International Journal of Plant Research 2015, 5(1): 13-18
DOI: 10.5923/j.plant.20150501.03

Physicochemical Characteristics of Local Varieties of Tamarind (*Tamarindus indica* L), Sudan

Abdel Moneim E. Sulieman[1,*], Salwa M. Alawad[2], Magdi A. Osman[2], Elnour A. Abdelmageed[1]

[1]Department of Biology, Faculty of Science, University of Hail, Hail, Kingdom of Saudi Arabia
[2]Department of Food Science and Technology, Faculty of Engineering and Technology, University of Gezira, Wad-Medani, Sudan

Abstract Tamarind is indigenous to tropical Africa, particularly in Sudan. Tamarind tree produces edible, pod-like fruit which are used extensively in cuisines around the world. Other uses include traditional medicines and metal polishes. The present study aimed to determine the physicochemical characteristics of some local varieties of Tamarind (*Tamarindus indica* L) grown in Sudan. Samples of tamarind fruit were collected from different sites in Sudan: Gedaref (GT), Damazin DT and Obeid (OT) during the period April-June, 2013. The nutritional value of tamarind fruit was assessed using chemical methods. The study showed that tamarind fruit has a high nutritional value. The sugar profile of tamarind fruit was determined using thin layer chromatography (TLC). The chemical analysis indicated an increase of moisture content of GT (15.2%) as compared with those of DT and OT which were 5.8% and 7.9%, respectively. The other chemical components of GT, DT and OT were as follows: the ash content: 4%, 5% and 3.9, protein content: 1.9%, 2.8% and 3.1%, fat content (5.6%), (5.4%) and (5.1%), fiber content: 2.5%, 2.9% and 3.3%, respectively. Moreover, the ascorbic acid content (mg/100g) of D.T, K.T and G.T were found to be 0.6, 0.5 and 0.4, respectively. The fruit also contained glucose, fructose and arabinose as inverted sugars, besides, it has a lower acidity, therefore, the study recommends efficient utilization of tamarind fruit in many products such as vinegar.

Keywords Tamarind, Acetic acid, Vinegar, Chemical composition

1. Introduction

Tamarind, *Tamarindus indica* L., is a multipurpose tropical fruit tree used primarily for its fruits, which are eaten fresh or processed, used as a seasoning or spice, or the fruits and seeds are processed for non-food uses. The species has a wide geographical istribution in the subtropics and semiarid tropics and is cultivated in numerous regions [1].

Tamarind endemic to tropical Africa, it is a leguminous tree in the family Fabaceae. The tree bears out edible pod-like fruit which are used in almost all cuisines round the globe. There are several other uses as well and it includes traditional medicine and metal polish. Attaining a maximum crown height of 12 to 18 metres (40 to 60 feet), it is a long-lived, medium-growth bushy tree with fruit that tastes sweet and sour. The fruit contains tartaric acid with rich nutritional profile.

Tamarind a naturally obtained, long lived, evergreen and less expensive raw material. It comprises organic acids like high content of tartaric acid 12-18%, malic acid, citric acid and byproducts like pectin, potassium Bitartrate.

Tamarind is a fruit that is popular in the foods of Southeast Asia, North Africa and India. While tamarinds are typically sweet and sour in flavor, they tend to become sweeter as they ripen. Due to their sweet, robust flavor, tamarinds are common in candies, chutneys, jams, desserts, steak sauces and Worcestershire sauce. In addition to its high energy and fiber content, the tamarind is a great source of B-vitamins and a number of minerals [2].

Tamarind fruit pulp is found in the pea-like pods (up to 15cm long by 2.5cm across) surrounding one to twelve seeds and 3 - 8 inch long, brown, irregularly curved pods. While at West India, has shorter pods containing only 3 – 6 seeds. Most tamarinds in the America are of the shorter type. Its medicinal actions are digestive, carminative, laxative and ant scorbutic. Leaves are eaten as a vegetable and are also used medicinally. Leaf juice is good for bilious fevers, urinary disorders and jaundice. A fresh leaf poultice is applied locally over swellings of ankles and joints, sprains, boils, sore eyes and scabies. A mature tree can bear about 160kg (350lb) of fruit annually. Tamarinds are long-lived, evergreen trees [3].

