

CHEMICAL AND TECHNOLOGICAL CHARACTERIZATION OF TIGERNUT (*Cyperus esculentus* L.) TUBERS

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ABSTRACT

From the obtained results, it can be concluded that tigernut tubers are a good source of oil as well as it contains valuable amounts of crude fibers and minerals such as potassium, phosphorus and magnesium. Chemical and physical properties of tigernut tuber oil were a like to those reported in the literature for different edible oils such as cottonseed, corn, sunflower and olive oils. Tigernut tubers oil has high nutritional value, hence, it contains high percentage of unsaturated fatty acids especially oleic acid and low in linoleic acid, it makes this oil desirable as it is more stable during cooking and frying. It can be recommended to use tigernut tuber oil as safe for human consumption as vegetable edible oils. Also, tigernut flour was evaluated for amino acids content and the results showed that sulfur-containing amino acids gave the minimal score for tigernut flour protein followed by threonine and isoleucine.

Keywords: Tigernut, oil, fatty acids, protein, amino acids, minerals.

INTRODUCTION

Tigernut (*Cyperus esculentus*) is a weed plant (yellow nut sedge) of tropical and Mediterranean regions. Tigernut is also known by various other names as chufa (in Spanish), earth nut, yellow nut sedge, groundnut, rush nut, and edible galingale (Oderinde and Tairu 1988). It is underutilized sedge of the family Cyperaceae which produce rhizomes from the base and tubers that are somewhat spherical. Also, it is sweet almond-like tubers are highly appreciated for their health benefits and nutritive value: high content of fiber, proteins, and sugars. They are rich in oleic acid and glucose, as well as in phosphorus, potassium, and vitamins C and E (Zapata *et al.*, 2012). Tigernut of the Cyperaceae family is a plant which was cultivated in ancient Egypt (Zohary and Hopf, 2000). Tigernut now grows widely in the West African region both as a cultivated and as a wild grass-like plant. It is known in other parts of the world, especially in the Valencia region of Spain where it is commonly known as "chufa" and the oil from the nut is now produced on a commercial scale for the European market (Tigernuts Traders, 1997–2010). Foods based on tigernut are prepared by a wide range of recipes and preparation methods. The best-know application of tigernut in food technology is the production of "horchata de chufa" (tigernut milk) (Mosquera *et al.*, 1996). It is also used successfully as a flavoring agent in ice cream. Flour of roasted tigernut is sometimes added to biscuits and other bakery products (Coşkuner *et al.*, 2002), as well as in extracting oil, soap, and starch

extracts (Adejuyitan 2011). Belewu and Abodunrin (2008) found tigernut useful in the preparation of kunnu (a local beverage in Nigeria). Tigernut was found to be a good substitute for cereal grains (Sanful, 2009). The fat is rich in oleic acid (75% of total fat) and linoleic acid (9% to 10% of total fat), and arginine is the major amino acid, followed by glutamic acid and aspartic acid. With the exception of histidine, the essential amino acids in natural "horchata de chufa" are higher than the amount in the model protein proposed for adults by the FAO/OMS (Cortés *et al.*, 2005). Tigernuts have also been reported to be rich in sucrose (17.40–20.00%), fat (25.50%) and protein (8%) (Umerie and Enebeli, 1997). The rootstock is brown on the surface and white inside. The tubers are used as a human food source in several countries around the Mediterranean Sea particularly Spain and Egypt (Coşkuner *et al.*, 2002). Therefore, this study was carried out to evaluate the chemical and technological properties of tigernut tubers grown in Egypt.

MATERIALS AND METHODS

Materials:

Tigernut tubers (*Cyperus esculents* L.) varieties yellow were purchased from local market at Tanta City, Egypt. All used chemicals were purchased from El- Nasr Company for Drugs Trading and Chemical, Cairo, Egypt.

Methods:

Some physical properties of tigernut tubers:

Weight of 1000 tubers were counted manually and weighted. Tubers dimensions (mm) were estimated using the average of length and width of 25 tubers as described by Adair *et al.* (1973).

