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Physical and chemical analysis and fatty acid composition of peanut, peanut oil and peanut butter from ÇOM and NC-7 cultivars

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RESUMEN

Análisis físico-químico y composición en ácidos grasos de cacahuete, aceite de cacahuete y manteca de cacahuete de plantaciones ÇOM y NC-7.

En las muestras de dos diferentes tipos de cacahuete y manteca de cacahuete, obtenidas de localidades diferentes de la misma región, se han determinado: humedad, proteína, grasa, celulosa, ceniza y energia. Por otro lado, se ha medido el peso de 1000 semillas y sus tamaños. En las muestras se han estudiado mediante un Espectrofotómetro de Emisión Atómica - Plasma con Acoplamiento Inductivo (ICP-AES) el contenido en Na, K, Ca, P, Fe, Zn, Cu, Mg, Mn, Al, As, B, Cs,Cr, Li, Pb, Se y V. En los granos y en la manteca de cacahuete se ha determinado la acidez, el índice de iodo, el índice de peróxido, la densidad relativa, el índice de refracción, los tocoferoles, el índice de saponificación y la materia insaponificable. Por cromatografía de gases se ha determinado en las semillas y en los aceites de manteca de ambas plantaciones los ácidos: mirístico, palmítico, palmitoléico, esteárico, oleico, linoleico, linolénico, araquídico, gadoléico y behénico. Los ácidos grasos mayoritarios de las mantecas y semillas de cacahuetes en las dos variedades fueron los ácidos oleico, linoleico y palmítico. Ambas variedades mostraron altas concentraciones de ácido oleico. Por consiguiente, las mantecas y semillas de cacahuetes de ÇOM y NC-7 aparecen ricas en aceite, proteína, ácidos oleico y linoleico y minerales. El aumento de la relación alto oleico/linoleico y del contenido en tocoferoles es muy importante debido a la estabilidad del aceite. También, la manteca de cacahuete es equivalente nutricionalmente al grano de cacahuete.

PALABRAS-CLAVE: Aceite – Ácidos grasos – Cacahuete (Arachis hypogaea L.) – Manteca de cacahuete – Propiedades físicas – Propiedades químicas - Minerales.

SUMMARY

Physical and chemical analysis and fatty acid composition of peanut, peanut oil and peanut butter from ÇOM and NC-7 cultivars.

In the samples of two different peanuts and peanut butters which were obtained from different locations of the same region, moisture, protein, oil, cellulose, ash and energy have been determined. Furthermore, the weight of 1000 seeds peanuts and their sizes have been measured. In the samples, Na, K, Ca, P, Fe, Zn, Cu, Mg, Mn, Al, As, B, Cs,Cr, Li, Pb, Se and V amounts have been established by using Inductivelly Coupled Plasma-Atomic Emission Spectrophotometer (ICP-AES). In the kernels and peanut butter, acidity, iodine and peroxide value, relative density, refractive index, tocopherol, saponification number and unsaponifiable matter have been determined. In the seed and butter oils of ÇOM and NC-7 cultivars, respectively; myristic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic, arachidic, gadoleic and behenic acids were identified mainly by gas chromatography. The major fatty acids of peanut seeds and butter of both cultivar were oleic, linoleic and palmitic acids. Both variety exhibited higher concentrations of oleic acid.

Consequently, peanut seeds and butters of ÇOM and NC-7 were found rich in oil, protein, oleic and linoleic acids and mineral compositions. Increasing of high oleic / linoleic ratio and tocopherol contents are very important due to stability of oil. Also, the peanut butter are nutritionally equivalent to peanut kernel.

KEY-WORDS: Chemical properties – Fatty acids – Mineral composition – Oil – Peanut (Arachis hypogaea L.) – Peanut butter – Physical properties.

1. INTRODUCTION

The genus *Arachis,* a member of the family Leguminoseae, is widely distributed in the tropics and moderate regions. Peanut (*Arachis hypogaea* L.) is an important source of edible oil for millions of people living in the semi tropic region.

The fact that Turkey possesses varying climatic conditions results in cultivation of a wide range oil bearing crops trees and nuts. Peanut is located mainly in the Mediterranean and South-West Anatolian coastline. In Turkey, 63.800 tons of peanuts are being produced annually (Yazicioglu and Karaali 1983, Ergül 1998). Peanuts are among the oldest oil crops of Turkey. Peanuts are mostly consumed as snack food after roasting like other nuts (Yazicioglu and Karaali 1983, Bansal *et al.* 1993, Jambunathan *et al.*1993).

