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MANUFACTURE OF YOGHURT FROM COW'S MILK FORTIFIED WITH TRYPSIN MODIFIED WHEY PROTEINS

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ABSTRACT: ***Two types of whey protein concentrates (WPC) heat precipitated salted sweet whey (SWPC) ultra filtrated acid whey (FWPC) were hydrolyzed with trypsin at the rate of 0.4 gm / 100 gm protein. Nine treatments of yoghurt were made to study the effect of replacing non-fat dry milk with trypsinized WPC on the quality of yoghurt. Replacement of non-fat dry milk with hydrolyzed WPC caused significant ($p \leq 0.05$) increase total protein, ash, non-protein nitrogen and diacetyl (DA) and acetyl methyl carbinol (AMC) contents, curd tension and scores of organoleptic properties, while syneresis decreased. On the other hand, fortification of cow's milk with trypsinized whey protein concentrates (mFWPC and mSWPC) did not affect significantly the total solids content, acidity and pH values of the resultant yoghurt treatments. The type of WPC did not have significant effect on total solids, total protein, ash and non-protein nitrogen contents, while mFWPC was effectively increased the DA + AMC, scores of organoleptic properties and decrease the syneresis of whey as compared to yoghurt treated with mSWPC. Total solids, total protein, non-protein nitrogen and ash content did not change significantly during the storage period; however, the acidity increased and pH value decreased as the storage period proceeded. DA and AMC increased, while whey syneresis decreased up to the 6th day of storage, thereafter DA + AMC decreased, whilst whey syneresis increased up to the end of storage period. It could be replace non-fat dry milk with mFWPC up to 75% and mSWPC up to 50% without detrimental effects on yoghurt quality made from cow's milk.***

Key Words: ***Cow's milk, yoghurt fortification, modified whey protein concentrate, non-fat dry milk.***

INTRODUCTION

Yoghurt is the most popular fermented milk produced in Egypt and worldwide. The consumption of yoghurt has been increased markedly in Egypt. The value of yoghurt in human nutrition is based on the strict nutritive effect of digested milk constituents occurring during lactic acid fermentation and on the beneficial effect of intestinal microflora, prophylactic and heeling effects (Rasic and kurmann, 1978; Agerbaek *et al.,* 1995; Tvede, 1996; Buttriss, 1997 and Hussein and Kebary, 1999).

One of the draw backs of the manufacture of yoghurt from cow's milk is the weak body and texture. Therefore, it has been suggested that fortification of cow's milk with non-fat dry milk, or using stabilizers, ropy culture and whey protein are good methods to improve the body and texture of the resultant yoghurt (Abd El-Salam *et al.,* 1996; Harby and El-Sabie, 2001; Zedan *et al.,* 2001; Kebary *et al.,* 2004; Badawi *et al.,* 2004 and El-Sonbaty *et al.,* 2008). Using non-fat dry milk is the most widely method used.

It has been estimated that, the annual amount of whey and milk permeate could be more than one million ton. This amount is disposed in the sewage system that might cause environmental pollution. According to the environmental law issued recently in Egypt whey should be treated before drainage into sewage system. Therefore, getting whey proteins from whey will be very important for dairy plants. Heat treatment is a common steps used during the production of whey proteins, which might affect the functional properties of the resultant whey proteins and limit their utilization in formulated foods (Morr, 1972). The functional properties of whey proteins (solubility, water absorption, oil absorption, foam and emulsification capacity) have improved by enzyme modification. Ultrafilterd acid whey hydrolyzed with 0.4 gm trypsin / 100 gm protein (Kebary *et al.,* 2009). The best whey proteins gave functionalities.

The objectives of this study were to investigate the effect of replacing non-fat dry milk that used to fortify the cow's milk with trypsin hydrolyzed whey protein on the quality of yoghurt and to follow up the changes during storage of yoghurt quality.