Preparation of tigernut tubers for analysis:

Tigernut tubers were manually cleaned to remove all visible foreign matters; ground into fine powder using a laboratory electronic mill (Braun, Model 2001 DL, Germany), then passed through a 60 mesh sieve screen. The powder was stored in tightly polyethylene bags at -18 °C until used.

Gross chemical composition of tigernut tubers:

Moisture, protein, ash, and crude fibers contents were determined according to the methods of A. O. A. C. (2005). Carbohydrates were calculated by difference. Crude fat was extracted and determined using n-hexane at room temperature according to the method described by AOCS (1998).

Some physical and chemical properties of tigernut tubers crude oil:

Refractive index (RI) and specific gravity (SG) of the oil were measured at room temperature (25±2°C) according to the methods described in A. O. A. C. (2005). Peroxide and iodine values were determined according to the methods outlined by Leonard *et al.* (1987). Acid, saponification values and unsaponifiable matters were analyzed according to the methods described by A. O. A. C. (2005).

Fatty acids composition:

Fatty acids composition were separated and identified using gas liquid chromatography (GLC) at High Institute of Public Health, Alex. University, Alexandria, Egypt.

GLC conditions:

Fatty acids methyl esters of oil sample were quantified using gas-liquid chromatography (HP 6890 GC capillary) equipped with a flame ionization detector (FID) using a 6m × 0.32mm × 0.25µm DB-23 capillary column. The injector and detector temperatures were set at 230 °C and 250 °C; respectively. Hydrogen gas (at flow rate 40 ml/min) was used as carrier gas and temperature programming was from 150 to 170 °C at 10°C/min and then from 170 to 192 °C at 5°C/min, holding five min then 192 to 220 °C during 10 min. Individual methyl esters were identified by comparison to known standards.

Evaluation of tigernut tubers flour:

Fat content of tigernut tubers was cold extracted using n-hexane. N-hexane traces were evaporated, then the produced flour are to be ready for further analysis.

Minerals determination:

Minerals contents of flour were carried out in the Central Laboratory, Fac. of Agric., Kafrelsheikh. Univ., using Atomic Absorption (NC.9423-400-30042), England according to A. O. A. C. (2005).

Amino acids composition of tigernut flour protein:

Amino acids composition was determined using HPLC at Regional Center For Food and Feed (RCFF), Agricultural Research Center, Cairo, Egypt according to the methods of Duranti and Cerletti (1979). Amino acids score (AAS) were computed using the FAO/WHO (1973) reference protein, according to Pellet and Young (1980). The lowest score was taken as the first limiting acid.

Organoleptic evaluation:

Sensory properties of potato chips fried in tigernut and sunflower oils were evaluated according to the method outlined by El-Sheik (1999).

Statistical analysis:

The obtained data were statistically analyzed using General Linear Models Procedure Adapted by SPSS, (1997) for user's Guide Duncan Multiple Range Test was used to test the difference among means (Duncan, 1995).

RESULTS AND DISCUSSION

Some physical properties of tigernut tubers:

Data presented in Table (1) indicate that tuber index (weight of 1000 tubers in gram) was 368.0g and their dimensions including (length and width) were 11.20 and 4.30mm; respectively.

Table (1): Some physical properties of tigernut tubers.

Properties	Tigernut tubers
Tigernut index (g)	368.0
Tuber dimensions (mm):	
Length	11.20
Width	4.30

Gross chemical composition of tigernut tubers:

Gross chemical composition of whole tigernut tubers and flour are given in Table (2). The obtained results indicate that crude fat, crude protein, ash, crude fibers and available carbohydrates contents of whole tubers were 22.39, 6.57, 2.11, 9.30 and 59.63% on dry weight basis; respectively. While, available carbohydrates of flour were 70.11%, crude fibers 13.87% and crude protein 10.75%. These results are in agreement with those reported by Coşkuner *et al.*, (2002); Abd-El-Hamied (2010); Bamishaiye and Bamishaiye (2011).

Table (2): Gross chemical composition of tigernut tubers (dry weight basis).

