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FATTY ACID COMPOSITION, TEXTURAL AND ORGANOLEPTIC PROPERTIES OF WHEY BUTTER

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ABSTRACT

Two cream butters and two whey butters were prepared. Cream butters were traditionally prepared by centrifugal separation of milk and churning the produced cream into butter. Whey butters were prepared by centrifugal separation of whey of Ras cheese and whey of Mozzarella cheese and churning the produced cream into butter. The obtained butters were analyzed for fat, moisture, salt and SNF. Fatty acid composition, texture and organoleptic properties of butters were determined. Data revealed that whey butter had higher content of short chain fatty acids and total unsaturated fatty acids than cream butter, consequently, it had softer texture, some stickiness and high spreadability comparing with cream butter. Data of textural analysis were consistent with the fatty acids pattern of gas chromatograph where whey butter showed lower values of hardness and cohesiveness and higher values of adhesiveness and springiness. Whey butter had higher flavor score and lower texture, color and appearance score, suggesting that it will be more suitable for cooking rather than table butter. In addition, its higher content of unsaturated fatty acids comparing to cream butter characterizes whey butter as healthier than cream butter.

INTRODUCTION

Whey has long been considered as a by-product of dairy industry causes environmental pollution. Throughout the last decades of the 20th century, research and development (R&D) paid a great attention to find utility to the huge amounts of whey produced from cheese making. Sweet (rennet) whey contains significant amounts of protein (0.85%), fat (0.36%), lactose (5.14%) and ash (0.53%) (USDA National Nutrient Database for Standard Reference, Release 21, 2008). These components vary according to the milk source, type of cheese, and manufacturing process. By means of modern industrial techniques (membrane filtration) it becomes possible and economical to recovering whey components, separate protein fraction, lactose, fat or minerals from whey in an edible quality with different concentrations and purity. Therefore, today whey is recognized as a source of valuable nutritious elements.

Whey butter is one of whey products produced commercially by the traditional centrifugal separation of whey to getting whey cream, and by churning, butter is obtained. Whey butter has not been a subject of extensive studies yet; despite it is already in use as it is being absorbed by the butter industry (Jinjarak, *et al.*,2006)

Animal feeding, seasonal variations, stage of lactation and animal breed are the main factors affecting the fatty acids composition of milk fat (Hawke and Taylor, 1994; Nickerson, 1995; Shi *et al.*, 2001; Bobe *et al.*, 2003and Chen *et al.*, 2004). Differences in milk fat composition influencing physicochemical properties, texture and keeping quality of butter (Bornaz *et al.*, 1993; Jensen *et al.*, 1991and Precht, 1988). In addition, method of cheese processing determines the fatty acids composition of butter producing from whey.

In Egypt, there is a great demand on milk fat products because of people's habits in preparing foods and cooking. Beside the local production, the annual import (2001, 2002, 2003 and 2004) from butter and other fats and oils derived from milk was 66,909; 66,098; 57,746 and 46,225 million US$ respectively, (World Trade Organization). Therefore, whey cream production from Ras cheese and Mozzarella cheese whey has widely known and produced not only by large scale dairy plants but also by private small and medium capacity cheese manufacturers. Considerable amounts of whey cream producing by centrifugal separation of salted whey from Ras cheese or sweet whey from Ras cheese (before salting) or mozzarella cheese. In all cases, salt is added to the separated cream as a preservative and ghee (samna) is produced either directly from cream by boiling or after churning of cream into butter and then boiling to produce ghee.

The present study was carried out to determine the rheological and organoleptic properties and the fatty acids profile of whey butter as detrimental factors affecting the quality of butter.