MATERIALS AND METHODS

Modified whey proteins:

Two types of dried whey protein concentrates were prepared, one of them was precipitated by heat treatment from salted whey (SWPC) and the other was prepared by ultrafiltration (FWPC) of acid whey. Trypsin concentrate at the rate of 0.4 gm / 100 gm protein (Sigma Chemical Comp., St. Louis, USA) as described by Kebary *et al.* (2009).

Starter cultures:

Streptococcus thermophillus EMCC 1043 and *Lactobacillus delbrueckii* subsp. *bulgaricus* EMCC 1102 were obtained from Cairo MIRCEN (Faculty of Agriculture, Ain Shams University). These strains were activated separately three successive transfers in sterile skim milk.

Manufacture of yoghurt:

Fresh cow milk (3%) obtained from the herd of Tokh Tanbisha, Faculty of Agric., Minufiya University was divided into 9 equal portion. One portion was fortified with 3.0% non-fat dry milk (Ecoval N.V., Paris, France) used as a

control (Kebary *et al.,* 2004). The other eight portions, non fat dry milk was replaced with hydrolyzed either salted whey protein concentrate (SWPC) or filtrated whey protein concentrate (FWPC), respectively, at the ratio of 25, 50, 75 and 100%, respectively. All batches were heated to 85°C for 20 min. then cooled to 40°C. Yoghurt batches were inoculated with 1% of *Str. thermophilus* + 1% *L. delbrueckii* subsp. *bulgaricus*. The inoculated batches were packed in plastic cups (capacity 100 g) and incubated at 42°C until complete setting (3.0 – 3.5 hr). Resultant yoghurt was stored for 12 days at 6 ± 2°C. All yoghurt batches were sampled for analysis at days 1, 3, 6, 9 and 12 days. This experimental design was triplicated.

Rheological analysis:

Syneresis was determined according to the methods of Dannenberg and Kessler (1988) with slight modification. Hundred gram yoghurt in plastic cup was cut into four sections and transferred into a funnel fitted with 120 mesh metal screen. The whey was drained into graduated cylinder. The amount of whey drained off was measured after 120 min. at room temperature (20 ± 1°C).

Curd tension was determined by a penetrometer supplied by "Koehler" Instrument company Inc. New York, USA was used. The test was performed as mentioned by El-Shabrawy *et al.* (2002) as follows: the penetrometer cone was adjusted to touch the surface of yoghurt sample. Then, the cone was released to skin into the sample for 5 sec. The penetration depth was recorded in units of 0.1 mm penetrometer reading which is related inversely to the firmness of sample.

Sensory evaluation:

Yoghurt samples were evaluated for flavour, appearance, acidity and body and texture by 15 panelists of the staff members of Department of Dairy Science and Technology Minufiya University, Shibin El-Kom Egypt according to Nelson and Trout (1981). Samples were presented to judges in plastic cups in random order. Judges were provided with room temperature rinse waster, plastic spoons and score sheets.

Statistical analysis:

Factorial design 2 factors × 3 replicates and the Completely Randomized design were used to analyze all the data, and student Newman Keuls test was followed to make the multiple comparisons (Steel and Torrie, 1980) using COSTAT program. Significant differences were determined at $P \leq 0.05$.

RESULTS AND DISCUSSION

Replacement of non-fat dry milk that was used to fortify cows milk with hydrolysed whey protein concentrates (mFWPC and mSWPC) did not affect significantly ($P > 0.05$) the total solids content of the resultant yoghurt

(Tables 1, 6). Similar results were obtained by Abd El-Baky *et al.* (1981); El-Neshawy and El-Shafie (1988) and Hofi *et al.* (1995).

Yoghurt treatments made with mFWPC were not significantly (P > 0.05) different from the corresponding yoghurt treatments made with mSWPC. On the other hand, total solids content of all yoghurt batches did not change significantly (P > 0.05) throughout storage period (Tables 1, 6).