Constituents (%)	Whole tubers	Defatted flour
Dry matters	93.10 N.S	94.40
Moisture	6.90 N.S	5.60
Crude oil	22.39a	0.78b
Crude protein	6.57b	10.75a
Ash	2.11b	4.49a
Total carbohydrates*	68.93b	83.98a
-Crude fibers	9.30b	13.87a
-Avail. carbohydrates**	59.63b	70.11a

*Total and **available carbohydrate were calculated by difference.

Means of values having the same case letter(s) within a column are not significantly different ($p > 0.05$). N.S= not significant

Some physical and chemical properties of tigernut tubers oil:

Refractive index of tigernut oil was measured at 25°C which is lower (1.4605) than that of olive oil (1.4660). Ezebor *et al.* (2005); Abd El-Hamied (2010) found that refractive index of tiger nut oil determined at 25°C was 1.4675 and 1.4672; respectively. Specific gravity of tigernut oil was 0.9005. Umerie *et al.* (1997) reported that specific gravity of tigernut oil was 0.9000.

Table (3): Some physical and chemical properties of tigernut tubers oil compared with olive oil.

Properties	Tigernut	Olive*
Refractive index (25°C)	1.4605	1.4660
Specific gravity (25°C)	0.9005	-
Acid value (mg KOH/g oil)	1.54	0.20
Iodine value (gI/100g oil)	92.10	89.00
Saponification value (mg KOH/g oil)	197.81	186.00
Peroxide value (meq.O ₂ /Kg oil)	1.32	2.50
Unsaponifiable matters (%W/W)	0.45	-

* Arafat *et al.* (2009).

Apparent also, from the same Table that acid value was 1.54 mg KOH/g oil. This value is indicator of decomposition degree of glycerides. This result may be due to that tigernut crude oil was not refined. On the other

hand, the acid value of tiger nut oil was higher than that of olive oil which was 0.20 mg KOH/g oil. Peroxide value of tigernut oil was 1.86 meq. O₂/Kg oil, which was much lower than that of the stipulated maximum level of CAC (1982), which permitted the peroxide value, is not more than 10 meq.O₂/Kg oil for edible oils. These results are in agreement with that found by Ekeanyanwu and Ononogbu (2010). From the previous results, it could be observed that the iodine value of tigernut oil was higher (92.10 gl/100g oil) than that of olive oil (89.00 gl/100g oil). These results are in agreement with those reported by Oderinde and Tairu, (1988); Abd El-Nabey, (2001); Abd El-Hamied, (2010). The saponification value of tigernut oil was 197.81 mg KOH/g as shown in Table (3), which was higher than that of olive oil (186.0 mg KOH/g oil). This result reflected that the glycerides of tigernut oil composed of high molecular weight fatty acids. These results are in agreement with that found by Oderinde and Tairu, (1988); Abd El Hamied, (2010). The unsaponifiable matters include hydrocarbons, higher alcohols and sterols. Most oils and fats of normal purity contain less than 2% of unsaponifiable matters (CAC, 1982). The unsaponifiable matters of tigernut oil recorded about 0.45%. This result was in agreement with that found by Ezebor *et al.* (2005), who found that tigernut tubers oil contained 0.50% unsaponifiable matters. The above mentioned physical and chemical properties of tigernut oil seem to be within normal values of known edible oils.

Fatty acids composition of tigernut tuber oil:

Fatty acids composition of tigernut oil is tabulated in Table (4). Saturated and unsaturated fatty acids were separated and identified in tigernut tubers oil. The unsaturated fatty acids recorded (82.69%) which play important role of nutrition of tigernut oil, while (16.55%) saturated fatty acids were detected. Generally, it is accepted that increasing the proportion of unsaturated to saturated fatty acids in a diet will reduce the level of blood coronary heart disease (Fick, 1984).

Table (4): Fatty acids composition of tigernut tubers oil.

