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CHEMICAL COMPOSITION AND TECHNOLOGICAL EVALUATION OF CHUFA TUBER *(Cyperus esculentus L.)*

CHUFA YUMRUSUNUN (*Cyperus esculentus L.)* KİMYASAL BİLEŞİMİ VE TEKNOLOJİK DEĞERLENDİRİLMESİ

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ÖZET: Çok yıllık ot benzeri bir bitki olan *Cyperus esculentus* L. Afrika ve Güney Avrupa ülkelerinde doğal olarak yetişmekte ve küçük tatlı yumruları "chufa" olarak adlandırılmaktadır. Yumru badem veya fındığın tipik aromasına sahiptir. Chufanın kimyasal bileşiminde % 20.1-41.7 nişasta, % 20.9-30.2 yağ, % 10.6-20.2 şeker ve % 5.1-15.1 düzeyinde ham lif bulunmaktadır. Akdeniz Ülkelerinde ve özellikle İspanya'da yumrular insan gıdası olarak kullanılmaktadır. Tüketimi genellikle taze, suda ıslatma, kurutma ve kavurma şeklinde olmaktadır. Buna ek olarak dondurma üretiminde flavor verici olarak kullanılmakta, kavrulmuş chufa parçaları bazı zamanlar bisküvi ve diğer fırın ürünlerine eklenebilmektedir. Fakat gıda endüstrisinde en yaygın kullanım alanı "horcata de chufa" olarak bilinen ürünün üretimidir. Chufa; Türkiye'de sadece Çukurova Tarımsal Araştırma Enstitüsünde sınırlı miktarlarda üretilmekte ve ticari olarak değerlendirilmemektedir.

ABSTRACT: *Cyperus esculentus* L. is a kind of perennial grass-like plant native to Africa and Southern Europe which produce small sweet tubers called "chufa". The tuber has a taste typical of almond or hazelnut. Chufa has a high content of starch (20.1-41.7%), fat (20.9-30.2 %), sucrose (10.6-20.2 %) and crude fiber (5.1-15.1 %). They are used as human food in several countries around the Mediterranean Sea, particularly in Spain and eaten fresh, soaked in water, or dried and roasted. Also, it is used successfully as a flavoring agents in the ice cream formulation. Sometimes roasted chufa is added to biscuit and other bakery products. But the best known application of the chufa in food industry is in the production of the "horchata de chufa". Chufa is only grown in the Institute of Çukurova Agricultural Research found in Adana, Turkey and not evaluated commercially.

INTRODUCTION

Cyperus esculentus L. is an edible grass-like plant to Africa and Southern Europe and has been cultivated since early times. This plant characterized by it's creeping rootstocks, which produce small sweet tubers 1-2 cm in length with an abtuse end of irregular form when dry and round or egg-shaped when swollen in water. The rootstock is brown on the surface and white inside. Tubers are called in Spanish "chufa". Because of the almond like flavor these tubers also known as "Earth almonds" (MOKADY and DOLEV, 1970; LINSSEN et al 1988; ODERINDE and TAIRU, 1988; LINSSEN et al, 1989; ADEBAJO, 1993; MOSQUERA et al, 1996; CANTALEJO, 1997). Besides, chufa nut is known under different names such as tiger nut (TEMPLE et al, 1989), earth nut, rush nut and edible galingale (ABDEL-AKHER and MICHALINOS, 1963; ADDY and ETESHOLA, 1984).

Chemical Composition and Nutritive Value of Chufa

The chemical composition of chufa tubers is listed in Table 1. As can be seen, chufa nut tubers may be considered as one of the rich sources of starch (ABDEL-AKHER and MICHALINOS, 1963). The tubers contain almost double the quantity of the starch in potato or sweet potato tubers. In addition chufa contain considerable amount of sucrose and lipids. Previous researchers evaluated the nutritional components of chufa (ABDEL-AKHER and MICHALINOS, 1963; MOKADY and DOLEV, 1970; ADDY and ETESHOLA, 1984; NAZLICAN, 1984; LINSSEN et al, 1989; TEMPLE et al, 1989). They concluded that chufa has a low nutritional value, but this conclusion is based on the high level dietary fiber of chufa tubers. More recently the importance of cellulose

as dietary fiber has become clear. Addition of chufa flour to some food products increases the dietary fiber content significantly (MOKADY and DOLEV, 1970; ADDY and ETESHOLA, 1984; LINSSEN et al,1988; LINSSEN et al, 1989). Chufa tubers contain a rather amount of dietary fiber (Table 1). The main part of the dietary fiber consists of insoluble carbohydrates, mainly cellulose and lignin. Xylose is also present as a substantial proportion of the in soluble dietary fiber fraction. Because of the high amount of dietary fiber and the pleasant, nutty flavor, chufa could be useful as a good source of dietary fiber in food technology.