MATERIALS AND METHODS

a) Cream butter: Cream was obtained from fresh cow milk prepared to Ras or Mozzarella cheese making (obtained from a private factory for cheese making, Behera Governorate) by conventional centrifugal separation at 37°C. Cream was cold stored at refrigeration temperature for 24 hours and then it was churned manually into butter. Edible grade sodium chloride (ElNasr Salines Company, Egypt) was added at a rate of 2% and the butter was stored at -15°C until use.

b) Whey butter: Whey produced from either Ras or Mozzarella cheese undergone centrifugal separation at 37°C and the produced cream was cold stored at refrigeration temperature for 24 hours and then it was churned manually into butter. The produced butter from Ras cheese whey was stored at -15°C until use, while that produced from Mozzarella cheese whey was salted at a rate of 2% and stored at -15°C until use.

c) Chemical analysis of butter: Fat, moisture and salt content of butter were determined according to AOAC (2000). Milk Solids-Not Fat% (MSNF%) was calculated by subtract the sum of moisture, fat and salt percentages from 100.

d) Gas Chromatograph: Fatty acid composition of butter was analyzed by gas chromatograph. Dry fat was prepared from butter for gas chromatograph analysis according to Kuksis method described by Brink, and David, (1968). Fatty acid methyl esters were prepared from the dry fat as described by deMan, (1964).

Table (1): Chemical composition of prepared butter.

Butter	Fat %	MSNF %*	Moisture %	Salt %
Butter from milk prepared to Ras cheese making	79.4	2.00	16.62	1.98
Butter from Ras cheese whey	80.0	1.80	16.15	2.05
Butter from milk prepared to Mozzarella cheese making	79.2	2.10	16.80	1.90
Butter from Mozzarella cheese whey	80.7	1.90	15.45	1.95

Milk solids-not fat (MSNF) = 100 – (% fat + % moisture + % salt)

Fatty acid methyl esters / C_6-C_{24}, straight-chain, kit containing 19 standards for gas chromatograph analysis were supplied from Aldrich (USA).
Gas Chromatograph instrument model Packard 419
Detector: flame ionization detector (FID)
Column: Pyrex glass column 1000x3mm. Column was filled with Chromosorb WHP 100-120 mesh (Packard).
Stationary phase: 10% diethylene glycol succinate (DEGS) Packard.
Mobil phase (carrier gas): nitrogen (24 ml / min.).
Hydrogen (35 ml / min.).
Air (200 ml / min.).
Injector temperature: 210°C.
Detector temperature: 280°C.
Heating: Programmed from 70°C to 210°C (5°C / min.).
Cooling: 9 min.
Stabilization: 6 min.
Recorder: Radelkis, type OH-184 / 1, 10mV. Paper speed 30cm / hr.
Integrator: Autolab 6300 digital.

e) Textural properties:

The textural Profile Analysis test (TPA) such as hardness, springiness, cohesiveness, gumminess, adhesiveness and chewiness of butter were measured on the unmelted butter by LFRA Texture analyzer (1000) using computer interface software (CNS-Farnell, Bore Hardwood, Hertfordshire, England WD61WG) according to Breen, (1975) and Bourne, (1978). Butter samples were cut into cubes 5x5x5 cm and kept at 8°C/12hrs before analysis. The probe was TA 15 (45° and 30mm diameter), at speed 1mm/sec and 8mm distance, using cycle or hold programs. Hardness, cohesiveness, gumminess, springiness, chewiness, and adhesiveness were determined in triplicate from the texture profile curve as described by Bourne (1978).

f**) Organoleptic properties**: Sensory evaluation was carried out by expert staff members according to the score card suggested by Bodyfelt, *et al.*, (1988), flavor 10 points, body and texture 5 points, color and appearance 5 points and salt 3 points.

RESULTS AND DISCUSSION

Fatty acid composition of butter

Gas chromatograph analysis of fatty acid composition of butter and the standard fatty acids has been shown in figures (1-5), and percentages of fatty acids as methyl esters are presented in table (2). Data revealed that short chain fatty acids "SCFAs" (C_4, C_6, C_8) were higher by 4.2% in butter prepared from Ras cheese whey and by 17.2% in butter prepared from Mozzarella cheese whey than the corresponding control butter. SCFAs have low melting points (C_4 = -7.9˚C, C_6 = -3˚C and C_8 = 16˚C), http://en.wikipedia.org/wiki/Main_Page . Therefore, the produced whey butters which have higher content of SCFAs expect to have softer and smoother body and texture and higher spreadability than cream butter. Shi *et al.*, (2001), mentioned that butter made from winter milk fat is harder than that made from summer milk (Bornaz *et al.*, 1993). Summer milk fat generally has higher concentration of the shorter-chain triacyl glycerols (TAG), with acyl carbon numbers between C_{30} and C_{42}, whereas winter milk fat has more saturated (C_{26} to C_{42}) and fewer unsaturated (C_{44} to C_{54}) TAG (Hinrichs *et al.*, 1992).

