COMPOSITION AND QUALITY OF SOFT CHEESE MADE FROM GDL-TREATED MILK

BY

Naeim, M.A. ; R.I.H.Al-Ahwall and N.M. Mehanna*

Animal Prod. Res. Inst., Kafr El-Sheikh and Fac. of Agric., Tanta Univ., Kafr El-Sheikh*

ABSTRACT

The current work was planned to study coagulation properties of GDL-treated cow's milk and their effects on yield, composition and quality of the resultant soft cheese.

GDL-treated milk at the rate of 1 and 2% coagulated directly on addition of the rennet, whereas curd tension and curd syneresis significantly increased and pH decreased.

Adding GDL without and with decreasing the amount of rennet added decreased yield of the fresh cheese and recovery of fat and protein only in case of 1% GDL. Loss of cheese weight during storage was the maximum in control cheese and decreased with increasing the amount of GDL added.

Adding GDL decreased the pH and increased acidity of the resultant cheese. Values of TS and protein were generally higher in the 2% GDL-treated cheese, whereas fat content had the minimum values in 1% GDL-treated cheese. Lipolysis and proteolysis during storage of cheese were affected with different rates by the applied treatments.

In general, quality of cheese made from 2% GDL-treated milk was preferable.

INTRODUCTION

Although it is generally accepted that cheese yield and composition are associated with nature and composition of milk as well as with coagulation properties of it, there are disagreement among various reports cited in the literature on how coagulation properties are related to cheese yielding capacity and composition. Banks and Muir (1984) and Mayes and Sutherland (1989) demonstrated that curd firmness at cutting affects the percentages recovery of milk fat and protein in cheese and hence cheese yield. This is quite important since ability of renneted milk to form a gel of sufficient strength to withstand mechanical cutting in the cheese vat without shattering is of paramount importance in commercial cheese manufacture. In this respect, Ng-Kwai-Hang et al. (1989) found that faster rate of coagulation and firmer curd were correlated ($P<0.01$) with a decrease in losses of milk fat, protein and total solids in whey.

On the other hand, factors which greatly affect curd firmness and subsequently rate of curd syneresis may include acidity and pH of milk. Increasing acidity by direct acidification using different acidulants was the way of numerous studies but using glucono-delta-lactone (GDL) was recently applied in this respect.

Hefny (1995 a,b) studied curd firmness and ripening of buffalo's milk as affected by using GDL, whereas Abd El-Salam et al. (1996) followed acid-induced gelation of buffalo's milk by GDL. More recently, Lucey et al. (1998) studied effect of heat treatments and gelation temperature on the rate of whey separation in acid skim milk gels made using GDL.

The objective of the current study was to investigate the effects of using GDL on rennet coagulation properties of cow's milk and yield, recovery of fat and protein as well as composition and quality of the resultant soft cheese.

MATERIALS AND METHODS

Fresh cow's milk used in the present study was obtained from cows herd belonging to Sakha Exp. Station, Animal Prod. Res. Inst.

In a preliminary experiment on the effect of adding GDL on some coagulation properties of milk, GDL was added at the rate of 1 and 2% to milk previously heated to 70°C for 5 min and cooled to 40°C. pH of the treated and untreated milk was determined as given by Ling (1963). Rennet coagulation time (RCT), curd tension and curd syneresis were measured according to Fahmi and Amer (1962), Chandrasekhara et al. (1957) and Mehanna and Mehanna (1989) respectively.

Soft cheese was mainly manufactured as given by Fahmi and Sharara (1950). In this respect, cheese milk was heated at 70°C for 5 min and then cooled to 45°C to be ready for adding calcium chloride (0.02%), sodium chloride (5%), GDL (0.0, 1 and 2%) and rennet.