Table 1. Proximate Composition of Chufa

	References					
(%)	(1)	(2)	(3)	(4)	(5)	(6)
Dry matter	93.0	-	95.5	93.0	94.2	90.3
Protein (N* 6.25)	3.78	5.1	3.8	-	7.0	5.1
Crude Lipid	25.1	22.0	32.8	24.8	25.7	25.5
Starch	39.2	-	-	17.2	-	30.5
Crude Fiber	4.8	13.0	8.80	-	5.5	9.6
Ash	2.5	-	6.70	-	1.9	2.2
Carbohydrates	-	60.0	47.9	-	60.0	-
Sucrose	19.1	-	-	22.3	-	17.4
Pentosans	1.1	-	-	-	-	-
Reducing sugar	0.5	-	-	-	-	-

(1) ABDEL-AKHER and MICHALINOS, 1963; (2) MOKADY and DOLEV, 1970; (3) ADDY and ETESHOLA, 1984; (4) NAZLICAN, 1984; (5) LINSSEN et al, 1989 and (6) TEMPLE et al, 1989.

One of the major obstacles to the wider use of lesser-known vegetables as food or animal feed is the presence of toxic substances. The level of the trypsin inhibitor in the chufa is much lower (42.7 Trypsin Inhibitor Units TIU mg^{-1} sample) than that found in soya products (73-110 TIU mg^{-1}sample). Boiling treatment for 1 h reduce the trypsin inhibitor in chufa by about 70% (ADDY and ETESHOLA, 1984). Several products containing dietary fiber have a rather high content of phytic acid which can bind essential minerals making them unavailable for absorption. Linssen et al. (1989) reported phytic acid content of chufa is 724 mg per 100 g dry matter.

Table 2. The Properties of Different Types of Starch (ABDEL-AKHER and MICHALINOS, 1963)

	Butanol treated starch		
	Chufa	Sweet potato	Corn starch
Viscosity	2.4	7.3	8.4
Ferricyanide number	2.0	1.0	1.0
Alkali number	29.2	2.8	2.3
Amylose (%)	Tr	25.4	23.3
Phosphorus (mg/100 g)	4.2	20.2	19.3

microscopically examination of the chufa starch shows that the granules egg-shaped and contain distinct concentric striation. They are similar in appearance to those of potato starch. However they are smaller size (ABDEL-AKHER and MICHALINOS, 1963).

Chufa contains approximately 4% (3.77–7.00%) crude protein, an amount similar to that some species of tubers. Considering the large amounts of extractable oils protein rich concentrates could be prepared by defatting samples (ADDY and ETESHOLA, 1984). The essential amino acid content of chufa is shown in Table 3.

The properties of different types of starches are given in Table 2. Chufa starch shows high values for the alkali number and for the ferricyanide number. It dissolves readily in alkaline solution (1% NaOH solution) giving clear solutions with low viscosity. The

Table 3. Comparison of the Essential Amino Acids Content (g 16 g^{-1} N) of Chufa and FAO Reference Protein

	References		
	(1)	(2)	(3)
Isoleucine	2.9	1,8	4.0-4.2
Leucine	5.4	2,9	4.2-4.7
Lycine	4.8	4,9	4.2-4.5
Cystine + Methionine	2.0	3,5	3.5-4.2
Phenylalanine + Tyrosine	5.7	3,2	5.6-6.0
Threonine	3.8	2,7	2.8-4.0
Tryptophan	1.0	1,0	1.0-1.4
Valine	5.1	2,5	4.2-5.0

(1) ADDY and ETESHOLA, 1984; (2) TEMPLE et al, 1989 and (3) ANONYMOUS 1973.

Another interesting component of chufa is the oil fraction. Chufa oil can be obtained by using a hydraulic press (LINSSEN et al, 1988) or by extracting with petroleum ether (ODERINDE and TAIRU, 1988). Oil content of chufa tuber (22.8%) compares well with those soybean and cotton seed oil (21% and 22.9% respectively) while it is more than five times greater than that in corn seed oil. Chufa oil characteristics are given in Table 4. Linssen et al. (1988) reported that yield from the oil pressing experiment of chufa tuber is between 45–55%. The lipid composition of chufa oil is given in Table 5. As can be seen from Table 5, the fatty acid composition of chufa and olive oil show a great similarity. This is surprising, because the oils are from different origins. Chufa is a tuber and olive is a fruit. The most abundant fatty acid in the triglyceride fractions of the chufa oil is oleic acid (Table 5). Linoleic acid is the second most abundant fatty acid. High proportions of oleic, palmitic and stearic acid in the triglyceride fraction of the oil make it of good potential for soap making while the presence of linoleic acid in the triglyceride fraction of the oil make it a good dietary lipid because it is known linoleic acid serves as the carrier of nutritionally essential fat-soluble vitamins (ODERINDE and TAIRU, 1988).