Medium chain fatty acids "MCFA" (C_{10} – C shorter than C_{16} including not identified fatty acids) in butter made from Ras cheese whey have been decreased by 5.6% and by only 1% in butter made from mozzarella cheese whey respectively. Despite C_{10} was increased by 15.5% and C_{12} by 9% in butter made from mozzarella cheese whey, it is not expect to has sensible effect on butter properties as both fatty acids represent little percentages of total fatty acids of butter, in addition to their moderate melting points (C_{10} = 31°C, C_{12} = 44°C) . On the other hand, C_{14} which has high melting point (58.8°C), has been decreased by 7.2% in butter of Ras cheese whey. This decrease may has an effect on butter properties due to its high percentage in fatty acid composition of butter and its high melting point.

Long chain fatty acids "LCFA" (C_{16} – C_{18} including $C_{18:1}$, $C_{18:2}$, $C_{18:3}$ and not identified fatty acids) showed a marked decrease in C_{16} in both types of butter from Ras cheese whey (13.1%) and from mozzarella cheese whey (11.1%), while changes in both $C_{18:0}$ and $C_{18:1}$ were minimal. Palmitic acid ($C_{16:0}$) is the most effective long chain saturated fatty acid on the physical and rheological properties of milk fat, hence it represents the highest percentage among saturated fatty acids. Palmitic acid has a hardening effect on the fat due to its high melting point (63°C). The decrease occurred in palmitic acid content resulted in higher spreadability and more softness of both whey butters in comparison with cream butters. Hall, (1970); Hutton *et al.*, (1969); Huyghebaert and Hendrickx, (1971) stated that in North America and Europe, summer milk fat (soft) is generally higher in $C_{18:0}$ and $C_{18:1}$ fatty acids, whereas winter milk fat (hard) is generally higher in $C_{16:0}$. $C_{18:2}$ nearly not changed in butter of Ras cheese whey while it was increased by 23.4% in butter from mozzarella cheese whey. $C_{18:3}$ was tremendously increased (more than 50%) in both types of whey butter. This marked increase of $C_{18:2}$ and $C_{18:3}$ has a great effect on lowering the softening point of whey butter due to their very low melting points ($C_{18:2}$ = -9°C) and $C_{18:3}$ ($C_{18:3}$ = -17°C) (Stephen R. Bolsover, 2004).

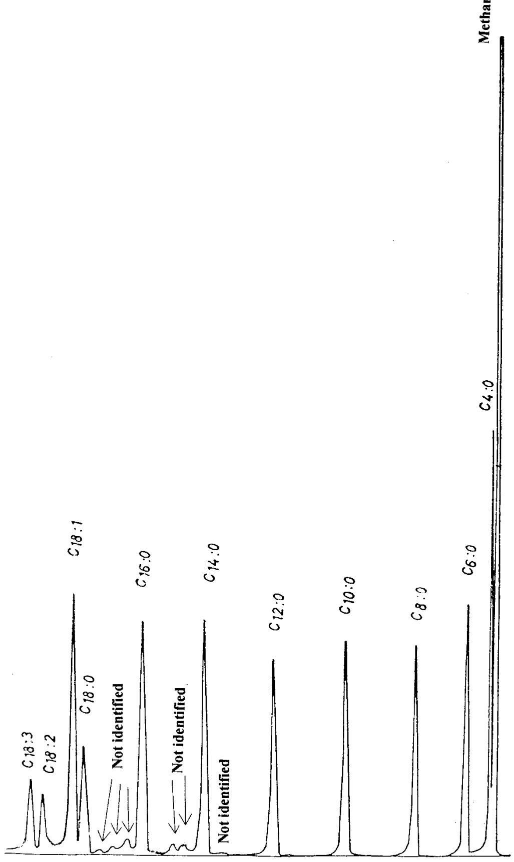

Figure (1): Pattern of internal standard fatty acid methyl esters (internal standard was prepared by mixing 10uL of standard fatty acids kit with 10uL fatty acid methyl esters prepared from anhydrous cow milk fat, then 10uL from the mix was injected in the gas chromatograph).