Fatty acids	% of total F.A.
Saturated fatty acids	
Lauric (C _{12:0})	0.04
Myristic (C _{14:0})	0.10
Palmitic (C _{16:0})	11.98
Stearic (C _{18:0})	3.80
Arachidic (C _{20:0})	0.63
Total saturated fatty acids	16.55
Unsaturated fatty acids	
Palmetioleic (C _{16:1})	0.18
Oleic (C _{18:1})	73.69
Linoleic (C _{18:2})	8.36
Linolenic (C _{18:3})	0.26
Eicosaenoic (C _{20:1})	0.20
Unknown	0.76
Total unsaturated fatty acids	82.69
Total fatty acids	100.00
Unsaturated/saturated ratio	4.99:1

The main unsaturated fatty acids in tigernut oil were oleic and linoleic acids, which together amounted about 82.05% of total fatty acids (Table 4). The high portion of unsaturated fatty acids of tigernut oil (82.69%) are considered it is a good source of essential fatty acids in human nutrition comparing with sunflower, cottonseed, corn and olive oils that recorded 72.48, 69.60, 78.61 and 79.48%; respectively. Tigernut oil contained high percentage of oleic acid (73.69%) and low percentage of linoleic acid (8.36%). Linolenic acid was found in minor value in tigernut oil (0.26%). These values were similar to those of olive oil, which contained 71.00% as oleic acid and 6.18% linoleic acid (Arafat *et al.*, 2009). Total saturated fatty acids were 16.55% and mainly composed of palmitic (11.98%), stearic (3.80%) and arachidic acids (0.63%). The results of tigernut oil revealed that this oil is characterized as oil which contained high contents of monounsaturated fatty acids namely oleic acid. Although this edible fatty acids had low nutritional value compared to the polyunsaturated fatty acids, especially linoleic acid, it makes the oils desirable of more stability in cooking and frying. These results are in agreement with Arafat *et al.* (2009); Muhammad *et al.* (2011); Zapata *et al.* (2012). Finally, it could be concluded that tigernut tubers are considered to be rich source of edible oil with high physical and chemical properties and could be used in nutrition.

Organoleptic evaluation of potato chips fried using tigernut and sunflower oils:

The results in Table (5) showed organoleptic properties of potato chips fried in tigernut tubers and sunflower oils. All organoleptic properties of potato chips fried in tigernut tubers oil were near to those fried in sunflower oil. Overall acceptability of potato chips fried in tigernut tubers oil was similar to those fried in sunflower oil. Also, Table (5) showed that the statistics of organoleptic qualities of fried potato chips in sunflower and tigernut tubers oils were revealed that no deferent significant variation between potato chips fried in sunflower and tigernut tubers oils except odor which had a significant variation between two samples at 5% level.

Table (5): Organoleptic evaluation of potato chips fried in tigernut tubers and sunflower oils.

Attributes Samples	Color	Taste	Odor	Texture	Appearance	Overall acceptability
Tigernut tubers oil	8.50b	9.00N.S	8.92b	8.58N.S	8.58 N.S	8.72b
Sunflower oil	9.42a	9.12	9.58a	8.92	9.00	9.20a

Means of treatments having the same case letter(s) within a row are not significantly different ($p > 0.05$). N.S = not significant.

Characterization of tigernut flour:

Minerals content:

Minerals content (mg/100g) of tigernut flour are given in Table (6). Data show that the least abundant minerals were copper and manganese; while potassium was the most abundant.

Table (6): Minerals content of tigernut flour (mg/100g dry weight).

Minerals	Contents (mg/100g)
Sodium (Na)	81.76
Potassium (K)	480.80
Magnesium (Mg)	70.00
Manganese (Mn)	0.38
Iron (Fe)	6.18
Zinc (Zn)	1.98
Cadmium (Cd)	0.00
Lead (Pb)	0.00
Copper (Cu)	0.40
Nickel (Ni)	0.04
Phosphorus (P)	196.34

Ekeanyanwu and Ononogbu (2010) also found that copper and manganese were the least minerals in tigernut tubers which recorded about 0.92 and 0.26 mg/100g; respectively. Iron content in tigernut flour was 6.18 mg/100g; this value is in agreement with that reported by Ekeanyanwu and Ononogbu (2010). Zinc content was 1.98 mg/100g which was in agreement with value reported by Arafat *et al.* (2009). Phosphorus was found to be the second highest mineral in tigernut tubers. The value of phosphorus (196.34 mg/100 g) was higher than (123.00) that reported by Arafat *et al.* (2009).

