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Nutritional Characterizations of Tamarind (*Tamarindusindica*, L.) Pulp Fruits

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Abstract

Chemical composition, minerals, amino acids, fatty acid characteristics and quality to their contents of phytochemicals were determined in tamarind (*Tamarindusindica*, L.)fruits pulp. The results showed that moisture; protein, fat, ash, fiber, carbohydrates and energy value as wet weight of tamarind fruits were 34.25, 6.01, 4.34, 2.27, 4.13, 49.00 % and 259.10 Kcal/100g, respectively. The highest mineral contents of tamarind recorded for calcium, sodium and phosphorus, while the lowest recorded for lead, nickel and zinc. The highest essential amino acids (EAA) content of tamarind fruit pulp recorded forleucine, while the lowest EAA recorded for tryptophan, cysteine and methionine.The highest fatty acids contents of tamarind fruit pulp recorded for linoleic, oleic and palmitic. The values were 3.42, 2.29 and1.80µg/g, respectively.Total phenols and antioxidants activity (DPPH) content were 21.36 mg/g and 67.90 %, respectively.The highest phenolics compounds of tamarind recorded for pyrogallol, catechein and benzoic acid. The values were 2588.84, 527.55 and 365.85 mg/kg, respectively. On the other hand, the lowest value recorded for cinnamic acid, reversetrol and coumarin. The highest flavonoid compounds of tamarind recorded for luteo.6-arbinose 8-glucose, luteo.6-arbinose 8-arbinose and Apig. 6- glucose 8- rhamnose, while, the lowest value of flavonoid compounds recorded for kampferol, apegnin and rhamnetin.As conclusion,tamarind fruits had high nutritional values due to its contents amino acids, fatty acid, minerals and phenolic compounds, it could be used for improvement human health against some diseases.

Key words: Tamarind fruits, chemical composition, phytochemicals.

Introduction

El-Siddig *et al.*, (1999)reported that tamarind (*Tamarindusindica*, L) of the *Fabaceae*, subfamily *Caesalpinioideae*, is an important food in the tropics. It is a multipurpose tree of which almost every part finds at least some usefulness, either nutritional or medicinal. Tamarind is indigenous to tropical Africa but it has been introduced and naturalized worldwide in over 50 countries. The major production areas are in the Asian countries India and Thailand, but also in Bangladesh, Sri Lanka, Thailand and Indonesia. America, Mexico and Costa Rica are not onlythe biggest producers. Africa on the whole does not produce tamarind on a commercial scale, though it is widely used by the local people. Minor producing countries in Africa are Senegal, Gambia, Kenya, Tanzania and Zambia.

Tamarind pulp typically contains 20.6% water, 3.1% protein, 0.4% fat, 70.8% carbohydrates, 3.0% fiber and 2.1% ash, thus the pulp has low water content and a high level of protein, carbohydrates and minerals. Nevertheless, the proximate composition of the tamarind fruit depends on locality **(Nordeide *et al.*, 1996).**

Tamarind fruit pulp is used for seasoning, as a food component, to flavour confections, curries and sauces, and is a main component in juices and certain beverages. Tamarind fruit pulp is eaten fresh and often made into a juice, infusion or brine, and can also be processed into jam and sweets. The refreshing drinks are popular in many countries around the world, though there are many different recipes **(El-Siddig *et al.*, 2006)**.

Pods contain 1-10 seeds, which are irregularly shaped, flattened or rhomboid. Seeds are very hard, shiny, reddish, or purplish brown. They are embedded in the pulp, lined with a tough parchment resembling a membrane, and joined to each other with tough fibers. There are great differences and variations in fruit size and flavour**(Kumar and Bhattacharya, 2008)**.

Fatty acid profile of tamarind fruit pulp is relatively poor in oil, greenish yellow in colour and liquid at room temperature. Saponification values of the oil are high, indicating that it contains a high proportion of low molecular weight fatty acids. With regard to the two essential fatty acids, the fruit pulp contains very little linoleic acid (3.42 mg/g dry weight) and even lower amounts of α-linolenic acid (0.21 mg/g dry weight) **(Glew *et al.*, 2005)**.