The following treatments were carried out:

- Control cheese: Cheese made without adding GDL.
- Treatment I (T_I): Cheese made with adding GDL (1%) and rennet.
- Treatment II (T_{II}): Cheese made with adding GDL (1%) and half the amount of rennet added.
- Treatment III (T_{III}): Cheese made with adding GDL (2%) and rennet.
- Treatment IV (T_{IV}): Cheese made with adding GDL (2%) and half the amount of rennet.

Yield of fresh cheese expressed as Kg/100 kg of milk was calculated. Recoveries of fat and protein were also calculated according to their actual amounts determined in cheese milk and the resultant cheese (Ling, 1963).

All cheese samples were analysed when fresh and after 15 and 30 days of storage in polyethylene pouchs at 4±1°C for pH, acidity, TS, fat, TN, NPN and SN as described by Ling (1963). Total volatile fatty acids content was measured as given by Kosikowiski (1978), whereas procedure of Tawab and Hofi (1966) was followed for determination of formol number. Soluble tyrosine and tryptophan were determined according to Vakaleris and Price (1959).

The losses in cheese weight during storage period were calculated relative to the corresponding fresh weight, whereas the organoleptic properties were assessed as recommended by Naguib et al. (1974).

The attained data were statistically analysed as described by Steel and Torrie (1984).

RESULTS AND DISCUSSION

Table (1) reveals that adding GDL greatly changed the values of pH, rennet coagulation time (RCT), curd tension and curd syneresis. pH value of control milk (6.55) significantly ($P<0.01$) decreased to 6.05 and 5.8 with adding 1 and 2% GDL respectively. Hydrolysis of GDL ($C_6H_{10}O_6$) to gluconic acid ($C_6H_{12}O_7$) is responsible for increasing acidity of milk and subsequently decreased the pH. Similar results were given by Hefny (1995 a,b).

Table (1): Effect of adding GDL on pH and some rheological properties of milk (Average of 3 replicates)

Property	Amount of GDL added (%)		
	0.0	1	2
PH	6.55	6.05	5.80
Coagulation time (sec)	880	45	40
Curd tension (g)	21.0	22.5	32.3
Curd syneresis after*			
10 min	5.63	5.70	6.31
30 min	7.39	7.84	8.21
60 min	8.50	9.11	9.44
120 min	9.52	10.33	10.61

* Expressed as the amount of whey (g) exudeted from 15 g of curd kept at room temperature (25±2°C) for the given time.

RCT (sec) was 880 in control milk and significantly ($P<0.01$) decreased to 45 and 40 when GDL was added at the rate of 1 and 2% respectively. This could be attributed to increase solubility of calcium salts in milk which by its turn accelerated the coagulation of casein. Using thrombolastograph, Abd El-Salam et al. (1996) reported the same finding and mentioned that measurements of acid-induced gelation by GDL showed changes similar to that of enzymatic coagulation of milk in which two phases can be distinguished i.e. the onset of gelation and development of firm curd.

Curd tension had an opposite trend to that of RCT being low in the control milk and significantly ($P<0.01$) increased in the treated samples. The recorded values (g) were 21.0, 22.5 and 32.3 with adding 0.0, 1 and 2% GDL respectively. This was coincidence with higher rates of curd syneresis at any given syneresis time. The higher was the amount of GDL added the higher was the amount of the exudate from the prepared curd. This agrees with the results given by Hefny (1995a). He demonstrated that increasing the amount of GDL added at any renneting conditions (amount of rennet and renneting temperature) increased curd tension and curd firmness of buffalo's milk. Abd El-Salam et al. (1996) found that both GDL concentration (1-3%) and reaction temperature (28-40°C) affected the curd firmness. At higher temperature or higher GDL concentration buffalo's milk formed firmer curd. On the other hand, Storry et al. (1983) reported that syneresis inversely related to fat content of milk and little affected by coagulaum strength.

In Table (2), the recorded values were the results of adding GDL at the rate of 1% (T_I) and 2% (T_{III}) to cheese milk, whereas T_{II} and T_{IV} represented adding 1 and 2% GDL in order with half the amount of rennet given in T_I and T_{III}.