Amino acids composition of tigernut flour:

Amino acids composition of tigernut flour is presented in Table (7). The obtained results indicate that tigernut flour contained 8 indispensable amino acids beside 9 dispensable amino acids. The major indispensable amino acids were phenylalanine (290 mg/100g), leucine (200 mg/100g) and lysine (200 mg/100g protein). Tigernut flour contained tyrosine (140 mg/100 g protein) which was not present in casein.

Table (7): Amino acids composition of tigernut flours (mg/100g protein).

Amino acids	(mg/100 g protein)
Indispensable amino acids	
Valine	150
Leucine	200
Isoleucine	110
Therionine	110
Methionine	60
Lysine	200
Tyrosine	140
Phenylalanine	290
Total indispensable amino acids	1260
Dispensable amino acids	
Cysetine	30
Serine	100
Alanine	190
Aspartic acid	280
Argenine	690
Glycine	150
Proline	120
Histidine	100
Glutamic acid	380
Total dispensable amino acids	2040
Total amino acids	3300

The lowest indispensable amino acid in tigernut flour was methionine (60 mg/100g protein). On the other hand, arginine, glutamic and aspartic acids were the major dispensable amino acids present in tigernut flour (690, 380 and 280 mg/100g protein; respectively). Cysteine, serine and histidine were the lowest dispensable amino acids that recorded (60, 100 and 100 mg/100g protein). These results are in agreement with those reported by Arafat *et al.*, (2009); Ekeanyanwu and Ononogbu (2010).

Chemical score (CS) of the indispensable amino acids:

Chemical score of indispensable amino acids of tigernut flours are shown in Table (8). The results revealed that sulfur-containing amino acids gave the minimal score for tigernut flour protein followed by therionine and isoleucine. Ekeanyanwu and Ononogbu (2010) found that the first and second limiting amino acids in tigernut flour protein are leucine (70 mg/100g protein) and lysine (80 mg/100g protein).

Table (8): Amino acids score of tigernut flour protein.

Indispensable amino acids	Amino acids score	FAO/WHO, 1973 standard protein (g/100g protein)	Casein
Theroenine	2.75	4.00	85.70
Valine	3.00	5.00	108.40
Methionine+cystine	2.57	3.50	84.50
Isoleucine	2.75	4.00	126.20
Leucine	2.82	7.00	131.40
Phenylalanine+tyrosine	7.17	6.00	136.50
Lysine	3.64	5.50	136.50

CONCLUSION

It can be concluded that tigernut tubers are a good source of edible oil. It had physical and chemical properties near to those of olive oil that makes this oil is stable during cooking and frying. Also, it had valuable amounts of minerals and crude fibers. Also, the results showed that sulfur-containing amino acids gave the minimal score for tigernut flour protein followed by therionine and isoleucine.

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التوصيف الكيماوي والتكنولوجي لدرنات حب العزيز

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**معهد بحوث تكنولوجيا الاغذية - مركز البحوث الزراعية - جيزة - مصر

تمت هذه الدراسة على درنات حب العزيز المنزرع في مصر بهدف البحث عن مصادر غير تقليدية للزيوت الغذائية. حيث تم دراسة التركيب الكيماوي وكذلك الخواص الطبيعية والكيماوية للزيت المستخلص لهذه الدرناات. وقد أوضحت الدراسة أن درنات حب العزيز تعتبر مصدرا جيدا للزيت وتعتبر قابل للاستهلاك الأدمي وتندرج ضمن الزيوت التي تحتوي على كميات كبيرة من حمض الأوليك وقليلة من اللينوليك ومتشابهه مع العديد من الزيوت النباتية وخاصة زيت الزيتون. كما تمت دراسه محتوى دقيق درنات حب العزيز بعد استخلاص الليبيدات الكلية ووجد أنه يحتوى على كميات كبيرة من المعادن وخاصة البوتاسيوم والفسفور والمغنسيوم. أيضا احتوت الدرناات على كميات جيدة من الالياف الخام والبروتين وان الاحماض الامينية الكبرى هي الاحماض الامينية المحددة لبروتين درنات حب العزيز يليها الحمض الامينى الثريونين والايزوليوسين.

قام بتحكيم البحث

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كلية الزراعة - جامعة كفر الشيخ

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