Peanuts make an important contribution to the diet in many countries. Peanut seeds are a good source of protein, lipid and fatty acids for human nutrition (Tai and Young 1975, Gaydou *et al.* 1983, Grosso and Guzman 1995, Grosso *et al.* 1997,1999). Oil, protein, alcohol-soluble sugars, mineral ash and lignin contents of 3 Virginia-type peanut kernels were established by Wallerstein *et al.* (1989).

Peanut are rich in oil, naturally containing from 47 to 50 %. The oil is pale yellow and has the characteristic odor and flavor of peanuts (O'Brien, 1998). Oil quality and its stability is therefore very important for the consumers (Jambunathan *et al.*1993). The composition of peanut and its oil of several cultivars of *Arachis* hypogaea and peanut species have been studied (Mozingo *et al.* 1982,

Mercer *et al.*1990, Jambunathan *et al.*1992, Hashim *et al.*1993, Grosso *et al.* 1994,1997 and 1999, Çelik 1995, Grimm 1996, Chiou *et al.*1997). The most recent contribution in this area is by Grosso and Guzman (1995), Grosso *et al.* (1997) and Jambunathan *et al.* (1992,1993). Sheppard and Rudolf (1991) researched total lipids, fatty acids and proximates properties of peanuts and peanut products. Çelik (1995) determined proximate and fatty acid composition of peanut seeds growing in Turkey. The proximate, fatty acid and sterol compositions of peanut seeds have been studied by Grosso *et al.*(1997).Grosso *et al.* (1999) studied the chemical composition of the oil of aboriginal peanut seeds from Uruguay. Grosso *et al.* (2000) have reported the oil, protein, ash, carbohydrate contents, iodine value and fatty acid composition of some wild peanut species (Arachis) seeds. The fatty acid composition of groundnut oil is well documented (Treadwell *et al.*1983). The effects of cultivar, location, and their interaction on fatty acid composition have been investigated (Brown *et al.*1975). In other study, fatty acid composition, protein levels, amino acid composition and other components have been investigated in peanut seeds (Ahmed and Young 1982). Leguminous seeds make an important contribution to the diet in many tropical countries. There are regional preferences in the choice of oils, and peanut oil is preferred in Southern Turkey.

The aim of this investigation was to determine the physical and chemical properties and fatty acid composition of peanuts, peanut butter and their oils from Turkey.

2. MATERIAL AND METHODS

2.1. Materials

ÇOM and NC-7 varieties of peanut were purchased from FISKOBIRLIK in Osmaniye province in Turkey in 1999. NC-7 and ÇOM peanut butters used in experiment were produced in Laboratory conditions. The flow diagram of butter production is given in Fig.1.

Reagents: All solvents and chemicals used were analytical, HPLC, ICP-AES and GC grade. Fatty acid standards were purchased from Sigma.

2.2. Methods

The weight of 1000 kernels and width/length were determined at randomized 250 kernels. The physical properties and chemical composition of kernel, peanut butter and their oils were analyzed according to AOAC (1984). Peanut kernels were ground,and oil was extracted for 8 h with diethylether in a soxhlet apparatus. Then, the solvent was completely removed under reduced pressure in a rotary evaporator. Oil percentages was determined by weight difference. The protein content was determined by the Kjeldahl method and used 5.46 as the conversion factor (Grosso *et al.*1999).

Determination of tocopherol: α-Tocopherol was analyzed by an HPLC chromatograhy equiped with a column Superspaer 100 RP-18 (CLICROCHART Company) and a UV detector at 292 nm. Acetonitril/methanol (1/1;v/v) was used as a mobile phase. The system was carried out isocratically at a flow rate of 1 ml/min. 10 μL from oil sample diluted with hexane was injected. Quantification was based on an external standard method (AOCS 1990).

Determination of fatty acids: Fatty acids were derivatized by using the boronitrifluoride method as described by Hisil (1988).