Total protein, non-protein, nitrogen and ash contents of yoghurt treatments increased significantly ($P \leq 0.05$) by replacing non fat dry milk with hydrolysed whey protein concentrates (mFWPC and mSWPC). There were no significant differences among corresponding yoghurt treatments made with either mFWPC or mSWPC (Tables 1, 2 and 6). Total protein, non-protein, nitrogen and ash contents of all yoghurt treatments did not change significantly (P > 0.05) during storage of yoghurt for 12 days (Tables 1, 2 and 6) this agree with the finding of Khader (1994).

Changes in the values of titratable acidity of yoghurt treatments are shown in Tables (3, 6). Yoghurt treatments were not significantly (P > 0.05) different from each other. Similar results were obtained by Khader (1994), who increased the total solids of buffalo skim milk with whey protein concentrates to make fat free yoghurt. Titratable acidity of all yoghurt treatments increased gradually ($P \leq 0.05$) as the storage period progressed (Tables 3, 6). These results are in agreement with those reported by Farooq and Haque (1992), Khader (1994), Salama and Hassan (1994), Abd El-Salam *et al.* (1996), Kebary *et al*. (1996), Badawi and El-Sonbaty (1997) and Kebary and Hussein (1999).

PH values of all yoghurt treatments during storage are presented in (Tables 3, 6). There were no significant (P > 0.05) differences among yoghurt treatments which means neither the type nor the concentration of hydrolyzed whey protein concentrates affected significantly (P > 0.05) the pH value of the resultant yoghurt (Tables 2, 6). pH values decreased gradually ($P \leq 0.05$) as storage period advanced. These results are in accordance with those reported by Badawi and El-Sonbaty (1997), Hussein and Kebary (1999) and Kebary and Hussein (1999).

Replacement of yoghurt with trypsin-treated whey protein concentrates caused a significant ($P \leq 0.05$) increase in diacetly and acetyl methyl carbinol content (DA + AMC) and this increase was proportional to the amount added from hydrolyhzed whey protein condcentates (mFWPC and mSWPC) (Tables 3, 6). It was found that yoghurt treatment made with adding mFWPC contained higher ($P \leq 0.05$) diacetyl and acetyl methyl carbinol than those yoghurt treatments made with adding of mSWPC.

Diacetyl and acetyl methyl carbinol content of all yoghurt treatments batches increased gradually ($P \leq 0.05$) and reached their maximum values at the sixth day of storage, then deceased up to the end of storage period

Table 1 -2

(Tables 3, 6). Similar trends were obtained by Yousef (1996). The decrease of diacetyl and acetyl methyl carbinol during storage may be attributed to the reduction of these compounds to acetone (Cogan, 1974).

Replacement of non-fat dry milk of yoghurt made from cows milk with hydrolyzed whey protein concentrates (mFWPC and mSWP) caused a pronounced ($P \leq 0.05$) reduction of syneresis compared to control yoghurt (Tables 4, 6). Similar results were obtained by Farooq and Haque (1992) who used sugar esters, Khader (1994) who used whey protein concentrates to increase the total solids of fat free yoghurt, Kebary and Hussein (1999) who used fat replaces to make low fat yoghurt. These results might be due to addition of hydrolysed whey protein concentrates which lead to form complex with casein micelles and prevent them from excessive fusion and form a five meshed gel network which is less susceptible to whey separation. These results are in agreement with those reported by (Danneberg and Kessler, 1988) and / or increasing water holding capacity as a result of increasing protein content of the fortified cow's milk. There was negative correlation between the rate of replacement and whey syneresis (Table 4, 6). Replacement of non-fat dry milk with mFWPC was more effective to reduce whey separation (syneresis) from the resultant yoghurt than corresponding treatments made with mSWPC. Syneresis from all yoghurt batches decreased gradually ($P \leq 0.05$) as storage period progressed and reached their minimum values at the sixth day of storage then increased up to the end of storage period (Tables 4, 6). These results are in agreement with those reported by Farooq and Haque (1992), Abd El-Salam *et al.* (1990), Khader (1994) and Kebary and Hussein (1999).