Table 4. Some Characteristics of the Chufa Oil

	References	
	(1)	(2)
Oil (on dry matter basis) (%)	22.6-22.9	20.0-30.0
Saponification number	193.2-195.6	165-193
Iodine number	80.2-83.3	73-96
Hydroxide number	10.3-10.7	10.5
Peroxide number	5.3-6.9	-
Refractive index (at 25 °C)	1.4674	1.4680

(1) ODERINDE and TAIRU, 1988 and (2) NAZLICAN, 1984

Table 5. Comparison of the Fatty Acid Composition of Chufa and Olive Oil (Area %)

	Chufa oil		Olive oil
References	(2)	(1)	(1)
Palmitic acid	10.21	13.4-14.1	10.8-11.5
Palmitoleic acid	-	0.2-0.3	0.6-1.5
Stearic acid	1.47	3.0-3.3	2.5-2.6
Oleic acid	75.72	71.7-73.5	70.5-75.5
Linoleic acid	11.64	8.7-9.1	7.5-15.1
Linolenic acid	0.64	0.4	0.5-1.0
Arachidic acid	0.32	0.2-0.5	0.3-0.5

(1) ODERINDE and TAIRU, 1988 and (2) LINSSEN et al, 1988.

Although the fatty acid composition and distribution of the chufa and olive oils are nearly the same, they are different in color and taste, caused by accompanying components. Olive oil has a green color while chufa oil has a gold-yellow color. The taste of olive oil very characteristic but the taste of chufa oil is neutral. Chufa oil can be used in the same manner as olive oil. Also these results show that it is very difficult to recognize a mixture of olive oil and chufa oil by usual analytical methods such as fatty acid composition and positional fatty acid distribution (LINSSEN et al, 1988).

Technological Evaluation of Chufa

Chufa is used as a food stuff and daily ingredients of the diet of many people in several countries around the Mediterranean Sea, particularly in Spain. Chufa tubers have been promoted in recent years by vegetarian organizations as a complete diet in European countries, in the U.S.A. and in Israel (MOKADY and DOLEV, 1970). Chufa is produced in the Southern United States as animal feed and is ranked in the top ten most important waterfowl foods (MOSQUERA et al, 1996). In Egypt, Chufa is soaked with water overnight and consumed fresh (LINSSEN et al, 1988). In many parts of Nigeria, the tubers (fresh or dried) are eaten like nuts or pounded in to cakes and served at the end of a meal (ADDY and ETESHOLA, 1984). The best known application of chufa in food technology is in the production of "Horchata De Chufa". Horchata is the milky-looking aqueous extract of chufa, which has a very pleasant and characteristic flavor. Horchata is mainly produced in Spain during the summer time. It's consumption has been very popular on the Eastern coast of Spain for several centuries, especially in Valencia, where it is considered to have originated (LINSSEN et al, 1988; MOSQUERA et al, 1996). Besides horchata other application of chufa tubers are possible in the food

industry. These are fresh consumption, drying, soaking in water, mixing with roasting peanut, roasting, using of roasted tubers as a caffeine free coffee substitute, using as a flavoring agent in ice cream formulation, adding to biscuit and other bakery products, milling and so on (MOKADY and DOLEV, 1970; ODERINDE and TAIRU, 1988; LINSSEN et al, 1989; MOSQUERA et al, 1996; CANTALEJO, 1997).

Previous researches had been used to chufa for citric acid production (ESUOSO et al, 1991) and alcoholic fermentation (ESUOSO et al, 1993), evaluation of tuber oil (LINSSEN et al, 1988; ODERINDE and TAIRU, 1988), evaluation of dietary fiber (LINSSEN et al, 1989), microbial counts and invert sugars in juice extracts (ADEBAJO, 1993), nutritive value of mixing chufa and baobab seeds (ADDY and ETESHOLA, 1984), separation and purification of starch (ABDEL-AKHER and MICHALINOS, 1963) and analysis of volatile components of raw and roasted chufa (CANTALEJO, 1997).

CONCLUSION

Chufa (Cyperus esculentus) is grown limited amount in the Çukurova region of Turkey. But it is used as human food in several countries around the Mediterranean Sea. Chufa contains high amount crude lipid and carbohydrate content and its fairly good essential amino acid composition make it a valuable source of food for both human and live stock. Foods based on the chufa is prepared by a wide range of recipes and preparation methods. Traditional processing and preparation methods include; drying, soaking, milling, roasting, extraction, mixing with other nuts and the best known application of chufa in food technology is in the production of "Horchata de Chufa". Horchata de Chufa is a milky looking extract which, when sweetened with sugar, produces a refreshing beverage with a very pleasent and characteristic flavor. In the future chufa production can be expected to increase if there is a demand for its tubers.

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