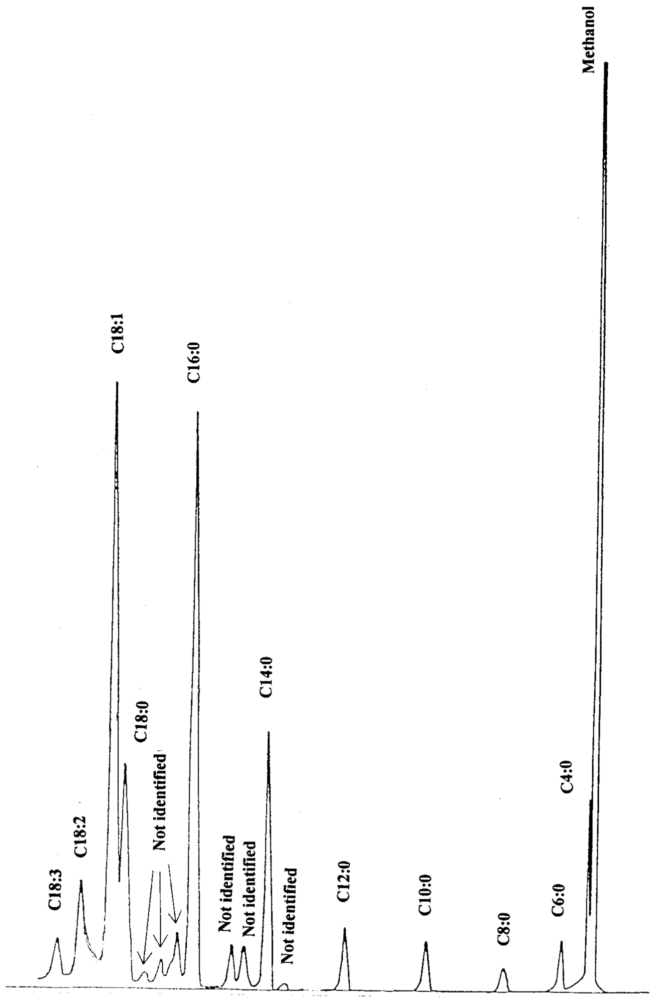

Figure (2): Fatty acids Pattern of cream butter made from milk prepared to Ras cheese making.