Curd tension of yoghurt treatments are presented in Table (4). Substitution of non fat dry milk with hydrolyzed whey protein concentrates (mFWPC and mSWPC) caused an obvious increase in curd tension of the resultant yoghurt. This increase was proportional to the rate of replacement (Tables 4, 6). These results are in accordance with those obtained by Guirguis *et al.* (1984) and Abd El-Salam *et al.* (1990). Yoghurt treatments made with mFWPC were firmer than those of correspond yoghurt treatments made with mSWPC (Tables 4, 6).

Table 3 -4

Scores of organoleptic properties (flavour, body and texture, appearance and acidity) during storage of yoghurt treatments are presented in Tables (5, 6).

Replacement of non-fat dry milk up to 50% with mSWPC increased ($P \leq 0.05$) the scores of body and texture, appearance and acidity of the resultant yoghurt (mS_1 and mS_2) compared with those of control yoghurt, while the scores for flavour and total scores were not significantly ($P > 0.05$) different from those of control yoghurt. Increasing the replacement rate to 75 and 100% with mSWPC decreased ($P \leq 0.05$) the scores of organoleptic properties and the total scores (Tales 5, 6). On the other hand, increasing the replacement rate of mFWPC up to 50% increased the scores of all orgnaoleptic properties (flavour, body and texture, appearance, acidity and total scores). Increasing the replacement rate to 100% of mFWPC caused a significant ($P \leq 0.05$) decrease in the score, of organoleptic properties compared with those of control yoghurt. These results revealed that yoghurt made with 50% mFWPC gained the highest scores of organoleptic properties and was significantly ($P < 0.05$) different from all yoghurt treatments, while yoghurt treatments made with replacement rate 50% with mSWPC was not significantly different from control yoghurt. However, yoghurt treatments that made with replacement rate of 75% with mFWPC was not significantly different from control yoghurt.

Yoghurt treatment made with mFWPC was more acceptable than corresponding yoghurt treatments made with mSWPC. Replacing non-fat dry milk with mSWPC up to 50% and with mFWPC up to 75% could be used without significant effect on yoghurt quality.

It could be concluded that replacement of non-fat dry milk with modified whey protein concentrates to make yoghurt cause a pronounced increase in total nitrogen, non-protein nitrogen, diacetyl and acetyl methyl carbinol contents, and curd tension, while decreased whey syneresis. Also, addition of hydrolyzed whey protein concentrates up to 50% increased the acceptability of yoghurt. Therefore, it could be replace non-fat dry milk with mFWPC up to 75% and mSWPC up to 50% without detrimental effects on yoghurt quality.

Table 5 -6

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تصنيع اليوجورت من اللبن البقرى المُدعم ببروتينات الشرش المعدلة بإنزيم التربسين

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الملخص العربي

تم تحضير نوعين من مركزات بروتينات الشرش ، إحداها بالترسيب الحرارى من الشرش المُملح (SWPC) والأخرى بالترشيح الفائق للشرش الحامضى (FWPC) .

ولقد تم تحليل هذه المركزات بإنزيم التربسين بتركيز ٠.٠٤ جرام / ١٠٠ جرام بروتين وهى (mSWPC) و (mFWPC) . وتم تصنيع ٩ معاملات من اليوجورت لدراسة تأثير استبدال اللبن الفرز المُجفف المُستخدم فى تدعيم اللبن البقرى ببروتينات الشرش المُعدلة إنزيمياً على صفات اليوجورت ، ولقد أوضحت النتائج المتحصل عليها بعد تحليلها إحصائياً ما يلى :