Tamarind has been used for centuries as a medicinal plant; its fruits are the most valuable part which have often been reported as curative in several pharmacopoeias [4]. Many parts of tamarind plant have long been used in traditional medicines for the treatment of a wide variety of ailments and diseases such as jaundice, gonococci and gastrointestinal disorders (Polysaccharides and their derivatives have been

* Corresponding author:
abuelhadi@hotmail.com (Abdel Moneim E. Sulieman)
Published online at http://journal.sapub.org/plant

the choice of polymers as rate controlling carriers in sustains drug delivery system [5]. The objective of the present study was to determine the physicochemical characteristics of some local varieties of Tamarind (*Tamarindus indica* L) grown in Sudan.

2. Materials and Methods

2.1. Preparation of Samples

Tamarind (*Tamarindus indica* l.) fruit sample were obtained from three sites, Central Sudan (Damazin), Western Sudan (Obeid), Eastern Sudan (Gedaref), and then transported into sacks to the Food Laboratory, Department of Food Science and Technology, University of Gezira, Sudan.

The tamarind samples were then cleaned from foreign material. For chemical analysis, samples were removed seeds from the pulp .for vinegar production, samples washed, soaked in water for 24 hours, and the seeds were removed from the soak by clearance and filtration.

2.2. Proximate analysis of Tamarind

Analysis of proximate composition was carried out on the samples of tamarind fruit pulp to determine the contents of crude protein, crude fat, crude fiber, moisture content, crude oil, ash and total carbohydrate according to AOAC [6] methods. The total carbohydrate was obtained by calculation as the difference between the sum of the other major ingredients, namely 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 Ascorbic Acid

The ascorbic acid (Vit C) was determined according to Association of Official Analytical Method [7] by using the titration method in which; 30gm of the pulp sample was blended with reasonable amount of 0.4% oxalic acid and then filtered by whatman No.1 filter paper. The volume of the filtrate was completed to 250 ml with 0.4% oxalic acid. 20 ml of the filtrate was pipettes into a beaker and then titrated with dye solution (0.2g 2.6-dicholorophenol-indophenol dissolve in 500ml solution) to a faint pink color. The ascorbic acid content was calculated by the following formula:

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{titer}(\text{ml})\,\text{x dye strength}}{\text{Factor}} \times 100$$

Factor =

$$\frac{\text{sample wt.}(30\text{gm})\,\text{sample volume for titration}(20\text{ml})}{\text{Total volume of sample}}$$

The dye strength was determined by taking 5ml of standard ascorbic acid (0.05g ascorbic acid /250ml 10%oxalic acid solution) in a beaker and titrate with dye solution to faint pink color.

2.4. Total Soluble Solids, Total Titrable Acidity and pH

Total soluble solids, total titrable acidity, and pH were carried out. The total soluble solids were determined using Hand Refractometer. PH values were determined according to the Association of Official Analytical Chemist [7] using the following method:

Five milliliter of the tested solution were taken in a beaker. Forty five ml of distilled water were added and brought to boil, 2-3 drops of phenolphthalein indicator were added and the sample was then titrated with 0.1M sodium hydroxide solution until a faint pink coloration persisted. The total titrable acidity was then calculated as follows:

$$\underset{\text{(as tartaric acid)}}{\%\text{Acid}} = \frac{\text{(ml of NaOH)(N. NaOH)(dilFactor)(EquWt.)}}{\text{Wt. of sample}} \times 100$$

2.5. Minerals Assay

Potassium (K), sodium (Na) and calcium (Ca) determinations were accomplished by means of flame photometer model (Corning 400) according to the AOAC [8] in which different concentrations (20, 40, 60, 80, 100 ppm) were prepared from stock solutions of Ca, Na and K using the flame photometer the readings were taken and a graph was made. The sample was prepared by weighing 3 grams of sample were weighed into a clean pre- dried and weighed porcelain dish. The dish containing the sample was placed in a muffle furnace at 550℃ and left burning for 5 hours at this temperature. Then, the dish with its content was weighed again after cooling in a desiccator to the room temperature and ash content was determined then ash was dissolved in distilled water and adding 10 ml HCl to make 100 ml. Then the absorption of the sample was measured and the concentration determined from the calibration, curve.