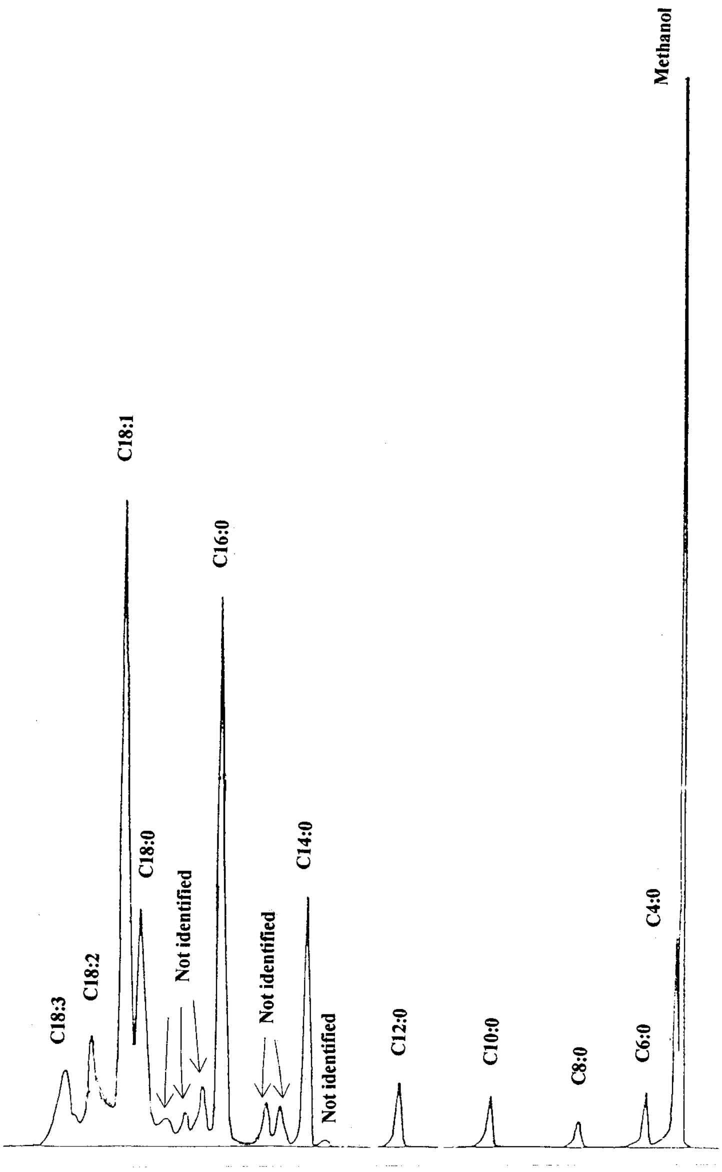

Figure (3): Fatty acids Pattern of whey butter made from Ras cheese whey.

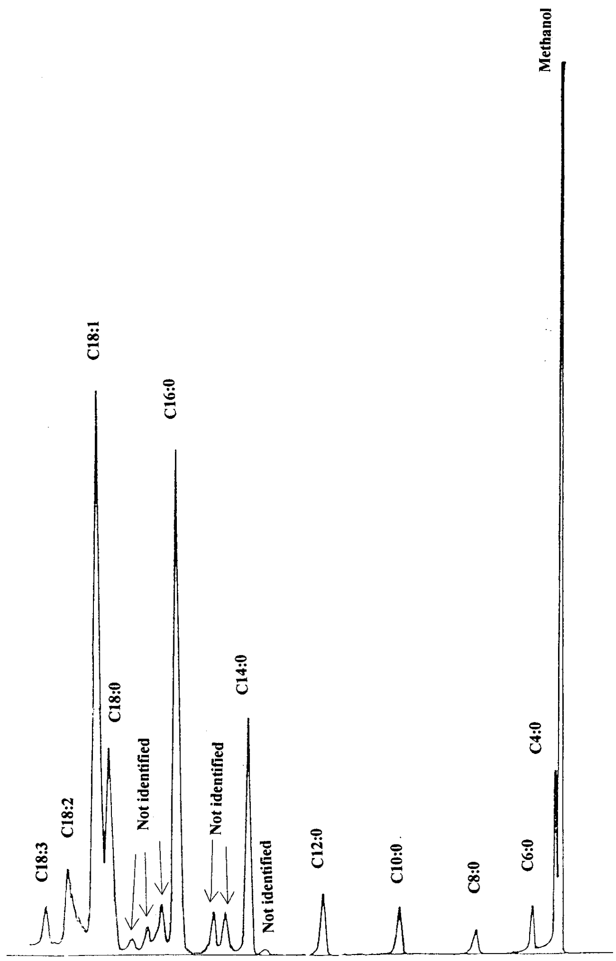

Figure (4): Fatty acids Pattern of cream butter made from milk prepared to Mozzarella cheese making.