- أدى استبدال اللبن الفرز المُجفف بواسطة مُركزات بروتينات الشرش المُعدلة لزيادة نسب كلٍ من البروتين الكلى – الرماد – النيتروجين الغير بروتينى – الداى أسيتيل ميثيل كاربينول – وقوة الخثرة ودرجات التحكيم ، بينما انخفضت نسبة انفصال الشرش .
- لم يُؤثر استبدال اللبن الفرز المُجفف بواسطة بروتينات الشرش المُعدلة إنزيمياً على نسب كلٍ من الجوامد الصلبة الكلية والحموضة وقيم الـ pH .
- لم يُؤثر نوع مركزات بروتينات الشرش المُعدلة معنوياً على نسب كلٍ من الجوامد الصلبة الكلية والبروتين الكلى والرماد والنيتروجين الغير بروتينى ، بينما احتوت المعاملة المُصنعة بإضافة (mFWPC) على نسب أعلى من الداى أسيتيل والأسيتيل ميثيل كربينول ونسب أقل من الشرش المنفصل عن المعاملات المقابلة لها المصنعة بإضافة (mSWPC).
- لم تتغير نسب كلٍ من الجوامد الصلبة الكلية والبروتين الكلى والنيتروجين الغير بروتينى والرماد أثناء التخزين ، بينما ازدادت الحموضة .

- ازدادت نسبة الداى أسيتيل والأسيتيل ميثيل كربينول بينما انخفضت نسبة انفصال الشرش حتى اليوم السادس من التخزين وبعد ذلك انخفضت نسبة الداى أسيتيل والأسيتيل ميثيل كربينول بينما ازداد انفصال الشرش حتى نهاية فترة التخزين .

ومن النتائج يُمكن استبدال ٧٥% من اللبن الفرز المُجفف بواسطة (mFWPC) ، ٥٠% من اللبن الفرز المُجفف بواسطة (mSWPC) دون أى تأثيرات معنوية على صفات اليوجورت الناتج .

Table (1): Effect of replacing non-fat dry milk with hydrolyzed dried whey protein concentrate on total solids and total protein of yoghurt made from cow's milk.

Yoghurt treatments	Total solids (%)					Total protein (%)				
	Storage period (days)					Storage period (days)				
	1	3	6	9	12	1	3	6	9	12
C	14.62	14.66	14.71	14.73	14.76	4.61	4.64	4.66	4.67	4.69
mS_1*	14.68	14.71	14.74	14.75	14.79	5.14	5.18	5.24	5.27	5.28
mS_2	14.72	14.73	14.76	14.78	18.82	5.65	5.68	5.70	5.73	5.77
mS_3	14.78	14.78	14.81	14.83	14.85	6.28	6.32	6.33	6.37	6.39
mS_4	14.88	14.91	14.95	14.97	14.98	6.72	6.76	6.79	6.81	6.85
mF_1**	14.58	14.63	14.67	14.67	14.71	5.08	5.14	5.17	5.21	5.24
mF_2	14.65	14.69	14.70	14.73	14.73	5.59	5.65	5.67	5.71	5.72
mF_3	14.74	14.75	14.77	14.80	14.81	6.24	6.28	6.32	6.33	6.36
mF_4	14.83	14.85	14.85	14.87	14.91	6.69	6.74	6.76	6.79	6.81

C = yoghurt made from cows milk fortified with 3.0% non fat dry milk.

* mS_1, mS_2, mS_3 and mS_4: Yoghurt treatment made by replacing non fat dry milk with hydrolysed salted whey protein concentrates at the rate of 25, 50, 75 and 100%, respectively.

** mF_1, mF_2, mF_3 and mF_4: Yoghurt treatment made by replacing non fat dry milk with hydrolyzed filtrated whey protein concentrates at the rate of 25, 50, 75 and 100%, respectively.

Table (2): Effect of replacing non-fat dry milk with hydrolyzed dried whey protein concentrate on ash and non-protein nitrogen contents of yoghurt made from cow's milk.