Almeida*et al.*, (2009), reported that the consumption of 100 g tamarind fruit pulp by an adult will cover 10.69% of the recommended daily intake of calcium, 20.49% of magnesium, 14.21% of phosphorous, 12.07% of iron, 2.61% of manganese, 1.29% of zinc, 32.22% of copper and 9.21% of selenium, respectively.

Hefnawy and Youssef (1985) mentioned that meat as the main component of beefburger is a suitable medium for the growth of microorganisms starting to be contaminated in the slaughtering house till its manufacture in the beefburger factory. The microbial activity leads to certain changes in either flavor, or color and accumulation of toxins in meats.

During storage, quality attributes of the product deteriorate due to lipid oxidation and microbial growth. Lipids oxidation is responsible for reduction in nutritional quality as well as changes in flavor, while microbial contamination can precipitate major public health hazards and economic loss in terms of food poisoning and meat spoilage. Thus, the application of suitable agents and possessing showed that stopping both antioxidant and antimicrobial activities may be useful for maintaining meat quality, extending shelf-life and preventing economic loss **(Yin and Cheng, 2003)**.

The development of rancidity rapidly occurred especially when the products are exposed to air and cooked in frying oil**.** In addition to the undesirable quality, the adverse effect of lipid oxidation leads to the development of free radicals which are involved in diseases and a range of disorders including cancer, arthritis, atherosclerosis, Alzheimer’s disease, and diabetes. The supplement of synthetic antioxidants is a method of inhibiting lipid oxidation in meat products **(Baydar *et al.*, 2007)**.

The lipid oxidation is one of the major problems in meat industries. Meat products that are constituted of lipid and polyunsaturated fatty acids (PUFAs) tend to deteriorate due to lipid oxidation, leading to development of unpleasant flavors during processing and storage **(Mielink*et al.*, 2008)**.

Some plant extracts from spices and herbs, however are excellent sources of natural antioxidants that can improve meat shelf-life and quality mainly by retarding lipid oxidation and microbial growth **(Velasco and Williams, 2011)**.

This work was conducted to study the chemical composition, minerals, amino acids, fatty acid characteristics and phytochemicals quality of tamarind fruit pulp.

Materials And Methods

Materials

The fresh fruit of tamarind (*Tamarindusindica*, L.) was obtained from Herbalist, transferred frozen and stored at –18^{o}C until analysis and processing.

Chemicals

Folin-Ciocalteu reagent and standard substances including gallic acid, sinapic acid, caffeic acid, chlorogenic acid, *p*-coumaric acid and dihydroxy benzoic acid were purchased from SigmaChemical Company (St. Louis, USA), vanillic acid, ferrulic acid, rutin and quercetin from Fluka St. Gallen, Switzerland. All reagents and standards were prepared using Milli-Q deionized water (Millipore, Bedford, USA). All other chemicals and reagents were of analytical reagent grade and purchased from Al-Ghomhoria Company, Egypt.

Methods

Preparation of tamarindfruits

A part of the fresh tamarind fruit pods appropriated has been dried at 45^{o}C for approximately6 hours in an hot air, then minced by milling using a locally Milling machineand then kept in plastic sackets at room temperature (25^{o}C±2^{o}C).

Analytical Methods

Moisture, Protein (N x 6.25 Keldahl method), fat (hexane solvent, Soxhielt apparatus), fiber and ash were determined according to the method recommended by **A O A C (2000)**.

Carbohydrates and energy value

Carbohydrate calculated by differences as follows:

% Carbohydrates = 100 - (% moisture + % protein + % fat + % ash + % fiber).

Energy value was estimated by the sum of multiplying protein and carbohydrates by 4.0 and fat by 9.0 according to **FAO (1982)**.