2.6. Qualitative Analysis of Sugar by Thin Layer Chromatography (TLC)

Sugars in tamarind concentrated extract were identified by TLC described by AOAC [8] as follows:

The extract was prepared by taking 10 gm of tamarind pulp in 20 ml of distilled water and allowed to stand for 24 hrs, then filtrated, About 1 ml of the crude extract will be dissolved in 3 ml of solvent of ethanol 96%, lastly the sample was taken from it (a few micro liters). The solution will be applied as a band , using amicrosyrine on a paper for TLC, the standard were prepared by weighing 1 gram of the standard sugar, glucose, fructose and arabinose in 10 ml of isopropyl alcohol . A few micro liters were taken and spotted on the paper. The paper was developed in a tank containing the solvent mixture ethyl acetate, isopropanol, pyridine and distilled water, the separation completed when the solvent front reached to 2/3 or 15 cm length. Then the paper was taken out from the tank and dried in the oven.

A colouring agent was sprayed after the drying of the paper and put again in the oven at 100°C for 3 – 5 min. the spots which appeared were recognized by comparison with the standard.

TLC solvent system and reagent was composed of Ethyle acetate, Isopropanol, distilled water, pyridine (26:14:7:2). The colour reagent was prepared by adding 5ml from aniline 1% in acetone with 5ml from diphenylamine 1% in acetone with 1ml from phosphoric acid 85%, and then the mixture was shaken well. The paper was then taken on the tank for 45 min and dried on the oven, the sugar spots were made visible by spraying the paper with a colour reagent. Then the thin layer was air dried at room temperature and treated at 105°C for 2-5 min to produce the characteristic colour for each sugar.

3. Results and Discussion

3.1. Chemical Composition of Tamarind Fruit Pulp

The chemical composition of the tamarind fruit pulp is shown in Table (1). The moisture content of the tamarind pulp from Gedaref was found to be 15.20%, which is slightly lower than documented values by Gursharan *et al*., [9], Coronel [10], Feungchan *et al*., [11], Morton [12] and Mohammed [13], who reported a value ranged between 17.8 – 35.8%, and higher than the value 11.22% reported by Abd Alhameed [14], while moisture content of tamarind from Damazin and Obeid was found to be 5.8%, 7.9%, which is greatly lower than the values reported by the above mentioned authors, and also lower than that reported by Abd Alhameed [14]. The variation in moisture content of tamarind could be due to the storage conditions, environmental conditions, as known Sudan has a tropical climate which is hot most of the year.

The ash represents total content of minerals in a food. In the present study, the ash content of tamarind fruit pulp from Obeid was found to be 3.9%, this value falls within the range of the results obtained by Gursharan *et al.* [9] and Coronel [10], Feungchan *et al.* [11] and Morton [12], who reported a range of 2.6% - 3.9%, while the ash content of tamarind from Damazin and Gedaref were found to be 5% and 3.95%, which is higher than those documented by Gursharan *et al.* [9] and Coronel [10], Feungchan *et al.*[11] and Morton [12] who reported a range of 2.6% - 3.9%, respectively, however, the values obtained in the present study were higher than those reported by Abd Alhameed [14] and Mohammed [13], who reported 2.01%, 2.44% values, respectively. The variation in ash content could be attributed to the difference in environmental factors (Land types).

The protein content of tamarind fruit pulp from Obeid was found to be 3.1%, which is similar to result recorded by Gursharan *et al.* [9] and Morton [10] who reported a value of 3.1%, while protein content of tamarind from Damazin and Gedaref were to be 2.8% and 1.9%, which is slightly lower than that reported by Gursharan *et al.* [9] and Morton [10] who reported a value of 3.1%, in addition, the values were lower than that of Mohammed [13] and Abd Alhameed [14], who reported a protein content of 5.44% and 5.3%, respectively. The differences in protein contents are probably associated with difference in environmental conditions in different areas.

From Table (1), tamarind fruit pulp from Gedaref, Damazin and Obeid were found to contain high contents of crude oil which was: 5.6%, 5.4% and 5.1%, respectively. Thes values were higher than those of Gursharan *et al.* [9] and Coronel [10], Feunghchan *et al.* [11], Morton [12], Abd Alhameed [14] and Mohammed [13], who recorded 0.1%, 0.6%, 0.6%, 0.99%, 4% and 1.99% values, respectively. The variation of these values could be attributed to the genetic variations.