Yoghurt treatments	Ash content (%)					Non-protein nitrogen content (%)				
	Storage period (days)					Storage period (days)				
	1	3	6	9	12	1	3	6	9	12
C	0.713	0.714	0.716	0.719	0.723	0.136	0.139	0.139	0.140	0.141
mS_1*	0.831	0.834	0.835	0.836	0.838	0.154	0.156	0.157	0.157	0.158
mS_2	0.63	0.965	0.966	0.966	0.967	0.158	0.160	0.162	0.163	0.163
mS_3	1.074	1.076	1.077	1.077	1.078	0.177	0.179	0.179	0.180	0.181
mS_4	1.187	1.188	1.189	1.191	1.192	0.188	0.189	0.191	0.191	0.192
mF_1**	0.832	0.835	0.836	0.836	0.837	0.156	0.158	0.158	0.159	0.160
mF_2	0.969	0.972	0.972	0.973	0.973	0.163	0.166	0.166	0.167	0.167
mF_3	1.078	1.079	1.081	1.082	1.082	0.181	0.183	0.184	0.185	0.186
mF_4	1.191	1.193	1.194	1.195	1.196	0.195	0.196	0.196	0.197	0.197

C, *, ** see Table (1).

Table (3): Effect of replacing non-fat dry milk with hydrolyzed dried whey protein concentrate on titratable acidity, pH values and diacetyl & acetyl methyl carbinol (DA + AMC) of yoghurt made from cow's milk.

Yoghurt treatments	Titratable acidity (%)					pH values					DA + AMC (□ mol/100 ml)				
	Storage period (days)					Storage period (days)					Storage period (days)				
	1	3	6	9	12	1	3	6	9	12	1	3	6	9	12
C	0.87	0.97	1.08	1.17	1.26	4.69	4.61	4.50	4.24	4.10	21.79	26.38	29.91	27.23	23.52
mS_1*	0.88	0.98	1.11	1.19	1.27	4.68	4.60	4.50	4.25	4.10	28.46	31.16	32.65	31.49	26.72
mS_2	0.90	0.98	1.14	1.22	1.29	4.68	4.61	4.47	4.23	4.08	31.89	35.85	36.79	35.16	30.96
mS_3	0.91	0.97	1.12	1.25	1.26	4.66	4.62	4.48	4.22	4.10	32.13	36.58	39.93	37.68	31.79
mS_4	0.92	0.98	1.11	1.21	1.26	4.66	4.61	4.51	4.23	4.11	35.29	38.16	40.16	39.67	32.72
mF_1**	0.90	0.99	1.12	1.20	1.30	4.65	4.60	4.49	4.22	4.07	30.58	34.27	37.61	35.17	28.18
mF_2	0.91	1.02	1.13	1.24	1.31	4.66	4.58	4.46	4.23	4.06	33.63	36.92	37.72	35.18	31.61
mF_3	0.92	1.03	1.14	1.27	1.29	4.64	4.57	4.47	421	4.08	34.29	38.93	40.28	38.16	32.12
mF_4	0.92	1.02	1.12	1.21	1.27	4.63	4.58	4.48	4.23	4.10	37.12	41.79	43.55	42.27	33.96

C, *, ** see Table (1).

Table (4): Effect of replacing non-fat dry milk with hydrolyzed dried whey protein concentrate on whey syneresis and curd tension of yoghurt made from cow's milk.

Yoghurt treatments	Whey syneresis (%)					Curd tension (gm/100 gm) after one day
	Storage period (days)					
	1	3	6	9	12	
C	45	41	36	37	39	21.25
mS_1*	40	37	31	33	38	23.50
mS_2	36	33	28	29	32	24.30
mS_3	34	30	27	28	30	26.10
mS_4	32	29	25	26	28	27.50
mF_1**	38	35	31	32	34	24.00
mF_2	34	31	29	28	30	25.00
mF_3	30	28	25	26	29	26.70
mF_4	29	27	23	24	28	28.50

C, *, ** see Table (1).