Determination of minerals content

Minerals content (Na, Ca and K) were determined in the diluted solution of ashsamples by using emission flame photometer (Model Corning 410). The other minerals (Cu, Zn, Mn, Fe, P and Mg) were determined by Atomicabsorption spectrophotometer (PerKin – Elmer Instrument Model 2380, Germany), according to the method described by**Nzikou*et al.*,(2009)**.

Determination of amino acids

Amino acids were determined using amino acid analyzer (LC 3000), according tothe methods of **Bassler and Buchholz (1993)**.

Determination of total antioxidant activity of tamarind fruits

Antioxidant activity was determined according to the method described by **Zhangand Hamauzu (2004)** as follows: Five grams of tamarind fruits pulp in different parts were extractedby 100 ml 80 % methanol. Different concentrations (10 to 50 µmol) were used todetermine the antioxidant activity using 2,2 – diphenyl – 1 – picryl hydroxyl (DPPH).

Total phenolics were estimated according to **AOAC (1990)**, by using photometricmethod with FolinCiocalteu reagent. Flavonoids were extracted and determined according to**Zhuang*et al.*, (1992)**.

Determination of phenolic compounds

Extraction, separation and quantificationof phenolic compounds were carried out according to the method described by **Goupy*et al.*, (1999)**.The HPLC system Perkin Elmer PE200 was composed of a binary pump, a column thermostat and an auto sampler. The mass spectrometer used was a 3200QTRAP MS/MS with ESI ionization (Applied Biosystems / MDSSciex, Foster City, USA). The experimental conditions where: Mobile phase A: 50%acetonitrile, 50%aceticacid (0.5%); mobile phase B: 2% acetic acid, flow rate: 0.7 ml /min; injection volume: 20 µL.Stocksolutions of standards were diluted in the mobile phase toobtain working standard solutions. Concentrations of the compounds were calculated from chromatogram peak areas on the basis of calibration curves. The method linearity was assessed by means of linear regression of the mass of compounds injected vs. its peak area. All solvents were of HPLC grade and were filtered and degassed before use.

Statistical analysis

Data were recorded as means and analyzedby (SPSS) (Ver.10.1). One–way analysis of variance (ANOVA) andDuncan comparisons were tested to signify differences between variable treatments of tamarindfruits**(SAS 1988)**.

Results And Discussion

1. Chemical composition of fresh tamarind pulp

The proximate chemical composition of fresh tamarind pulp is shown in table (1). The obtained results indicated that moisture; protein, fat, ash, fiber, carbohydrates and energy value as wet weight of tamarind fruits pulp were 34.25, 6.01, 4.34, 2.27, 4.13, 49.00 % and 259.10 Kcal/100g, respectively. These results are in agreement with **Amoo and Atasie, (2012)**who found that tamarind pulp*(T. indica*)was rich in protein (7.64%).While, crude fat and carbohydrates values in this study were lower than the obtained results. Crude fat content of the samples was (1.03%), carbohydrate values was 56.00%.The high crude fiber content helps to maintain the health of the gastro-intestinal tract **(Ajayi*et al.,* 2006)**.

2. Mineral content of tamarind fruit pulp

Data presented in table (2) show the mineral content of tamarind fruit pulp. It is clear to notice that the highest mineral contents of tamarind which recorded for calcium, phosphorus and sodium. The values were 465.75, 97.00 and 76.66 mg/100g, respectively. On the other hand, the lowest mineral contents of tamarind were recorded for lead, nickel and zinc. The values were 0.01, 0.52 and 1.56 mg/100g, respectively. These results are in agreement with **Glew*et al.,* (2005)**, who reported that tamarind fruit pulp is a good sourceof calcium and phosphorus, but is unfortunately, extraordinarily low in iron while the reverse recorded in present work (table 2) . Also, **Almeida *et al.,* (2009)** indicated that tamarind is a rich sourceof all minerals available, especially magnesium, copper and potassium, in addition to being a good source of calcium, phosphorous and selenium.

