid. The foam can be produced by whipping air into liquid as much and fast as possible (Sikorski, 2002). Foaming capacity of fruit are depend on some criteria including type of fruit, acidity, pH and temperature of the medium as well whipping methods. As shown in table (2). The results (6.17%) were indicate that tamarind pulp had poor foaming capacity, this result were lower to that found in guar gum by findings of (Eldirany, 2009) who stated that foaming capacity for four guar genotypes range between 26.0 and 27.94 %.

Table 2 Functional proprieties of tamarinds fruit pulp

Functional properties	
Water Holding capacity	54.49 %
Emulsifying stability	1.18 ES
Foaming capacity	6.17 %

3.4. Mineral content of tamarind fruit pulp:

Table (3). Shows the content of tamarind (FP) from mineral , these findings were in some point similar to the finding of Eltom (2006) who stated that the tamarind fruit pulp varieties grown in Darfur and kordofan have content of Sodium (400 – 700 ppm), Calcium (2200 – 1900 ppm), Phosphorous (1000 – 1100 ppm), Iron (105 – 248 ppm), Copper (6 ppm) and Zinc (12 – 16 ppm) Sulfur (1900 – 1500 ppm), Potassium (3200 – 5400 ppm) and Magnesium (2100 – 1600 ppm) respectively.

These results were also similar to the values obtained by Abdelrahman (2011) who reported that the tamarind (FP) varieties grown in Sudan has content of Calcium (1490 ppm), potassium (3620 ppm) and Iron (396 ppm).These results also are similar to the values obtained by Marangoni *et al*. (1988); Ishola *et al*. (1990); Bhattacharya *et al*. (1994); Parvez *et al*. (2003). Who reported that tamarind (FP) contain of Sodium (30 – 767 ppm), Calcium (810 – 4660 ppm), Phosphorous (860 – 1900 ppm), Iron (13 – 109 ppm), and Nickel (5 ppm) and Potassium (620 – 5700 ppm) and lower in Copper (8 – 12 ppm) Zinc (8 – 11 ppm), Magnesium (250 – 720 ppm) and Nickel (5 ppm).Table (3). Show the content of tamarind (SP) from minerals. These results are comparable to the values obtained by Marangoni *et al*. (1988); Ishola *et al*. (1990); Bhattacharya *et al*. (1994) and Parvez *et al*. (2003). Who reported that tamarind seed contain of Sodium (192 – 288 ppm), Calcium (93 – 7860 ppm), Phosphorous (684-1650 ppm), Iron (6.5 ppm), and Potassium (2728-6100 ppm) , Copper (16-190 ppm) Zinc (2.8 ppm), Magnesium (175-1183 ppm), Nickel (5 ppm) and Manganese (9 ppm).

Table 3. Mineral content of tamarind (FP) and (SP)

Minerals	(FP) ppm	(SP) ppm
Na	350	130
S	610	410
Ca	1501	680
K	1666	4640
Mg	5960	4160
P	1150	140
Fe	90	20
C	955700	97800
Al	760	80
Si	1090	220
Cl	140	70

4. Conclusions

Tamarind pulp holds significant commercial potential for the production of beverages and jams on an industrial scale in Sudan. The fruit pulp exhibits a complex chemical composition, characterized by low water content, high carbohydrate levels, and essential minerals, similar to many other fruits. This makes it a valuable nutritional source for human consumption.

ACKNOWLEDGEMENTS

The authors express their sincere appreciation to the staff members and technicians of the Department of Food Science and Technology, Faculty of Agriculture, University of Khartoum for their unlimited assistance.

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