Working conditions of gas chromatography:
Instrument : Hewlett-Packard 6890 Series II
Constant phase: 10 % DEGS (Diethylene Glycol Succinate) + %H3PO4
Support matter: Chromosorb G (100/120 mesh)
Column: %100 Sianopropil polysyloxan, silica capillar column (CP Sil 88,50 m x 250 μm i.d., 0.20 μm film; Chrompack, Middelburg, Holland)
Detector : FID (Flame Ionization Detector)
Temperature Column: 177 ^{o}C
Temperature Injector: 250 ^{o}C

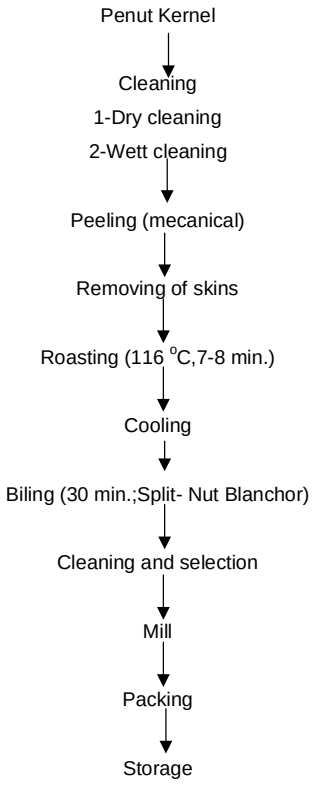

Figure 1
The Flow diagram of peanut butter production

Temperature Detector: 250 °C
Flow rate Carrier gas (He): 1 ml/min.
Flow rate Burnt gas (H_2): 33 ml/min.
Flow rate Dry gas: 400 ml/min.
Injection amount: 5 µl

A standard fatty acid methyl ester mixture (Sigma Chemical Co.) was used to identify sample peaks. Commercial mixtures of fatty acid methyl esters were used as reference data for the relative retention times AOCS (1990). Quantitative analysis of the fatty acids were performed using the heptadecanoic acid methyl ester as internal standard. The results are mean values of two replicates.

Determination of mineral composition: About 0.5 g dried and ground fruit was put into burning cup and added pure 15 ml HNO_3. The sample was incinerated in CEM-MARS 5 Microvawe Oven at 200 °C temperature. Before each element read in equipment, standards at different concentrations for each element were read in ICP-AES. Then, quantitative concentrations were determined with an ICP-AES (Skujins 1998).

Working conditions of ICP-AES:
Instrument: ICP-AES (Varian-Vista)
RF Power: 0,7-1,5 kw (1,2-1,3 kw for Axial)
Plasma gas flow rate (Ar) : 10,5-15 L/min. (radial)
15 L/min. (axial)
Auxilary gas flow rate (Ar): 1,5 L/min.
Viewing height: 5-12 mm
Copy and reading time: 1-5 s (max.60 s)
Copy time: 3 s (max. 100 s)

Sensory analysis: Sensory analysis was undertaken at specific intervals by the puvan method from quantity-quality tests. Puvans used in experiment are; 1-5 (very poor), 6-10 (poor), 11-15 (normal), 16-20 (good) and 21-25 (perfect) (Altug *et al.* 1995). Sensory evaluation was performed by seven trained panelists. Panelists individually listed terms that described the flavor, odor, color and sensory firmness notes they perceived in the samples. Samples were presented to the panelists in petri-plates. Distilled deionized water was used to rinse the mouth between samples.

Statistical analyses: Results of the research were analysed for statistical significance by analysis of variance (Püskülcü and Ikiz, 1989) and differences among groups were established according to Minitab (1991). ANOVA and a randomized complete block design were used for differences among means, partitioned by the Waller-Duncan test (Mstat 1980).

3.RESULTS AND DISCUSSION

3.1. Physical and chemical properties of peanut and peanut butter

In this study, their proximate and fatty acid composition and sensory properties of the peanut and peanut butter were determined (Table I-V). The physical properties of peanut kernels are given in Table I. Differences between weight of 1000 seeds and width/length values of ÇOM and NC-7 cultivars were not significant.

Chemical compositions of peanut and butter are shown in Table I. Differences among moisture, protein, oil, cellulose and energy values of seed and butter were significant at level $p<0.05$. Ash percentages were 2,05-2,01% and they did not exhibit significant differences among varieties.