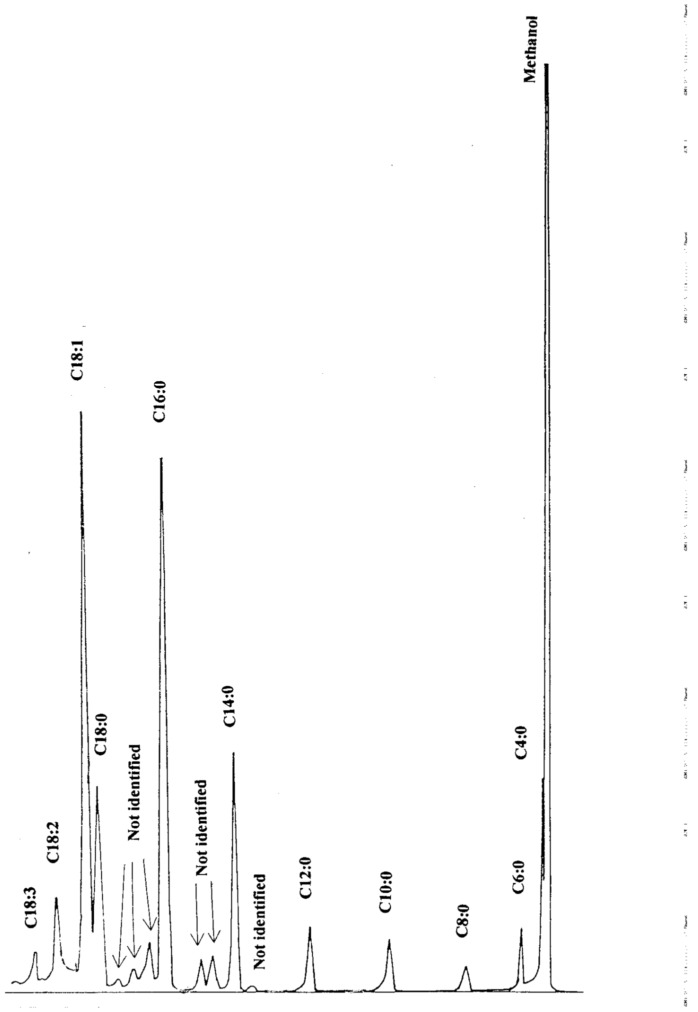

Figure (5): Fatty acids Pattern of whey butter made from Mozzarella cheese whey.

Total long chain fatty acids almost have not changed either in butter from Ras cheese whey or in butter from mozzarella cheese whey. Fortunately, peaks appeared in the chromatogram (see figures) which have not identified by fatty acids standard, represent limited amount of total fatty acids content except the peak appeared after C_{14} and that appeared after C_{16}. The peak after C_{14} represents nearly 2% of total fatty acids and decreased by 9.9 and 10.6% in whey butter from Ras and mozzarella cheese respectively, while that appeared after C_{16} (nearly 3% of total fatty acids) was almost unchanged.

Total saturated fatty acids comprise about 60% and unsaturated 40% of milk fat composition of fatty acids. Saturated fatty acids were decreased by

4.9% and 4.1%, while unsaturated fatty acids were increased by 7.6% and 6.5% in whey butter made from Ras cheese whey and Mozzarella cheese why respectively. Such changes led to produce soft butter. Moreover, low melting point fatty acids (SCFA and unsat.F.A.) were always higher in whey butter than cream butter. The sum of both SCFA and unsat.F.A. was increased by 6.7 and 8.7% in whey butter from Ras and mozzarella cheese respectively.