Control cheese had the maximum yield (23.44%) whereas the recorded values were 19.63, 20.94, 21.50 and 22.13% for treatments I, II, III and IV, respectively. This suggests that adding GDL significantly ($P<0.01$) decreased the yield of fresh cheese, whereas decreasing the amount of rennet added minimized such effect. More shrinkage of the treated curd as a result of more acid content may be responsible for lower moisture content in the resultant treated cheese and subsequently the decreased yield of the GDL-treated cheese. However, the correlations between coagulation properties of milk and cheese yielding capacity and cheese composition were the aim of some recent studies. Ng-Kwai-Hang et al. (1989) mentioned that partial correlation coefficients between coagulating properties and cheese yield, cheese composition and milk components in whey were found.

Table (2): The fresh yield and recoveries of fat (FR) and protein (PR) in the resultant soft cheese as affected by applying some treatments (Average of 3 replicates)

Treatments*	Yield (%)	FR (%)	PR (%)
Control	23.44	88.51	84.13
T_I	19.63	68.92	73.02
T_{II}	20.94	72.97	77.38
T_{III}	21.50	98.65	89.68
T_{IV}	22.13	95.95	85.71

* Control cheese represents cheese made without adding GDL.

T_I represents cheese made with adding 1% GDL and rennet.

T_{II} represents cheese made with adding 1% GDL and half the amount of rennet.

T_{III} represents cheese made with adding 2% GDL and rennet.

T_{IV} represents cheese made with adding 2% GDL and half the amount of rennet.

Recovery of fat was 88.51% in control cheese (Table 2) and significantly ($P<0.01$) decreased to 68.92 and 72.97% in T_I and T_{II} and increased to 98.65 and 95.95% in T_{III} and T_{IV}, respectively. This was also observed with respect to protein recovery, since the recorded values were 84.13% in control cheese and 73.02, 77.38, 89.68 and 85.71% in cheese from treatments I to IV, respectively. Firmness of curd in the last two treatments may be responsible for such higher figures.

Table (3) reveals that the maximum loss in cheese weight during the cold storage period was recorded for the control cheese and much lower values were given for all treated cheese. The higher was the amount of GDL added, the lower were the values of loss. It may be of interest to note that the maximum loss in control cheese weight was accompanied by the weakest curd (low curd tension) given in Table (1).

The maximum pH of 6.7 (Table 3) was recorded for the fresh control cheese, whereas fresh cheese from T_I and T_{II} had values less than 5, whereas fresh cheese from T_{III} and T_{IV} had values less than 4. The opposite was noticed for acidity since the lowest value (0.13%) was given for fresh control cheese and much higher values were observed in case of adding GDL.

During storage of cheese, the control one showed a gradual significant decrease in pH and an increase in acidity, whereas the changes in the treated cheese were insignificant.

Table (3): The loss of cheese weight (%) and some properties of soft cheese during cold storage as affected by applying some treatments

Storage period (days)	Treatments*	The loss (%)	pH	Acidity (%)	T.S. (%)	Fat %	Fat On DM %	Protein %	Protein On DM
0	Control	-	6.70	0.13	36.38	14.0	38.48	11.24	30.90
	T_I	-	4.70	1.06	34.83	13.17	37.82	11.86	34.05
	T_{II}	-	4.55	1.03	34.00	13.0	38.24	11.65	34.27
	T_{III}	-	3.57	1.68	38.64	17.0	43.99	12.79	33.10
	T_{IV}	-	3.58	1.63	37.14	16.0	43.08	12.22	32.90
15	Control	13.25	6.00	0.30	36.22	14.5	40.03	10.72	29.60
	T_I	4.40	4.56	1.03	34.53	13.0	37.65	10.72	31.04
	T_{II}	4.38	4.09	1.11	32.40	14.5	44.75	10.23	31.57
	T_{III}	0.00	3.33	1.58	37.96	16.5	43.47	12.57	33.11
	T_{IV}	2.50	3.30	1.50	35.83	15.7	43..82	12.08	33.72
30	Control	20.20	5.43	0.80	34.59	15.0	43.37	10.29	29.75
	T_I	5.68	5.00	0.86	32.33	12.0	37.11	10.20	31.57
	T_{II}	7.07	5.06	0.91	31.94	14.0	43.93	10.20	33.97
	T_{III}	2.50	3.87	1.43	35.07	16.0	45.62	11.48	32.74
	T_{IV}	2.50	3.31	1.30	35.68	15.7	44.01	12.00	33.63