Water (except for butter), protein and oil values of ÇOM cultivar were higher in comparison with NC-7 kernel and butter. Crude protein, crude oil and crude cellulose of butter of both varieties were decreased according to their seeds. While crude oil and ash contents of seeds were found lower compared with those of Grosso *et al.* (1999) and (2000), protein content was higher. The amounts of the oils were 44,09% and 31,52% in ÇOM and NC-7 kernels, respectively.

Table I
Proximate composition, energy, weight of kernels and width/length ratio of peanut kernel and butter

Cultivars	Moisture (%)	Protein (%)	Oil (%)	Cellulose (%)	Ash (%)	Energy (kcal)	Weight of 1000 kernels(g)	Width/Length
Kernel								
ÇOM	6,07	36,93	44,09	1,11	2,05	7,33	903,7	0,541
	±0,05*C**	±1,290A	±0,435A	±0,01B	±0,05	±0,26B	±11,0	±0,002
NC-7	5,59	35,97	31,52	1,22	2,02	7,07	1014,0	0,550
	±0,09B	±0,874A	±1,261B	±0,01A	±0,24	±0,02D	±9,3	±0,0117
Butter								
ÇOM	6,06	35,07	24,55	1,00	1,86	7,81	-	-
	±0,18C	±0,416AB	±1,120C	±0,03C	±0,07	±0,02A		
NC-7	6,06	32,93	18,67	1,03	2,04	7,13	-	-
	±0,10A	±0,737B	±1,942C	±0,04C	±0,04	±0,03C		

* means ± standard deviation.
** Mean values followed by the same letter within each column are not significantly different at $p<0.05$.

Table II
Mineral composition of peanut kernel and butter

Minerals (ppm)	Kernel		Butter	
	ÇOM	NC-7	ÇOM	NC-7
Na	7811,2*±1,6C**	14814,4±5,1A	3891,2±1,3D	11012,8±3,2B
K	207649±6D	241206±5C	283327±139B	291415±4A
Ca	79449,9±4,7B	89377,9 ±5,6A	11474,4±0,3D	12325,2±10C
P	402013±6D	491860±3B	489836±10C	593990±9A
Fe	1917,86±1,88C	2311,55±2,96C	3656±4,93B	4342,76±2,54A
Zn	2777,6±5,1C	3228,8±1,8B	3609,2±77,6A	3338,9±53,0B
Cu	829,43±1,03C	486,49±1,09D	965,32±3,72A	922,99±1,96B
Mg	166560±37D	189381±1C	224451±4B	239982±5A
Mn	1414,33±2,77D	2811,46±2,98A	2574,99±3,54B	2052,15±2,52C
Al	1680,03±9,31C	1348,87±2,25D	3242,15±1,92B	3714,71±1,76A
As	330,68±1,0B	9830±0,62C	396,69±4,57A	414,88±2,68A
B	2743,6±3,5B	2721,0±2,0C	2744,9±3,3B	13841,0±3,8A
Cd	10,963±0,602D	30,617±0,520B	22,343±0,651C	58,370±0,579A
Co	28,713±0,650C	31,807±0,268B	71,547±0,576A	32,177±0,612B
Cr	30,940±0,457C	28,193±0,599D	62,857±0,488A	57,583±0,775B
Li	766,1±117,7C	1040,8±1,2B	1194,3±3,0AB	1321,7±2,1A
Pb	646,33±7,0B	356,66±1,55D	810,71±1,28A	560,51±1,06C
Se	203,58±2,28B	395,80±1,12A	93,01±0,79D	164,79±1,48C
Sr	1664,44±2,51D	1993,66±2,66C	2206,98±3,77B	2350,61±3,71A
V	326,49±6,60D	420,38±1,06C	492,81±1,47B	504,90±2,16A

* means ± standard deviation.
** Mean values followed by the same letter within each column are not significantly different at p<0.05.