3.Amino acids composition of tamarind fruit pulp

Data given in table (3) show the amino acids contents of tamarind fruit pulp. It is clear to notice that the highest non essentialamino acids contents of tamarind fruit pulp recorded for glutamic acid**,**aspartic acid and for essential amino acids (EAA) isleucine and lysine. The values were 16.70, 12.00, 8.89, and 8.22 mg/g, respectively. While, the lowest amino acids contents of tamarind fruit pulp was recorded for tryptophan, cysteine and methionine 1.04, 1.35 and 2.48 mg/gdw, respectively. These results are in agreement with **Ishola and collaborators (1990)** mention that the tamarind pulp is a good source of protein. Amino acid profiles of tamarind reveal that the proteins contain fairly balanced essential amino acid levels. Also, **El-Siddig*et al.*, (2006)** reported that in terms of protein content and WHO reference protein, tamarind pulps score well for 3 of the 8 essential amino acids. However, for each of the eight essential amino acid categories baobab leaves score close to or above the 100% mark, except from tryptophan.

4. Fatty acids composition of tamarind fruit pulp

Data in table (4) presented the fatty acids contents of tamarind fruit pulp. The obtained results showed that the highest fatty acids contents of tamarind fruit pulp recorded for linoleic, oleic and palmitic. The values were 3.42, 2.29 and1.80μg/g, respectively. While, the lowest fatty acids contents of tamarind fruit pulp recorded for C12:0, C14: myristic,C15:0 C20:2n-6, C22:1 and C15:0. The values were 0.01,0.01, 0.01, 0.01and 0.01 μg/g, respectively. These results are in agreement with **Glew*et al.*, (2005)** reported that tamarind fruit pulp is relatively poor in oil (25.3 g/kg of crude lipid), greenish yellow in colour and liquid at room temperature. Saponification values of the oil are high, indicating that it contains a high proportion of low molecular weight fatty acids. With regard to the two essential fatty acids, the fruit pulp contained very little linoleic acid (3.42 mg/g dry weight) and even lower amounts of α-linolenic acid (0.21 mg/g dry weight). Also,**Ajayi*et al.*, (2006),** who found that tamarind, have a higher percentage of unsaturated (55.6%) fatty acids than saturated (44.4%) fatty acids. Linoleic acid, present in tamarind seed oil, is undoubtedly one of the most important polyunsaturated acids in human food because of its association in the reduction or prevention of heart vascular diseases.

5. Total phenols and antioxidant activity of tamarind

Table (5) showed the total phenols and antioxidants activity content of tamarind.It could be observed that the total phenols and antioxidants activity (DPPH) content were 21.36 mg/g and 67.90 %, respectively. These results are in the same line of **Mahmood*et al.*,**

(2012), who reported that *Tamarindusindica*, L. contained a large number of polyphenolic compounds with potential for antioxidant activity. However, the quantities of antioxidants may vary with geographical location.

6.Identification of phenolics compounds of tamarind

Data given in table (6) show the identification of phenolic compounds of tamarind. It is clear to mention that the highest phenolic compound of tamarind recorded for pyrogallol, catechein and benzoic acid. The values were 2588.84, 527.55 and 365.85 mg/kg, respectively. On the other hand, the lowest value of phenolic compounds of tamarind recorded for cinnamic acid, reversetrol and coumarin. The values were 2.78, 4.95 and 5.52 mg/kg, respectively. These results are in agreement with **El-Siddig*et al*., (2006),** who reported thattamarind fruit being a plant contained a biologically important source of mineral elements and with a high antioxidant capacity associated with high phenolic content that can be considered beneficial to human health. The phenolics include gallic acid equivalent of 626-664 mg per 100g. Also, **Khairunnuur*et al*., (2009)** reported a wide range of total phenolic content in tamarind parts. Their contents ranged from 1.83±0.02 to 19.21±0.29 mg gallicacid equivalent (GAE)/100g of dried samples, with an average of 9.64 mg (GAE)/100g fresh sample.

