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Chufa Tubers (*Cyperus esculentus* L.): As a New Source of Food

[1]*Shaker M. Arafat,* [2]*Ahmed M. Gaafar,* [1]*Amany M. Basuny and* [3]*Shereen L. Nassef*

[1]Fats and Oils Department, [2]Special Foods Department, [3]Bread Pastries Department,
Food Technology Research Institute, Agriculture Research Center, Giza, Egypt

Abstract: This work reported the proximate evaluation of dry Chufa (*Cyperus esculentus* L.) tubers with emphasis on the characterization of its oil extracted as compared with olive oil (*Oleo europea*). Moreover, fatty acids compositions of both oils were analyzed by gas liquid chromatography (GLC). Minerals content of chufa tubers were analyzed by atomic absorption spectrophotometer. Also, amino acids content of chufa tubers was determination by amino acid analyzer. Chufa coated with chocolate was prepared from chufa tubers and sensory qualities were evaluated as compared with commercial peanut coated with chocolate. Results indicated that Chufa tubers were characterized by low moisture content (3.75 %), high levels of starch (295 g / kg) and high fat content (30.00 %). Tubers contained significant amounts of fiber (4.30 %), rich in Ca (152.00 ppm), P (123.00 ppm) and Na (140 ppm). Moreover, Chufa tubers are a good source of total amino acids. Amino acid profiles were dominated by, aspartic acid followed by glutamic acid, leucine, alanine and arginine. It is remarkable that the Chufa and olive oils are similar in fatty acid composition. Chufa and olive oils contained palmitic acid as the main saturated acid and oleic acid as the predominant unsaturated acid. In conclusion, the results obtained show that preparation of Chufa coated with chocolate from Chufa tuber was cheaper, more nutritious highly acceptable healthy food. The results provide additional information about the nutritional value and confirm that of chufa tubers are an interesting healthy food.

Key words: Chufa tubers · Proximate analysis · Chufa oils · Minerals · Amino acids · Chufa tuber with chocolate

INTRODUCTION

Chufa (*Cyperus esculentus*) a grass like plant of the family Cyperaceae (sedge family), order Cyperales or Graminales [1] and genus Carex [2] is widely distributed in many north temperature locations [3] within South Europe as its probable origin [4]. Like other sedges the plant is most frequently found inhabiting wet marshes and edges of streams and ponds where it grows in coarse tufts [2]. In most countries, the plant is grown as a weed of cultivation to serve as sand or soil binders. Chufa produces rhizomes from the base with somewhat spherical tubers. In Egypt, it is used as a source of food, medicine and perfumes [5].

Chufa is commonly known as earth almond, tiger nut, chufa, yellow nut sedge and zulu nuts. It is known in Nigeria as "Ayaya" in Hausa, 'Ofio" in Yoruba and "Akiausa") in Lgbo where three varieties (black, brown and yellow) are cultivated [6]. Among these only two varieties yellow and brown are readily available in the market. The yellow variety is preferred to all other varieties because of its inherent properties like its bigger size, attractive colour and fleshier body [7]. Tiger nut can be eaten raw, roasted, dried, baker or be made into a refreshing beverage called (Hochata De Chufas) or tiger nut milk [8]. Also, it can be used as a flavoring agent for ice cream and Biscuits [9].

Tiger nut was reported as healthy and it helps in preventing heart attacks, thrombosis and activates blood circulation. It helps in preventing cancer, due to high content of soluble glucose. It was also found to assist in reducing the risk of colon cancer [10]. The nut is rich in energy content (starch, fat, sugars and protein), mineral (phosphorus, potassium) and vitamins E and C [11].

Tiger nut reduces the risk of colon cancer and it is suitable for diabetic persons and also helps in loosing weight [12]. It was equally reports to have high content of oleic acid with positive effect on cholesterol level due to its high content of vitamin E. The nut was found to be ideal for children, older persons and the sportsman [13]. The tubers contain about 25 % oil, which are resistant to

Corresponding Author: Shaker M. Arafat, Fats and Oils Department, Food Technology Research Institute, Agriculture Research Center, Giza, Egypt

peroxidation, 50 % digestible carbohydrates, 4 % protein and 9 % crude fiber [14,15]. Oil extracted from tiger nut can be used as food oil as well as industrial purposes [16,17].