The value of crude fiber of tamarind from Gedaref, Damazin and Obeid were found to be 2.5%, 2.9% and 3.3%, respectively as shown in Table (1) which were relatively lower than the value 5.6% documented by Gursharan *et al.* [9] and Morton [10], and greatly lower than the values 8.04% and 13.05%, reported by Abd Alhameed [14] and Mohammed [13], respectively.

As shown in Table (1), the carbohydrates content of tamarind from Gedaref, Damazin and Obeid were found 70.9%, 78.1% and 76.8%, respectively, which were in close agreement to those reported by Morton [12] and Gursharan *et al.* [9], and higher than that of Mohammed (2007)[13], who reported a value of 55%. The greater amount of carbohydrate in tamarind fruit pulp can encourage its utilization in many fermented products such as vinegar production; it must be converted by enzymatic or acid hydrolysis to obtain a readily fermentable source of hexose sugar. Unavailable carbohydrates are considered as dietary fiber.

Table 1. Chemical composition of tamarind fruit pulp and some quality characteristics, (per 100 g fruit)

Constituents	G.T	D.T	K.T
Moisture %	15.20 ± 5.79	5.80 ± 0.45	7.90 ± 0.05
Ash %	3.95 ± 0.38	5.01 ± 1.03	3.90 ± 0.38
Protein %	1.90 ± 0.15	2.80 ± 0.14	3.10 ± 0.25
Fat %	5.60 ± 0.35	5.43 ± 0.58	5.10 ± 0.43
Fiber %	2.50 ± 5.29	2.90 ± 0.21	3.30 ± 5.16
Carbohydrate %	70.90 ± 5.98	78.08 ± 1.00	76.80 ± 0.32
Ascorbic acid	0.35 ± 0.13	0.57 ± 0.00	0.53 ± 0.00

G.T = Gedaref tamarind; D.T = Damazin tamarind; K.T = Kordofan tamarind

3.2. Ascorbic Acid (Vitamin C) of the Tamarind Pulp

As shown in Table (1), the ascorbic acid content of tamarind pulp from Gedaref, Damazin and kordofan were found to be 0.4 mg/100g, 0.6 mg/100 g and 0.5 mg/100g, which were lower than the value 3.0 mg/100g reported by Coronel [10], Feungchan *et al.* [11] and Gursharan *et al.* [9], also lower than the other result 1.4 mg/100g reported by Abd Alhameed [14].

Ascorbic acid (Vit. C) Contributes to the nutritional value of fruits juices and is an essential water – soluble vitamin. It also aids in formation of liver bile which helps to detoxify alcohol and other substances. It had been reported that ascorbic acid reduces the activity of the enzyme, aldose reductase which helps to protect people from diabetes. It may also protect the body against accumulation or retention of the toxic mineral lead. It may also plays as antioxidant as well as co-factor functions for enzyme metabolism inside the body. The health benefits of ascorbic acid from Tamarind include also the prevention and cure of scurvy, treatment of common cold, boosting the immune system, lowering hyper tension, cure of lead toxicity, curing cataracts, treatment of cancer, combating stroke, maintain elasticity of skin, healing of wounds, and controlling the symptoms of asthma.

3.3. Titrable Acidity, Total Soluble Solids (TSS) and pH

From Table (2), the titrable acidity of tamarind pulp from Gedaref, Damazin and Obeid were 30%, 38.5% and 28.7%, respectively, as tartaric acid which is relatively lower than 43.4% documented by Abd Alhameed [14].

In the present study, the total soluble solids of tamarind pulp from Gedaref, Damazin and Obeid were recorded 42.7o, 46.6° and 39.9° Brix, respectively, which were slightly lower than that documented by Baragana de Mosqueda [15] and Benero *et al.* [16] which range from 54° to 69.9° Brix, as well as the result of this study is lower than the result obtained Abd Alhameed [14], who reported a value of 63° Brix.