7.Identification of flavonoides compounds of tamarind

Data tabulated in table (7) presented the identification of flavonoides compounds of tamarind. It is clear to mention that the highest phenolics compounds of tamarind recorded for luteo.6-arbinose 8-glucose, luteo.6-arbinose 8-arbinose and Apig. 6-glucose 8- rhamnose. The values were 4147.57, 291.40 and 239.58 mg/kg, respectively. On the other hand, the lowest value of flavonoid compounds of tamarind recorded for kampferol, apegnin and quercetin. The values were 1.01, 2.14 and 4.92 mg/kg, respectively. These results are in agreement with **Lamien-Meda*et al*., (2008)** reported that lower levels of flavonoids (2.18 ± 0.21 mg QE/100 g) in fruit methanolic extracts and (5.68 ± 0.10 mg QE/100 g) in fruit acetone extracts found in tamarind growing in Burkina Faso.

Table (1): Chemical composition of fresh tamarind

Constitutive	% (W/W)	% (D/W)
Moisture	34.25	-----
Protein	6.01	9.15
Fat	4.34	6.60
Ash	2.27	3.45
Fiber	4.13	6.28
Carbohydrates	49.00	74.52
Energy value (Kcal/100g)	259.10	394.08

W/W= Wet weight D/W= Dry weight

Table (2): Mineral content of tamarind fruit pulp

Mineral contents	Concentrations (mg/100g Dw)
Calcium	465.75±0.10
Copper	21.83±0.11
Iron	8.49±0.03
Potassium	62.00±0.13
Magnesium	72.03±0.15
Manganese	21.50±0.22
Sodium	76.66±0.01
Nickel	0.52±0.40
Phosphorus	97.00±0.20
Lead	0.01±0.03
Zinc	1.56±0.12

Table (3): Amino acids composition of tamarind fruit pulp

Amino acids	Concentrations (mg/g Dw)
Aspartic acid	12.00
Glutamic acid	16.70
Serine	6.88
Glycine	5.15
Histidine	3.37
Arginine	8.74
Threonine	6.05
Alanine	6.20
Proline	7.61
Tyrosine	4.34
Valine	6.97
Methionine	2.48
Isoleucine	5.20
Leucine	8.89
Phenylalanine	4.78
Lysine	8.22
Cysteine	1.35
Tryptophan	1.04

Table (4): Fatty acids composition of tamarind fruit pulp

Fatty Acid	Concentrations(μg/g Dw)
C12:0	0.01
C14:0 Myristic	0.01
C15:0	0.01
C16:0 Palmitic	1.80
C16:1 Palmitoleic	0.12
C18:0 Stearic	0.70
C18:1n-9 Oleic	2.29
C18:1n-7	0.55
C18:2n-6 Linoleic	3.42
C18:3n-3 α-linolenic	0.21
C20:0 Arachidic	0.07
C20:1 Gadoleic	0.02
C20:2n-6	0.01
C22:0	0.03
C22:1	0.01
C24:0	0.03
C24:1	0.20

Table (5): Total phenols and antioxidant activity of tamarind

Active compounds	Total phenols(Mg/g)	Antioxidant activity(DPPH)%
Tamarind	21.36±0.10	67.90±0.02

Table (6): Level of individual phenolic compounds of tamarind

Phenolics compounds	Dried tamarind (mg/kg)
Galic acid	43.16
Pyrogallol	2588.84
4-Amino benzoic	18.48
Protocatchuic	271.01
Catechein	527.55
Chlorogenic acid	74.45
Catechol	348.87
Epicatachin	219.29
Caffeine	39.92
P-OH-benzoic	106.77
Caffeic acid	27.32
Vanilic acid	161.92
***p*-cumaric acid**	8.09
Ferulic acid	13.80
Isoferulic acid	8.09
Reversetrol	4.95
Ellagic acid	114.03
e-vanilic acid	123.84
Alpha-coumaric	17.60
Benzoic acid	365.85
3,4,5-methoxy cinnamic acid	10.76
Coumarin	5.52
Salycilic acid	40.25
Cinnamic acid	2.78