The present investigation was carried out to determine the proximate composition and functional properties of Chufa tubers, characterizing the oil fraction and production of Chufa tuber coated with chocolate as compared with peanut coated with chocolate as a children food.

MATERIALS AND METHODS

Materilas

Source of Tubers: Tiger nut (Chufa) tubers (*Cyperus esulentus*) were obtained from the local markets at Tanta city, Egypt and olive fruits (Coratina variety) were obtained from Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. Chocolate and peanut with chocolate (S and S) were obtained from local market.

Methods

Proximate Analysis: A.O.A.C. [18] methods were used to determine moisture, protein, fat, crude fiber and ash contents, while carbohydrate was calculated by difference. Starch content was determined according to Abdel-Akher and Michalinos [19]. Sugar content was extracted by the method described by Pearson *et al.*[20].

Minerals Analysis: The method described by A. O. A.C. [18] was used for mineral analysis. The ash was digested with 3 ml of HCl and made up to the mark in a 100 cm^3 standard flask with 0.36 ml HCl before the mineral elements were determined by atomic absorption spectrophotometer (PYE Unicom, UK, Model SP9).

Amino Acid Determination: Amino acid of Chufa nut was carried out in National Research Center, Giza, Egypt, as follows: samples were subjected to acid hydrolysis using 6N Hcl. The hydrolyzate was recovered by removing the acid by evaporation in a rotary evaporator. Amino acids were performed in hydrolyzate using amino acid analyzer, LC 3000 amino acid analyzer, High performance system, a product of LC Biochrom EPPDROP. Germany, A.O.A.C. [18].

Oil Extraction: Chufa tubers and olive fruits were crushed and pressed by hydraulics laboratory press. The extracted oils were dried over anhydrous sodium sulphate, filtered through Whitman No. 1 filter paper and kept in brown bottles at 5°C until analysis.

Physico-Chemical Properties of Oils: Refractive index, colour, acid value, peroxide value, iodine number and saponification number were determined according to A. O. A. C. [18]. Oxidative stability of both oils (Chufa and olive) was determined by the Rancimat method at 100°C±2°C [21].

Fatty Acid Determination: Fatty acid composition was analyzed on the gas liquid chromatography (GLC). The oil was etherified before GLC analysis using the method described by Stahle [22]. The methyl esters of fatty acids were prepared using benzene: methanol: concentrated sulfuric acid 86: 10: 4 and the methylation process were carried out for one hour at 80-90°C.

A pye Unicom PU 4550 equipped with dual flame ionization detector was used. The fractionation of fatty acid methyl esters was conducted using a coiled glass column (1.5 mm X 4 mm) packed with diatomic (100-120 mesh) and coated with 10 % polyethylene glycol adipate. The oven temperature was programmed at 8°C / min. from 70°C to 190°C then isothermally at 190°C for 10 min. With nitrogen at 30ml / min. as a carrier gas, the flow rates for hydrogen and air were 30 ml/ min. and 320 ml / min. respectively. Detector and injector temperature were 300°C and 250°C, respectively. The chromatogram of the authentic fatty acids was used to characterize the unknown fatty acids according to their retention times. Present normalization of each fatty acid was calculated by the normalization with response factor method using the PU 4810 competing integration. The fatty acid composition was expressed as percentage of total fatty acid [23].

Preparation of Chufa Coated with Chocolate: A Chufa tuber was soaked in water, dried in air oven at 100°C for 1 hrs, cooled to room temperature and coated with chocolate.

Sensory Evaluation: Twenty panelists evaluated the organoleptic properties of chufa coated with chocolate compared with peanut with chocolate (S & S) as reported by Carpenter [24].

Statistical Analysis: Analysis of variance and the least significant difference (LSD) test at $P > 0.05$ were used for comparison between the mean values of the studies parameters [25].

RESULTS

Chemical Composition: Table 1 shows the chemical composition of the Chufa tubers flour. It was clear that Chufa tubers flour has high contents of carbohydrate, fat and fiber with low contents of ash and protein.

Minerals Content: Elemental compositions of Chufa nut are shown in Table 2. K, Na and Ca were the major inorganic constituents of the ash in all studied samples. Among the trace elements (except zinc, copper and iron) the values found in Chufa nut are low and within the limits advised for nutrition.

Amino Acids Composition: The amino acids compositions of Chufa nut flour are presented in Table 3. Aspartic acid was the most predominant amino acid followed by glutamic, alanin, leucine, lysine and glycine. Cyctine and methionine were in the lowest levels in Chufa nut flour. On the other side, essential amino acids represented 28.68, while nonessential amino acids represented 43.81 and E/N was 0.65 for Chufa nut flour.