As shown in Table (2), the pH of tamarind from Gedaref was found to be 3.4, which was higher than those obtained by Duke [17] who reported a pH of 3.15, while the pH of tamarind from Damazin and Obeid were found to be 3.1 and 2.9, respectively, which was lower than the value obtained by Duke [17] who reported a value of 3.15. The result of the present study were found higher when compared with those obtained by Abd Alhameed [14], who reported a value of 2.8. The reduction of pH leads to inhibition of food spoilage microorganisms growth, hence extending the shelf life of tamarind and its products like juice, vinegar and pickles.

Table 2. Titrable acidity, total soluble solid and pH of tamarind extract

Parameter	G.T	D.T	O.T
Titrable acidity (%)	30.00 ± 5.03	38.50 ± 3.54	28.60 ± 2.40
TTS (Brix)	42.70 ± 0.70	46.60 ± 1.05	39.90 ± 1.40
pH	3.40 ± 0.04	3.10 ± 0.15	2.95 ± 0.26

G.T = Gedaref tamarind; D.T = Damazin tamarind; O.T = Obeid tamarind

3.4. Mineral Content

The content of minerals of tamarind fruit pulp is presented in Table (3). The tamarind fruit pulp from Damazin and Obeid were found to contain 20.8 and 21.2 mg/100g sodium content which were lower than the value reported by Morton [12] who reported a value of 24 mg/100g, while tamarind pulp from Gedaref contained 26.6 mg/100g which was higher than the value reported by Morton [12]. The concentration of sodium in the three samples falls within the range 3.0-76.7 mg/100g reported by Marangoni *et al*. [18], Ishola *et al*. [19] and Bhattacharya *et al.* [20].

The calcium concentration in the tamarind pulp from Gedaref, Damazin and Obeid were found to be 179.5 mg/100g, 149 mg/100g and 139 mg/100g, respectively, which were higher than the value (111.0 mg/100g) obtained by de Oliveira *et al*. [21]. The concentration of calcium in tamarind pulp from Damazin and Kordofan of 149 mg/100g and 139 mg/100g was found to be within the range 35-170 mg/100g that previously found by Morton (1987), while Gedaref tamarind contained a value 179.5 mg/100g, which was in close agreement to the value obtained by Morton.

The concentration of potassium in tamarind pulp from Gedaref, Damazin and Obeid were be 345.5, 139.2 and 110 mg/100g which were lower than those reported by de Oliveira *et al*. [21] and Morton [12] who reported a value of 691.0 mg/100g and 375 mg/100g, respectively. It has been reported that tamarind contains 377 milligrams of potassium in every one-half cup of raw pulp, or approximately 8 percent of the 4,700-milligram recommended daily intake of the mineral for adults [25]. Potassium is both a mineral and an electrolyte. It plays a crucial role in the repair and development of bones, activates enzymes required for carbohydrate metabolism and helps regulate the chemical balance that neurons need to transmit impulses and muscles need to contract. Eating plenty of potassium regularly may decrease your chances of suffering from osteoporosis, kidney stones, stroke or high blood pressure.

The concentration of iron of tamarind from Gedaref, Damazin and Obeid (Table 3) was found to be 95.0 mg/100g, 98.0 mg/100g and 100 mg/100g, respectively. It has been reported that a one-half-cup serving of raw tamarind pulp contains 1.68 milligrams of iron. This amount supplies 21 percent of the Food and Nutrition Board's recommended daily allowance of iron for a man, and 9 percent of the requirement per day for a woman [25]. Iron is necessary for the production of red blood cells and adenosine triphosphate, or ATP, the main source of cellular energy. Without rich sources of iron in your diet, you may be more likely to develop anemia or neurological problems such as attention-deficit hyperactivity disorder. To absorb the maximum amount of iron from tamarind, it has been recommended to eat it with meat and a source of vitamin C, such as a meat-based soup containing tomatoes.

Table 3. Minerals content of tamarind pulp (mg /100g)

Continuant	G.T	D.T	O.T
Sodium mg/100 g	26.59±.09	20.75±.75	21.15±1.15
Potassium mg/100 g	345.50±.10	139.15±.59	110.00±1.00
Calcium mg/100 g	179.50±.50	149.00±3.00	139.00±1.00
Iron mg/100 g	95.0	98.0	100.0
Phosphor mg/100 g	3.4	5.6	9.5

G.T = Gedaref tamarind; D.T = Damazin tamarind; O.T = Obeid tamarind.