* See legend to Table (2) for detailes.

Values of TS and protein of fresh cheese (Table 3) were significantly higher in T_{III} and T_{IV} treated cheese as compared to the control one. These increases were not parallel to the amount of GDL added. Decreasing the amount of rennet (T_{II} and T_{IV}) decreased the recorded values when compared with T_I and T_{III}. This was not always true with respect to the stored cheese.

Concerning fat content, the minimum values were given for T_I and T_{II} and the maximum values were recorded for T_{III} and T_{IV}. This was almost true for the fresh and stored cheese (Table 3) and the differences in this respect were highly significant.

Values of TVFA (Table 4) were higher in fresh control cheese, whereas all fresh treated cheese had the value of 10. During storage the rate of lipolysis was much higher in the control cheese ($P<0.05$).

It seems from the percentages of NPN/TN and SN/TN that cheese made using 1% GDL had the highest values at any given storage time and the differences due to the applied treatments were significnat. In general, the recorded values were in a significant increase during storage suggesting occurrence of proteolysis but with different rates. This trend was confirmed-in part-by formol No and values of Tyr and Try. Thus, the observed values were almost higher in fresh control cheese, whereas cheese from T_{III} and T_{IV} had – in general -significantly lower values. This was true when cheese was stored for 15 and 30 days.

Table (4): Lipolysis and proteolysis indices during cold storage of soft cheese as affected by applying some treatments.

Storage period (days)	Treatments*	TVFA**	NPN/TN (%)	SN/TN (%)	Formol No	Tyr+Try mg/100g
0	Control	12	2.10	7.04	3.0	112.31
	T_I	10	2.42	9.31	3.0	84.05
	T_{II}	10	2.36	11.50	2.0	55.94
	T_{III}	10	2.29	5.64	2.5	56.51
	T_{IV}	10	1.88	7.05	1.5	56.83
15	Control	22	3.20	8.11	13.0	110.04
	T_I	13	3.21	11.96	10.0	94.46
	T_{II}	16	2.93	12.41	10.0	72.33
	T_{III}	14	2.49	8.57	10.0	66.76
	T_{IV}	14	2.38	8.35	6.5	78.27
30	Control	25	5.46	19.28	18.0	115.84
	T_I	15	6.69	21.71	14.0	128.71
	T_{II}	16	5.57	19.26	12.0	133.15
	T_{III}	14	6.28	12.28	12.0	84.84
	T_{IV}	14	5.16	10.15	12.0	94.73

* See legend to Table (2) for details

** TVFA expressed as ml 0.1 N-NaoH/100 g cheese

Quality of cheese (Table 5) was significantly affected by GDL treatments. A compact texture with firmer and silky body were observed for 2% GDL-treated cheese. The differences in the scoring points given for body and texture were significant. This was accompanied by a slight pleasant acidic taste in case of using 2% GDL. The scoring points of the organoleptic properties are shown in Table (5) and suggested-with the previous given data-priority of making cold stored soft cheese from 2% GDL-treated cow's milk. In this respect, Fahmi et al. (1973) studied effect of acidity of salted milk on quality of Domiati cheese. They reported importance of increasing acidity of cow's milk to 0.26% by means of adding lactic acid to improve quality of the resultant cheese. The same conclusion was given by Hassan and Abo-Zeid (1988) and El-Deeb (1989) when white soft cheese was made from GDL-treated milk.