Table (7): Level of individual flavonoid compounds of tamarind

Flavonoids compounds	Dried tamarind(mg/kg)
Luteo.6-arbinose 8-glucose	4147.57
Luteo.6-arbinose 8-arbinose	291.40
Apig. 6-arbinose 8-glactose	14.43
Apig. 6-rhamnose 8-glucose	89.19
Apig. 6-glucose 8- rhamnose	239.58
Luteo.7- glucose	19.63
Luteolin	80.54
Narengin	25.31
Rutin	48.74
Hespirdin	210.81
Rosemarinic	6.65
Apig.7-O-neohespiroside	18.90
Kamp.3,7-dirhamoside	21.36
Apig.7-glocouse	28.32
Quercetrin	6.18
Quercetin	4.92
Kaemp.3-(2-P-comaroyl) glucose	98.91
Naringenin	8.87
Hespirtin	11.84
Kampferol	1.01
Rhamnetin	3.00
Apegnin	2.14
Acacetin	58.55

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الخصائص التغذوية للب ثمار التمر هندى

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قسم التغذية وعلوم الأطعمةـ كلية الأقتصادالمنزلى ـ جامعة المنوفية ـ مصر

الملخص العربى

التركيب الكيماوى والاملاح المعدنية والأحماض الأمينيةوالأحماض الدهنيةبالاضافة إلى المركبات الكيمائية الطبيعية تم قياسهم فى لب ثمار التمر هندى. وقد كانت قيم كلا من الرطوبة والبروتين والدهون والرماد والألياف والكربوهيدرات وقيمة الطاقة على أساس الوزن الرطب من ثمار التمر الهندي ٣٤,٢٥، ٦,٠١، ٤,٣٤، ٢,٢٧، ٤,١٣، ٤٩,٠٠٪ و ٢٥٩,١٠كيلو كالوري / ١٠٠جم على التوالى. وقد وجد أن أعلى محتوي للأملاح المعدنية فى ثمار التمر الهندي سجلت مع عنصر الكالسيوم والصوديوم والفوسفور، في حين كان أقل محتوى هو عنصر الرصاص والنيكل والزنك.كانأعلى محتوى من الأحماض الأمينية الأساسية فى لب ثمار التمر الهندي سجلت مع الحمضالليوسين ، في حين أن أقل محتوى سجل مع الحمض الأمينالتربتوفان، السيستين والميثيونين .أما أعلى محتوى من الأحماض الدهنية فلب ثمار التمر الهندي سجلت مع الحمض الدهنالينوليك، الاوليكوالباليتيك.حيث كانت القيم ٣,٤٢، ٢,٢٩,١,٨ميكروجرام / جرام على التوالي .وبلغ محتوى الفينولات الكلية و نشاط مضادات الأكسدة ٢١,٣٦ملجم / جم و ٦٧,٩٠٪ على التوالي .أعلى قيم للمركباتالفينوليةالتى تم التعرف عليها فثمار التمر الهندي سجلت مع حمض البيروجالول، الكاتيشينوحمض البنزويك .حيث كانت القيم ٢٥٨٨,٨٤، ٥٢٧,٥٥ و٣٦٥,٨٥ ملجم / كجم، على التوالي .من ناحية أخرى، سجلت أقل قيمة مع حمض السيناميك، حمض الريفيرستولوالكومارين .أعلى قيم للفينولاتالتى تم التعرف عليها فى التمر الهندي سجلت مع مركبليوتيلو ٦ـ أرابينوز 8 جلوكوز، وليوتيلو ٦ـ أرابينوز 8 أرابينوز، بينما أقل قيمة من الفلافونيدات سجلت معأبيجينوكامبيفيرولوراميستين . من هنا نستخلص أن لب ثمار التمر الهندي ذات قيمة غذائية عالية نظرا لأحتواءهعلى الأحماض الأمينية، والأحماض الدهنية والمعادن والمركبات الفينولية ومضادات الأكسدة، وعليه فإنه يمكن استخدامهلحماية و تحسين صحة الإنسان ضد بعض الأمراض.

الكلمات الدالة: ثمار التمرهندى, التركيب الكيماوى, المركبات النباتية الطبيعية.