Tamarind fruit pulp contained: 3.4 mg/100g, 5.6 mg/100g and 9.5 mg/100g phosphorous, respectively. However, these values fall within the range of the values recorded by Marangoni *et al.* [18], Ishola *et al.* [19] and Bhattacharya *et* *al*. [20] which were 86.0-190.0 mg/100g (phosphorous) and 1.3-10.9 mg/100g (iron).

3.5. Separation of Sugar by Thin Layer Chromatography

Fig. (1) shows that tamarind pulp contained three monosaccharides (simple sugars) including glucose, fructose and arabinose and other sugars. Tamarind fruit pulp contains inverted sugar 25 – 45% by Anon [23], Duke [17]) and Ishola *et al.* (1990) [19]. Also contains starch 33.1% as documented by Anon [23], Morad *et al.* [24], Ishola *et al*. [19] and Bhattacharya *et al.* [20]. It has been stated that while the sugar content varies between different varieties and cultivars of tamarind, there are approximately 68.88 grams of sugar in 1 cup of sweet tamarinds, according to the United States Department of Agriculture, National Nutrient Database. With .72 grams of fats and 3.36 grams of protein, the majority of the 287 calories in 1 cup of sweet tamarinds comes from sugar. In addition to providing a large amount of energy for short-term use, sweet tamarinds promote digestive health with 6.1 grams fiber in a 1 cup serving [25].

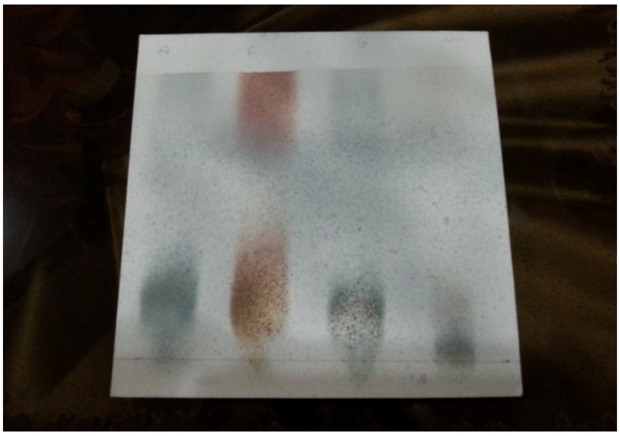

Figure 1. Separation of sugar by Thin Layer Chromatography

4. Conclusions

Tamarind pulp has an attractive commercial future for producing drinks, jams on an industrial scale in Sudan. The tamarind fruit pulp had a complex chemical composition. It is characterized by the presence of low amount of water, high amount of carbohydrate, protein and minerals like many other fruits, which make it a good source of nutrients for human. But in spite of these high levels of nutrients it did not contribute to the human nutrition because it is not eaten frequently in large amounts as fresh fruit; and upon utilization in other ways it is greatly diluted with water or other food ingredients. Beside this tamarind price is very low in the Sudanese market. All these factors motivated the researcher to use tamarind in production of a valuable product such as vinegar and hence improve its economical value.

Tamarind fruit pulp has great potentialities (its high sugar concentration, low pH) to be used industrially in many products such as concentrates, pickles, confections, powdered….etc.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to the staff members and technicians of the Department of Food Science and Technology, Faculty of Engineering and Technology, University of Gezira for their unlimited assistance.

REFERENCES

[1] Bibitha B., Jisha V.K., Salitha, C.V., S Mohan S., Valsa A.K . (2002). Indian Journal of Microbiology 42: 361-363.

[2] http://www.livestrong.com/article/516215-the-benefits-of-sweet-tamarind.

[3] Gullipalli S. and Kasiviswanatham V. (2013). Extraction of Tartaric Acid From Tamarind Pulp and Analysis of the Acid Composition in Leaves. International Journal of Students Research in Technology & Management Vol 1 (05):478-488.

[4] Srinivasan D, Perumalsamy LP, Nathan S, Sures T. (2001). Antimicrobial activity of certain Indian medicinal plants used in folkloric medicine. J Ethnopharm 94: 217-222.

[5] Dipali Y. JadhavA., Akshaya K., Shahoo, J.S. Ghosh R., Rahul C., Ranveer M. and Aruna M. (2010). Characterization of Some Antimicrobial Substances from Seed Coat of *Tamarindus indica* Linn. British Journal of Pharmacology and Toxicology, 1(1): 29-32.