Table 2: Fatty acid composition of cream butter and whey butter

Symbol	Butter from milk prepared for Ras cheese making	Butter from Ras cheese whey	Difference %	Butter from milk prepared for Mozzarella cheese making	Butter from Mozzarella cheese whey	Difference %
$C_{4:0}$	3.51	3.70	+ 5.4	3.55	4.18	+ 17.7
$C_{6:0}$	1.56	1.60	+ 2.5	1.61	1.86	+ 15.5
$C_{8:0}$	0.87	0.89	+ 2.5	0.88	1.04	+ 18.1
T.SCFA[1]	**5.94**	**6.19**	**+ 4.2**	**6.04**	**7.08**	**+ 17.2**
$C_{10:0}$	1.82	1.87	+ 2.7	1.93	2.23	+ 15.5
$C_{12:0}$	2.21	2.22	+ 0.4	2.42	2.64	+ 9.0
NI*	0.36	0.38	+ 5.5	0.32	0.31	- 3.1
$C_{14:0}$	9.01	8.36	- 7.2	9.31	9.03	- 3.0
NI	2.02	1.82	- 9.9	2.16	1.93	- 10.6
NI	1.72	1.53	- 11.0	1.53	1.35	- 11.7
T.MCFA[2]	**17.14**	**16.18**	**- 5.6**	**17.67**	**17.49**	**- 1.0**
$C_{16:0}$	23.59	20.49	- 13.1	23.75	21.10	- 11.1
NI	3.11	3.10	- 0.3	2.93	2.89	- 1.3
NI	1.42	1.57	+ 10.5	1.25	1.23	- 1.6
NI	1.06	1.48	+ 39.6	0.94	0.92	- 2.1
$C_{18:0}$	11.75	12.32	+ 4.8	11.92	11.41	- 4.2
$C_{18:1}$	27.32	28.22	+ 3.2	28.38	28.60	+ 0.7
$C_{18:2}$	4.97	5.05	+ 1.6	4.00	4.94	+ 23.4
NI	0.72	0.87	+ 20.8	0.69	0.52	- 24.6
$C_{18:3}$	2.98	4.53	+ 52.0	2.43	3.82	+ 57.2
T.LCFA[3]	**76.92**	**77.63**	**+ 0.9**	**76.29**	**75.43**	**- 1.1**
T.Sat.F.A.	**54.32**	**51.45**	**- 5.2**	**55.37**	**53.49**	**- 3.3**
T.Unsat.F.A.	**35.27**	**37.80**	**+ 7.1**	**34.81**	**37.36**	**+ 7.3**
T.Sat.F.A.%**	**60.63**	**57.65**	**- 4.9**	**61.40**	**58.88**	**- 4.1**
T.Unsat.F.A.%***	**39.37**	**42.35**	**+7.6**	**38.60**	**41.12**	**+ 6.5**
Sum of SCFA and unsat.F.A.	**41.21**	**43.99**	**+ 6.7**	**40.85**	**44.44**	**+ 8.7**

1 = Total short chain fatty acids, 2 = Total medium chain fatty acids, 3 = Total long chain fatty acids. * Not identified, ** Total saturated fatty acids, * total unsaturated fatty acids.**

Deffense, (1993) suggested that milk fat (triacyl glycerols) contains 5-10% high melting component made up of long-chain saturated fatty acids; 25% middle-melting component made up of two long-chain fatty acids and either one short- chain or a cis-unsaturated fatty acid, and 65 to 70% low-melting component made up of one long-chain saturated fatty acid and two short chain or cis-unsaturated fatty acids.

From health and nutritional points of view, the essential fatty acid linolenic ($C_{18:3}$) that increased by more than 50% in both types of whey butters added advantage to their nutritional value. As well as, the elevated ratio of unsaturated fatty acids put whey butter as healthier butter considering the risk of atherosclerosis results from the consumption of fat from animal origin which contain high ratio of saturated long chain fatty acids.

Textural properties of butter

Textural properties of either cream or whey butters were measured and presented in table (3).

Texture analysis (table 3) of butter showed lower values for hardness and cohesiveness in both types of whey butter comparing with the corresponding cream butters. Hardness and cohesiveness refer to firm texture, Therefore, the obtained values are consistent with the changes occurred among fatty acids content of whey butters which expected to lead to softer butter. On the other hand, adhesiveness and springiness that refer to sticky soft texture showed higher values for whey butters than cream butters. These results are agree with the results of chromatograph analysis. Gumminess and chewiness are secondary parameters derived from hardness, springiness and cohesiveness. Any change in the values of hardness, springiness or cohesiveness led to change in gumminess and chewiness.

Table (3): Textural profile analysis of butter

Butter	Hardness	Cohesiveness	Adhesiveness	Springiness	Gumminess	Chewiness
Cream butter[1]	996	1.65	147	3.04	1643	4994
Whey butter[2]	891	1.37	160	4.39	1220	5355
Cream butter[3]	955	1.58	158	3.26	1509	4919
Whey butter[4]	864	1.22	186	4.54	1054	4785

1 = Cream butter made from milk prepared to Ras cheese making, 2 = Whey butter made from Ras cheese whey, 3 = Cream butter made from milk prepared to Mozzarella cheese making, 4 = Whey butter made from Mozzarella cheese whey.