Table III
Physical and chemical properties of peanut kernel and peanut butter oils

	Cultivars	Acidity (oleic%)	Peroxide value(meq O_2/kg)	Iodine value	Relative density(d^{20}_{20})	Refractive index(n^{20}_{D})	Saponification Value	Unsaponifiable matter(g)	α-tocopherol (mg/kg)
Kernel	ÇOM	0,98 ±0,18*B	1,99 ±0,16B**	82 ±2a***	0,954 ±0,003a	1,459 ±0,007	190,33 ±5,69a	0,99 ±0,10A	3,87 ±0,05B
	NC-7	0,93 ±0,09B	2,09 ±0,14B	75 ±2b	0,955 ±0,001a	1,455 ±0,005	166,00 ±5,57b	0,27 ±0,01B	4,47 ±0,06A
Butter	ÇOM	1,45 ±0,06A	2,08 ±0,11B	75 ±3b	0,951 ±0,001a	1,461 ±0,001	181,67 ±3,06a	1,16 ±0,08A	1,50 ±0,10D
	NC-7	1,53 ±0,06A	2,49 ±0,15A	81,67 ±4,51a	0,958 ±0,002a	1,456 ±0,003	178,00 ±10,54ab	0,42 ±0,05B	3,17 ±0,06C

* means ± standard deviation
** Mean values followed by the same capital letter within each column are not significantly different at p<0.05.
*** Mean values followed by the same small letter within each column are not significantly different at p<0.01.

It will be seen that when compared with literature limits, there are significant variations in some chemical composition of most of these kernels (Stalker *et al.*1989, Grosso *et al.*1999,2000). Peanuts are characterized by high oil and protein contents and low ash. Knowledge of these components is important in the end-products of the industry of peanut (Cherry 1977, Ahmed and Young 1982). Decreasing of crude oil and ash in butter is

Table IV
Fatty acid composition of peanut kernel and peanut butter oils (%)

	Cultivars	Myristic	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic	Linolenic	Arachidic	Gadoleic	Behenic
Kernel	ÇOM	0,13	8,70	0,30	3,77	55,07	25,13	0,20	1,90	1,37	3,17
		±0,05*	±0,17C**	±0,10	±0,15c***	±0,32A	±0,57D	±0,10	±0,10a	±0,25A	±0,21AB
	NC-7	0,23	13,03	0,23	4,53	43,13	35,20	0,30	1,53	0,40	2,40
		±0,13	±0,31A	±0,15	±0,21a	±0,45C	±0,46A	±0,26	±0,15a	±0,30C	±0,24B
Butter	ÇOM	0,33	9,37	0,37	4,00	55,10	26,53	0,23	1,93	1,23	3,47
		±0,21	±0,31C	±0,15	±0,10bc	±0,76A	±0,47C	±0,153a	±0,15a	±0,15AB	±0,42A
	NC-7	0,23	10,83	0,47	4,23	48,40	31,93	0,27	1,67	0,63	2,43
		±0,15	±0,49B	±0,31	±0,32ab	±0,30B	±0,21B	±0,15a	±0,15a	±0,25BC	±0,31B

* means ± standard deviation
** Mean values followed by the same capital letter within each column are not significantly different at p<0.05.
*** Mean values followed by the same small letter within each column are not significantly different at p<0.01.

Table V
Sensory properties of peanut butter

Variety	Color	Odor	Flavour	Viscosity	Sandy	Spread
ÇOM	21,00	22,43	19,43	18,71	20,43	19,71
	±6,27*A**	±3,16a***	±5,09A	±2,29a	±6,27a	±4,71B
NC-7	19,00	17,00	19,43	19,86	21,43	22,00
	±2,52B	±3,83b	±1,98B	±5,82a	±4,76b	±4,12A

* means ± standard deviation
** Mean values followed by the same capital letter within each column are not significantly different at p<0.05.
*** Mean values followed by the same small letter within each column are not significantly different at p<0.01.

probably due to removed of hulls or skin and contact equipment of oil.

3.2. Mineral composition of peanut and peanut butter

The mineral contents of peanut kernels and butter are given in Table II. Both seeds and butter of ÇOM and NC-7 cultivars were found rich in Na, K, Ca, P, Fe, Zn, Cu, Mg, Mn, Al, B and Sr. Mineral compositions (except for Cu, Al, Pb, Cr, and B) of NC-7 kernels were higher in comparison with ÇOM cultivar. In addition, mineral contents (except for Zn, Cu, Mn, Co, Cr and Pb) of ÇOM butter were found lower than that of NC-7 butter. Wallerstein *et al.* (1989), When-Hsin *et al.*(1997) and Gyu-Seong (1993) reported that peanut seeds are rich in K, Ca, Mg, P and S.