Table 1: Chemical composition of Chufa tubers

Components	Values
Moisture (%)	3.75±0.30
Protein (%)	5.00±0.08
Oil (%)	30.00±2.00
Carbohydrates (%)	47.00±1.50
Ash (%)	4.30±0.13
Fiber (%)	6.50±0.90
Starch (g / kg)	295.00±3.15
Sucrose (g / kg)	92.00±1.12
Reducing sugar (g / kg)	25.00±0.85

Table 2: Mineral content of Chufa tubers (ppm)

Minerals	Contents
Calcium (Ca)	152.00±1.31
Sodium (Na)	140.00±1.20
Phosphour (P)	123.00±1.15
Magnesium (Mg)	55.30±1.10
Manganese (Mn)	41.00±0.82
Iron (Fe)	2.00±0.25
Copper (Cu)	1.30±0.8
Zinc (Zn)	1.00±0.11

Values are mean ± SE of three estimations.

Table 3: Amino acid of Chufa tubers

Name of amino acid	Mg\ 16g N
Hist	4.43±1.10
I leu	4.84±0.90
Leu	8.03±0.83
Lys	6.50±0.67
Met	11.83±2.50
Phe	4.27±1.00
Thr	3.59±0.50
Val	5.93±0.81
Ser	4.96±0.91
Tur	3.31±0.49
Ala	9.24±1.90
Arg	5.79±1.23
Asp	14.79±3.00
Ceys	0.69±0.15
Glu	12.14±2.38
Gly	6.35±0.80
Prol	4.00± 1.00

Table 4: Characteristics of Chufa and olive oils

		Oils	
Characteristics		Chufa	Olive
Refractive index at 25°C		1.4653±0.001	1.4660±0.001
Coluor at 35 yellow Red		3.00±0.31	3.10±0.37
Acid value (% as oleic acid)		0.80±0.002	0.20±0.01
Peroxide value (Meq.O_2/ kg oil)		0.30±0.01	2.50±0.15
Iodine number (Hanus)		113.00±1.50	89.00±0.90
Saponification value (Mg KOH/g)		209.00±2.70	186.00±1.95
Oxidative stability (hrs)		28.00±1.00	30.00±1.15
Fatty acids composition (%)	$C_{14:0}$	0.80±0.001	0.40±0.001
	$C_{16:0}$	14.50±0.90	20.50±1.20
	$C_{16:1}$	1.50±0.10	2.00±0.10
	$C_{18:0}$	3.40±0.15	2.50±0.17
	$C_{18:1}$	69.50±2.13	71.00±3.10
	$C_{18:2}$	8.80±1.00	6.18±0.85
	$C_{18:3}$	0.40±0.001	0.30±0.001
	$C_{20:0}$	0.20±0.001	0.10±0.001

Values are mean±SE of three estimations.

Physico-Chemical Properties of Chufa and Olive Oils: Table 4 shows the physico-chemical properties of Chufa and olive oils. The obtained data indicated that the refractive index, the colour and the oxidative stability of Chufa and olive oils were similar. The results indicated that the acid value, iodine number and Saponification value of Chufa oil were higher than those of olive oil.

Table 6: Sensory evaluation of Chufa tubers coated with chocolate

Character	Chufa tuber	Peanut seed
Taste	8.30[a]±1.00	8.00[a]±0.94
Flavor	7.25[a]±0.90	6.90[b]±0.71
Colour	7.00[a]±0.82	7.00[a]±0.80
Texture	8.00[a]±0.95	7.50[b]±0.85
General acceptability	8.50[a]±0.98	7.50[b]±0.87

Values are mean±SE of three estimations.

Values in each row followed by the same latter are not significantly different at p = 0.05

Fatty acids compositions of Chufa nut as compared to olive oils are shown in Table 4. Chufa nut oils had high amounts of unsaturated fatty acids. The major unsaturated fatty acids were oleic (69.50) followed by palmitic (14.5%) and at the last was linolenic (8.8%).