Sensory evaluation of butter

Butter samples were sensory evaluated (table 4) for their flavor, body and texture, color and appearance and salt. Data revealed that whey butter from either Ras cheese or Mozzarella cheese whey gained higher flavor score than the conventional cream butter. The observed favorable flavor of whey butter may attribute to the acidity and the other minor components produced by the starter bacteria and by the action of rennet enzymes on milk fat and protein which directly affect the overall flavor sensation.

Cream butter had higher score for body and texture than whey butter. It has an even, spreadable and consistent body and texture where whey butter had much soft much spreadable with some sticky body and texture. Cream butter had chiny light- yellow color while whey butter had deep yellow color not very acceptable as normal color. Cream butter had a soft and palatable salt taste comparing to whey butter where salt taste was clear and sensible. These distinct differences in the organoleptic properties between the two types of butter (cream or whey) make it possible to suggest the preferable usage for each type. Hence cream butter has an advanced score order in body and texture, color and appearance and salt taste comparing to whey butter, therefore it still preferable in use as a table butter provided preparing without addition of salt. On the other hand, whey butter with high flavor score is more suitable to use in cooking or preparation of Samna (ghee). Jinjarak, *et al.*, (2006) studied the sensory attributes of whey (WB), cultured (CB), and regular sweet cream (SB) unsalted butters. They stated that significant differences between the 3 types of butters were obtained on yellow, shiny, acidic odor, melt rate, spreadable, cheese odor, nutty and grassy flavors. CB and SB were significantly shinier than WB, while WB was more yellow than CB which in turn was more yellow than CB. SB was significantly harder than CB and WB.

Table (4): Sensory evaluation of butter

Butter	Flavor (10 points)	Body & Texture (5 points)	Color & Appearance (5 points)	Salt (3 points)	Total (23 points)
Cream butter[1]	9.2	4.7	4.8	2.8	21.5
Whey butter[2]	9.8	4.2	4.3	2.5	20.8
Cream butter[3]	9.1	4.5	4.6	2.7	20.9
Whey butter[4]	9.7	4.0	4.2	2.2	20.1

1 = Cream butter made from milk prepared to Ras cheese making, 2 = Whey butter made from Ras cheese whey, 3 = Cream butter made from milk prepared to Mozzarella cheese making, 4 = Whey butter made from Mozzarella cheese whey.

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World Trade Organization (International Trade Center)
http://www.intracen.org/tradstat/sitc3-3d/ip023.htm

المحتوى من الأحماض الدهنية ، القوام والخواص الحسية لزبد الشرش

آمـال حسـن علـي
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في هذه الدراسة تم تصنيع نوعان من الزبد أحدهما من القشدة والآخر من الشرش حيث تم تصنيع زبـد القشدة بالطريقة التقليدية بفرز اللبن وخض القشدة الناتجة الي زبـد ، كذلك تم تصنيع زبـد الشرش بفرزالشرش الناتج من تصنيع جبن الرأس وجبن الموزاريلا وخض القشدة الناتجة الي زبـد ٠ وتم تحليل الزبد الناتج وتقدير الدهن والرطوبة والملح والجوامد الصلبة اللادهنية ، كما تم تقدير تركيب الأحماض الدهنية والقوام والخواص الحسية لنوعي الزبـد الناتج ٠ وقد أوضحت النتائج ان زبـد الشرش تميز بإرتفاع محتواه من الأحماض الدهنية قصيرة السلسلة والأحماض الدهنية الكلية غير المشبعة مقارنة بزبـد القشدة ٠ كذلك تميز زبـد الشرش بقوام أكثر طراوة مع بعض اللزوجة وقابلية للفرد من زبـد القشدة ٠ وكانت نتائج تحليل القوام متوافقة مع نتائج تقدير الاحماض الدهنية بالكروماتوجراف حيث كان لزبـد الشرش قيمة اقل في الصلابة والتماسك وأعلي في الالتصاق والمرونة كما كان لزبـد الشرش درجات أعلي في النكهة وأقل في القوام واللون والمظهر ويقترح بانه سيكون أكثر ملائمة لاغراض الطهي من زبـد القشدة ٠ بالاضافة الي ذلك فان إرتفاع محتواه من الأحماض الدهنية غير المشبعة يميزة عن زبد القشدة من وجهة النظر الصحية.