Table (5): Scoring of the organoleptic properties of soft cheese during cold storage as affected by applying some treatments (Average of 15 evaluations from 3 replicates)

Storage period (days)	Treat-ments*	Flavour (60)	Body & Texture (30)	Saltin-ess (5)	Appearance (5)	Total (100)**
0	Control	47.80	25.20	4.4	4.25	81.65
	T_I	51.70	23.40	3.53	3.50	82.13
	T_{II}	49.70	23.00	3.50	3.50	79.60
	T_{III}	51.40	28.00	4.43	4.60	88.43
	T_{IV}	50.90	28.70	3.8	5.00	88.40
15	Control	52.22	24.78	4.89	4.44	86.33
	T_I	46.33	19.89	4.06	3.17	73.45
	T_{II}	40.11	20.78	3.60	3.19	67.68
	T_{III}	51.33	26.44	4.60	4.67	87.04
	T_{IV}	50.33	24.78	4.5	4.61	84.22
30	Control	40.30	20.00	4.15	4.0	68.48
	T_I	30.51	15.11	2.3	1.16	49.08
	T_{II}	30.11	15.00	2.17	1.24	48.52
	T_{III}	56.00	27.50	4	3.1	90.50
	T_{IV}	55.60	27.00	4	3.1	89.60

* See legend to Table (2) for details

** Values in parenthesis represent the maximum attainable points.

REFERENCES

Abd El-Salam, M.H.; El-Dein, H.F.; El-Etriby, H.M.; Al-Khamy, A.F. and Shahein, N.M. (1996). The use of thrombolastograph to follow acid-induced gelation of buffalo milk by glucono-delta-lactone. Egyptian J. Dairy Sci., 24: 165.

Banks, J.M. and Muir, D.D. (1984). Coagulum strength and cheese yield. Dairy Ind. Int. 49: 17.

Chandrasekhara, M.R.; Bhagawan, R.K.; Swaminathan, M. and Subrahmanyan, V. (1957). The use of mammalian milk and processed milk foods in the feeding of infants. Indian J. Child Health, 6: 701.

El-Deeb, S.A. (1989). Acceleration of Domiati cheese ripening by different treatments. Alex. Sci. Exchange, 10: 241.

Fahmi, A.H. and Amer, S.N. (1962). A study on the preparation of liquid rennet extract. (In Arabic). Megallet El-Eloum El-Zeraeia, Cairo Univ., 15: 10.

Fahmi, A.H.; Metwally, M.; Abou-Dawood, A.E. and Abd El-Salam, I. (1973). The effect of acidity of salted milk on coagulation time and Domiati cheese. Egyptian J. Dairy Sci. 1: 148.

Fahmi, A.H. and Sharara, H.A. (1950). Studies on Domiati cheese. J. Dairy Res. 17: 312.

Hassan, H.N. and Abo-Zeid, N.A. (1988). The use of accelerating ripening agents to produce soft cheese. Alex. Sci. Exchange, 9: 211.

Hefny, A.A. (1995a). Effect of acid-forming glucono-delta-lactone on curd firmness of buffaloe's milk. Egyptian J. Dairy Sci. 23: 115.

Hefny, A.A. (1995b). Technological implications of glucono-delta-lactone (GDL) in buffaloe's milk ripening. Egyptian J. Dairy Sci. 23: 137.

Kosikowiski, F.V. (1978). Cheese and Fermented Milk Food. 2nd Ed., Published by the author, Cornell Univ., Ithaca, New York.

Ling, E.R. (1963). A Text Book of Dairy Chemistry. Vol. 2. Practical 3rd Ed., Chapman and Hall, London.

Lucey, J. A.; Munro, P.A. and Singh, H. (1998). Whey separation in acid skim milk gels made with glucono-delta-lactone: Effects of heat treatment and gelation temperature. J. Text. Stud. 29: 413.