Table (5): Scores of organoleptic properties during storage period of yoghurt made with hydrolyzed whey protein concentrates.

Treatments	Flavour (45)					Body and texture (30)					Appearance (15)					Acidity (10)					Total scores (100)				
	Storage period (days)					Storage period (days)					Storage period (days)					Storage period (days)					Storage period (days)				
	1	3	6	9	12	1	3	6	9	12	1	3	6	9	12	1	3	6	9	12	1	3	6	9	12
C	42	40	41	39	35	25	26	26	25	23	11	11	11	8	8	8	8	8	8	6	86	85	86	78	72
mS_1*	42	41	40	38	36	26	26	27	23	23	12	12	12	10	8	8	8	9	7	6	86	86	85	77	72
mS_2	41	42	40	39	35	26	25	26	25	25	13	12	12	10	8	9	9	9	8	6	89	86	85	79	71
mS_3	37	36	37	34	31	24	22	23	21	18	8	8	9	6	5	8	8	8	6	5	79	76	77	68	60
mS_4	35	33	35	29	26	21	21	20	18	16	7	8	8	6	5	7	7	7	4	4	71	68	71	57	50
mF_1**	42	41	42	38	34	25	25	26	26	25	12	11	11	11	9	9	9	8	8	7	88	86	86	81	75
mF_2	42	42	42	37	34	27	26	26	25	25	13	12	11	11	10	9	9	9	8	7	91	90	87	80	77
mF_3	39	40	37	36	34	25	24	24	25	22	9	9	10	7	6	9	8	9	7	6	82	81	79	76	68
mF_4	37	38	37	30	28	24	24	24	22	20	8	8	8	7	6	8	7	7	6	5	77	79	76	65	59

C, *, ** see Table (1).

Table (6). Statistical analysis of Zabady properties.

Zabady properties	Means square	Effect of treatments▪									Means square	Effect of storage (days)▪				
		Multiple comparison										Multiple comparison				
		C	mS_1•	mS_2	mS_3	mS_4	mF_1••	mF_2	mF_3	mF_4		1	3	6	9	12
T.S	24.10464665	A	A	A	A	A	A	A	A	A	0.25299333	A	A	A	A	A
Protein	1.5208253*	E	D	C	B	A	D	C	B	A	0.044173333	A	A	A	A	A
Ash	0.3825283	E	D	C	B	A	D	C	B	A	8.7074121	A	A	A	A	A
NPN	4.96725*	E	D	C	B	A	D	C	B	A	6.91	A	A	A	A	A
Acidity	6.746667	A	A	A	A	A	A	A	A	A	0.63469333*	E	D	C	B	A
pH	0.002317	A	A	A	A	A	A	A	A	A	0.755555*	A	B	C	D	E
Diacetyl and acetyl methyl carbinol	238.366606*	I	H	F	D	B	G	E	C	A	253.3571067*	C	B	A	C	D
Synersis	298.8666666*	A	B	D	F	G	C	E	H	I	227.56666667*	A	B	E	C	D
Curd tension	15.00833334*	I	H	F	D	B	G	E	C	A						
Organolepto properties:																
Falvour	144.5666666*	A	A	A	C	E	A	A	B	D	250.56666667	A	A	A	B	C
Body and texture	74.166666663*	C	C	B	F	G	B	A	D	E	34.93333331	A	A	A	B	C
Appearance	50.9999999*	D	C	B	F	G	B	A	E	F	51.43333333	A	A	A	B	C
Acidity	9.266666665*	B	B	A	C	E	A	A	B	D	37.733333333	A	A	A	B	C
Total scores	748.3499999*	BC	BC	B	D	F	B	A	C	E	1295.066667	A	AB	AB	B	C

C, •, •• see Table (1). * Significant at 0.05 level.

▪ For each different letters (the same row) means the multiple comparison are different from each others letter A is the highest followed by B, C… etc.