[6] AOAC. (2006). Association of Official Analytical Chemists. Official Method, 2006 Revision, AOAC International, Gaithersberg MD.

[7] AOAC. (2000). Official Methods of Analysis (17th ed.). Association of Official Analytical Chemists, Arlington, VA, USA.

[8] AOAC. (1970). Official Method of Analysis, 11th edition, Association of Official Analytical Chemists, Washington, DC., 20044.

[9] Gursharan, K., Amna N. and Bhupinder K. (2006). Tamarind "Date of India". Science and Technology Entrepreneur: Punjab.

[10] Coronel, R. E. (1991). *Tamarindus indica* L. In Plant Resources of South East Asia, Wageningen; Pudoc. No. 2. Edible Fruits and Nuts. (Eds). E.W.M. Verheij and R.E. Coronel, PROSEA Foundation, Bogor, Indonesia: 298 – 301.

[11] *Feungchan, S.,* Yimsawat, T., Chindaprasert, *S.* and Kitpowsong, P. (1996) *Tamarind* (*Tamarindus indica* L.) Plant genetic resources in Thailand. Thai Journal of Agricultural Sciences Special Issue No. (1): 1-11.

[12] Morton, J. (1987), Tamarind. Fruit of Warm Climates, Morton, J.F. (ed). Miami, USA, p 115 – 121.

[13] Mohammed S. M. I. (2007). Extaction of Pectin from Tamarind (*Tamaridus Indica* L.) Pulp and Its Use In Jam Production. M.Sc. Thesis. University of Gezira Wad Medani. Sudan.

[14] Abd Alhameed H. A.M. (2007). Chemical Analysis and Nutritional Evaluation of Pulp and Seed Kernel of "Aradeib" (*Tamarindus indica* L.). M.Sc. thesis. University of Gezira Wad Medani, Sudan.

[15] Baragana de Mosqueda, M. (1966). Technology of clarified tamarind juice. In Tropical and Subtropical Fruits. Nagy and Shaw, P.E., (Eds.), AVI Publishing, Westport, Conn., 375 p.

[16] Benero, J.R., Rodriguez, A.L. and Collazo de Rivera, A. (1972). Tamarind. Journal of Agricultural University, Puerto Rico, 56(2): 185 – 186.

[17] Duke, J. (1981). Handbook of Legumes of World Economic Importance. New York, NY and London, England: Plenum Press.

[18] Marangoni, A., Alli, I. and Kermasha, S. (1988). Composition and properties.

[19] Ishola, M.M., Agabaji, E.B. and Agbaji, A.S. (1990). A chemical study of *Tamarindus indica* (Tsamiya) fruits grown in Nigeria. Journal of Science Food and Agriculture 51: 141 – 143.

[20] Bhattacharya, S., Bal S., Mukherjee RK. and Bhattacharya, S. (1994). Functional and nutritional properties of tamarind (Tamarindus indica) kernel protein. Food Chemistry, 49(1): 1 – 9.

[21] De Oliveira, L.A., de Almeida, E., da Silva, R.B.F. and Filho, N.F.V. (2006). Elemental Contents in Exotic Brazilian Tropical Fruits Evaluated by Energy Dispersive X-Ray Fluorescence. Pirassununga, SP – Brasil.. Sci. Agric. (Piracicaba, Braz.), v. 63, n. l, p. 82 – 84.

[22] Kofler, L.A. and Hickey, R.J. (1954). Industrial Fermentation – Aceticacid-Vinegar Chemical publishing Co. Inc., 212 Fifth A venues New York, N.Y.17.498-355. of seeds of the tree legume *Tamarindus indica*. Journal of Food Science 53(5): 1452 – 1455.

[23] Anon. (1976). *Tamarindus indica* L. in the Wealth of India (Raw Material Series). Vol. X. 144 – 122. Council of Scientific and Industrial Research. New Delhi.

[24] Morad M.M., El Magoli, S.B. and Sedky K.A. (1978). Physicochemical properties of Egyptian tamarind seed oil. Fette Seifen Anstrichmittel 80: 357– 359.

[25] http://healthyeating.sfgate.com/minerals-tamarind-8396.html