Mayes, J.J. and Sutherland, B.J. (1989). Further notes on coagulum firmness and yield in Cheddar cheese manufacture. Australian J. Dairy Technol. 44: 47.

Mehanna, N.M. and Mehanna, A.S. (1989). On the use of stabilizers for improving some properties of cow's milk yoghurt. Egyptian J. Dairy Sci. 17: 289.

Naguib, M.M.; El-Sadek, G.M. and Naguib, Kh. (1974). Factors affecting quality of Domiati cheese. 1- Effect of heat treatment. Egyptian J. Dairy Sci. 2: 55.

Ng-Kwai-Hang, K.F.; Politis, I.; Cue, R.I. and Marziali, A.S. (1989). Correlation between coagulation properties of milk and cheese yielding capacity and cheese composition. Can. Inst. Food Sci. Technol. J. 22: 291.

Steel, R.G. and Torrie, J.H. (1984). Principles and Procedures of Statistics. A biometrical Approach. 2nd ed., Published by Mc. Graw Hill Int. Book Co. Inc., New York.

Storry, J.E.; Grandison, A.S.; Millard, D.; Owen, A.J. and Ford, G.D. (1983). Chemical composition and coagulating properties of renneted milks from different breeds and species of ruminant. J. Dairy Res. 50: 215.

Tawab, G.A. and Hofi, A.A. (1966). Testing cheese ripening by rapid chemical techniques. Indian J. Dairy Sci. 19: 39.

Vakaleris, D.G. and Price, W.V. (1959). A rapid spectrophotometric method for measuring cheese ripening. J. Dairy Sci. 42: 264.

الملخص العربي

دراسة على تركيب وجودة الجبن الطرى المصنع من اللبن المعامل بجلوكونو-دلتا-لاكتون

منال على نعيم ، رشاد ابراهيم هنداوى الأحول ، نبيل محمد مهنا*

معهد بحوث الإنتاج الحيوانى – كفر الشيخ و كلية الزراعة – جامعة طنطا – كفر الشيخ*

اهــتم البحث بدراسة تأثير اضافة جلوكونو-دلتا-لاكتون (GDL) لرفع حموضة اللبــن البقرى على خواصه التجبنية وعلى تركيب وجودة الجبن الطرى الناتج خلال فترة حفظــه فــى الــثلاجة (٤±١°م) لمــدة ٣٠ يومــا ، وأوضـــحت النتائج انخفاض الرقم الأيدروجينى للبن بزيادة GDL وسرعة تجبن اللبن بالرنين مع زيادة قوة الجذب الخثرى ومعدل طرد الشرش منها.

أدت اضـــافة GDL بنسبة ١، ٢% مع استخدام نفس كمية المنفحة المستخدمة فـــى حالـــة الكونـــترول (دون اضافة GDL) أو نصف الكمية إلى خفض تصافى الجبن الطـــازج الـــناتج وكان معدل استرجاع الدهن والبروتين فى الجبن الطازج أقل فى حالة اســـتخدام ١% GDL.. وواكب ذلك زيادة الفقد فى وزن الجبن غير المعامل أثناء حفظه فى الثلاجة لمدة ٣٠ يوماً وانخفض معدل الفقد فى الوزن بزيادة كمية GDL المضافة.

أدت اضـــافة GDL إلـــى خفض الرقم الأيدروجينى للجبن الناتج وزيادة الحموضة وكانـــت قيم الجوامد الكلية والبروتين أعلى فى الجبن المعامل بالمركب المذكور بنسبة ٢ %، بينما أنخفض الدهن إلى أقل محتوى عند استخدام ١% GDL.. كما أوضحت النتائج حـــدوث تحلـــلا فى الدهن والبروتين خلال تخزين الجبن ولكن بمعدلات مختلفة فى حين كانـــت جـــودة الجبـــن المعامل بالـــ GDL بنسبة٢% أعلى مقارنة بباقى عينات الجبن المعامل وغير المعامل.