3.3. Physical and chemical properties of peanut and peanut butter oils

Physical and chemical Properties of their oils are shown in Table III. While differences among acidity, peroxide values, unsaponifiable matter and tocopherol contents of both ÇOM and NC-7 seeds and butter were significant at level p<0,05, differences iodine value, relative density and saponification value were significant at level p<0,01. Acidity, peroxide value and tocopherol contents of butter of both varieties were decreased according to their seeds. The cultivar of NC-7 seed exhibited lower iodine value means than the other cultivar. Furthermore, the cultivar NC-7 showed lower saponification level means. Tocopherols are also of interest because of their antioxidant activity (Dutta *et al.* 1994). Tocopherol levels for var. *hirsuta* (295-337 ppm in oil) were similar to NC-7 (300 ppm) and lower than Flourunner (425 ppm). While peroxide and iodine value of oils were found lower compared with that of Jambunathan *et al.* (1993).

3.4. Fatty acid composition of peanut and peanut butter oils

Fatty acid composition of peanut and peanut butter oils are given in Table IV. Significant differences were found within fatty acids among

varieties of peanut seed and butter. Myristic (14:0), palmitic (16:0), palmitoleic (16:1), stearic (18:0), oleic (18:1), linoleic (18:2), linolenic (18:3), arachidic (20:0), gadoleic (20:1) and behenic (22:0) acids were quantified in peanut seeds and butters of ÇOM and NC-7 cultivars. While differences among palmitic, oleic, linoleic, gadoleic and behenic acids values of both ÇOM and NC-7 seeds and butters were significant at level p<0, 05, differences stearic and arachidic acids values were significant at level p <0, 01.

The major components of both oils were oleic, linoleic, palmitic and stearic acids. Palmitic and linoleic acid contents in the oil of content NC-7 were higher than that of ÇOM, while oleic acid was higher in ÇOM cultivar. Behenic acid content of peanut oil is in the same range as that of olive oil (Nas *et al.* 1992, O'Brien 1998). Peanut oil is used exclusively as an edible oil in Adana, Mersin (Anamur) and Antalya province in Turkey.

Gyu-Seong (1993) determined chemical composition of peanuts from plants (runner, semi-Spanish and Spanish). Predominant fatty acids in free acids were oleic, linoleic, palmitic and arachidic acids. When-Hsin *et al.* (1997) found linoleic acid as major fatty acid, followed by oleic and palmitic acids.

Peanut kernels were analysed for fatty acid composition. Palmitic, stearic, oleic, linoleic, arachidic, eicosenoic, behenic and lignoseric were found to be present in varying quantities cv. (Hammond *et al.* 1997). Anderson *et al.*(1998) studied the relationship between fatty acid composition of 6 high oleic acid peanut genotypes. Oleic acid and linoleic acid represented approximately 80% of the peanut fatty acid profiles, palmitic acid (16:0) 5-10% and stearic (18:0), arachidic (20:0), eicosenoic (20:1), behenic (22:0) and lignoseric (24:0) acids represented 1-3%. The ratio of oleic to linoleic acids was 23:1-32:1 for high oleic acid.

The range of concentrations of the fatty acids was similar to the previous published data (Grosso *et al.* 1994, Grosso and Guzman 1995, Çelik 1995; O'Brien 1998, Grosso *et al.* 2000). The cultivar ÇOM of both kernel and butter showed higher oleic acid and linoleic acid ratio (O/L;2:1).

The variations observed between the results of this work could be probably due to differences in climatic conditions, soil moisture and environmental temperature during maturation of peanut seeds (Worthington and Hammons 1971, Holaday and Pearson 1974, Ahmed and Young 1982, Grosso and Guzman 1995).

3.5. Sensory properties of peanut butter

Sensory analysis of peanut butter produced from ÇOM and NC-7 cultivars are given in Table V.

While differences among color, flavour and spread puvans of ÇOM and NC-7 butters were significant at level p<0, 05, differences odor, viscosity and sandy were significant at level p<0,01. ÇOM butter had advantage due to color, odor and sandy compared with NC-7 butter. Relation between viscosity puvans of ÇOM and NC-7 butters had observed similarity.

As a result, peanut kernels and butters of ÇOM and NC-7 were found rich in oil, protein minerals, oleic and linoleic acids. Its oils were used as edible, salad and frying oil because of high unsaturated fatty acid composition. Also, the peanut butter are nutritionally similar, to their kernels.

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