Sensory Evaluation of Chufa Coated with Chocolate: The sensory evaluation revealed that Chufa coated with chocolate prepared from Chufa tubers was more acceptable with the best taste, flavour, colour and texture compared with commercial peanut chocolate named S & S (Table 6). Chufa nut coated with chocolate had significantly ($P < 0.05$) improved flavour, texture and general acceptability. While, no significant difference s were found in texture and colour between Chufa nut and peanut coated with chocolate.

DISCUSSION

The obtained data for the composition of Chufa tubers indicated that the moisture content of Chufa tubers was 3.75 %. The carbohydrate content of Chufa tubers was found to be the first component in these tubers (47.00 %.) followed by oil content (30.00 %.). Moreover, protein, ash and crude fiber of Chufa tubers were 5.00, 4.3 and 6.50 %, respectively. The starch content of Chufa tubers was 295.00g / kg. It was reported that Chufa tubers contain almost twice the quantity of starch as potato or sweet potato tubers [26]. Regarding, total sugar content, reducing sugar and sucrose, in general tubers have high contents of sugar. When the sugar contents of Chufa tubers were compared with those of other tubers and nuts, the sugar level of Chufa was relatively low. However, the taste of Chufa depends on the sugar content to give a very characteristic flavor. Because of its pleasant nutty flavor, Chufa is consumed as a kind of snake food and could be useful in food technology.

The current study revealed that Chufa tuber have high calcium, sodium and copper and low magnesium, manganese, phosphorus, iron, zinc and copper mineral contents. The high values of calcium found in the Chufa, are adequate for bone and teeth development in infants. The presence of other minerals such as iron is highly important because of its requirement for blood formation. Therefore, Chufa nut flour could be used as supplementation for cereal flour to improve its content from Ca [8].

Atotal of seventeen amino acids was identified in the chufa tubers, namely cysteine (Cys), proline (Pro), L-alanine (Ala), L-aspartic acid (Asp), glycine (Gly), L-glutamic acid (Glu), araginine (Arg) and the essential amino acids: isoleucine (Ile), leucine (Leu), lysine (Lys), L-histidine (His), L-methionine (Met), L-threonine (Thr), L-phenylalanine (Phe), L-tyrosine (Tyr), L-serine (Ser) and L-valine (Val). The amino acids profile was dominated by Asp, which resulted from the conversion of asparagine [12]. Other important amino acids were Glu, which resulted from glutamine, followed by Leu, Ala and Arg. These results are in accordance with Oladele and Aina [8]. In general, Chufa tubers are good source of these compounds, however, amino acids profiles are not will balanced, with certain essential amino acids occurring in limiting concentration when compared to FAO [27] recommended levels.

Regarding the physico-chemical properties of Chufa and olive oils, the obtained data indicated that the refractive index of both oils were 1.4653 and 1.4660, respectively. The colour of Chufa and olive oils are clear bright yellow. The results indicated that the acid as (% oleic acid) of Chufa oil was lower (0.08 %) than those of olive oil (0.20 %). The peroxide value of Chufa oil is lower (0.30 meq./ kg oil) than that of olive oil (2.50 meq. / kg oil). The iodine value of Chufa oil is higher (113.oo) as compared with olive oil (91.00). Saponificatioon number of Chufa oil is higher than that olive oil. Oxidative stability of chufa and olive oils on 100°C using Rancimat method was 28.00 and 30.00 hours, respectively. These character as whole indicate the increase of shelf life of chufa oil compared with olive oil [21, 28].

Chufa oil analysis indicated that the most abundant saturated fatty acid is palmitic acid, whereas the main saturated fatty acids present are oleic and linoleic acids. Olive oil had the highest percentage of palmitic and oleic acid. There was no significant difference between levels of most the fatty acids in the Chufa and olive oils. The stearic and oleic acids content was virtually the same in both oils. The present study has shown that oleic acid is the major fatty acid in Chufa oil, just as reported by other investigators [28, 29]. These compositions indicated that the chufa oil is similar with olive oil in fatty acids composition [21].

The sensory evaluation in this work, revealed that Chufa coated with chocolate was more acceptable with the best taste, flavour, colour and texture compared with commercial peanut with chocolate (S & S). This result was in support of the other investigators who found tiger nut (Chufa) drink being highly acceptable. The resultant coating of tiger nut with chocolate is more nutritious and its sensory qualities make it more acceptable than peanut coated with chocolate.

In conclusion, the present results revealed that Chufa coated with chocolate could be used as a food for both the young and old persons due to the high nutrient contents (protein, fat, fiber, carbohydrates, minerals and etc).

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