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EFFECT OF USING GLUCONO-DELTA-LACTONE AS ACIDULANT ON THE CHEMICAL AND RHEOLOGICAL PROPERTIES OF MOZZARELLA CHEESE MAED FROM DIFFERENT TYPES OF MILK.

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ABSTRACT

Mozzarella cheese was made from mixtures of buffaloe□s and cow□s milk (1:1), buffaloe□s and goat□s milk (1:1) or cow□s and goat□s milk (1:1) using only 0.5% yoghurt starter, 0.75% GDL or admixture of 0.25% yoghurt starter + 0.37% GDL. Resultant cheese were examined for chemical, rheological and organoleptic properties when fresh and during storage period at -18°C for 60 days. Results showed that adding GDL to cheese milk increased acidity, TS and fat contents of cheese whey. Addition of 0.75% GDL to cheese milk decreased the yield, TS, fat, TN, ash, salt, calcium and oiling off values of resultant cheese while increased WSN,TVFA and meltability values of the cheese.

Mozzarella cheese made from buffaloe□s milk mixed with cow□s or goat□s milk had higher yield, TS, fat, calcium and also oiling off values, on the other hand, lowered acidity, ash, salt, WSN, TVFA and meltability values than that made from cow□s and goat□s milk mixture. Sensory evaluation showed that Mozzarella cheese made using a mixture of 0.25% yoghurt starter + 0.37% GDL gained the highest scores points for all types of mixed milk treatments.

Keyword: Mozzarella cheese- starter- GDL- goat milk- Meltability- Oiling off

INTRODUCTION

Mozzarella cheese is originally made from water buffaloe□s milk in Italy. Nowadays, it is made all over Europe and USA from cow□s milk. Recently, Mozzarella cheese of satisfactory quality has been made from buffaloe□s and cow□s milk or their mixtures(Kindstedt, 1993). In Middle east (especially in Syria) Mozzarella cheese known as (El-Medaffarah) is mainly made from ewe□s milk and sometimes goat□s milk may be added (Darwish 1977).

On the other hand, most traditional methods for making of Pasta filata cheeses involve the addition of starter to the milk for the development of required acidity during different steps of processing, the curd is kneaded when the pH values ranged between 4.9-5.3 according to the type of milk and cheese (Abdel-Kader, 1993).

Direct acidification (DA) technique had gained considerable commercial interest, as it does not rely on starter performance which is unpredictable and there is risk of phage infections as well as contamination of milk supply with antibiotics and helps towards mechanization of production (Fox 1978). The method of manufacture of Mozzarella cheese by (DA) involves the lowering of pH by different acids to have better control over pH variations, and to reduce manufacturing time. The different types of acids employed in these techniques include hydrochloric, phosphoric, lactic, acetic, malic or citric acid.

Metzger *et al* (2001) reported that preacidification of milk with organic acids to a pH of 5.8-5.6, in combination with a starter culture, resulted in a reduction in calcium level of low-fat (6% w/w) low moisture part skim Mozzarella cheese but did not significantly affect the levels of moisture; the experimental cheeses generally had a lower pH than the control. The reduction in calcium content resulted in an increase in protein hydration and a decrease in hardness of the unheated cheese, and an increase in flowability of the melted cheese.

Jensen *et al.* (1987) used glucono-delta-lactone(GDL) as an acidulant for low- moisture part skim milk Mozzarella cheese produced from ultrafiltrated milk. El-Sayed et al (1998) studied the effect of GDL on the growth and biochemical activities of certain lactic acid bacteria and pathogenic bacteria in cow□s and buffaloe□s milk. Results showed that the addition of 0.5% GDL increased the total acidity V.F.A, free amino groups and acetaldehyde production by both strains of lactic acid bacteria *Strep. thermophilus* and *L. bulgaricus* and they were higher in cow□s milk than buffaloe□s milk. On the other hand 0.5% GDL decreased the counts of *Listeria monocytogenes, E. coli* CNRZ 7 and *Staphylococcus aureus* CNRZ 4 in cow□s milk than buffaloe□s milk.

No available literature about the use of GDL as acidulant with admixture milk. So, this study was conducted to investigate the effect of using GDL alone or with starter as acidulant with different milks on some chemical and rheological properties of Mozzarella cheese.

Materials and Methods

Materials:

Fresh buffaloe□s milk was obtained from El-Gemmeza Animal Production Research Station, whereas fresh cow□s and goat s milks were obtained from El-Serw Animal Production Research Station, Animal Production Research Institute, Agriculture Research Center. The chemical composition of used milks is recorded in Table (1).

Yoghurt starter culture (Yo-Fex,YC-350,DVS) consists of *Streptococcus saliverus* ssp. *thermophilus* and *L. delbrueckii* ssp. *bulgaricus* were obtained from Chr. Hansen□s Lab A/S Copenhagen, Denmark.

Liquid calf rennet was obtained from local market and was added to milk at a ratio of 30 mL 100 kg^{-1} milk. Dry coarse commercial food grade salt was obtained from El-Nasr Company of Alexandria. All chemicals were of laboratory grade.

Table (1):Chemical composition of used milks in Mozzarella cheese manufacture.

Type of milk	Acidity %	pH	TS %	Fat %	TP %
Buffaloe□s milk	0.17	6.60	15.44	6 1	3.52
Cow□s milk	0.19	6.49	12.11	3 8	3.13
Goat□s milk	0.18	6.53	13.09	4 2	3.42
Buffaloe□s and cow□s milk (1:1)	0.18	6.55	14.07	4.8	3.30
Buffaloe□s and goat□s milk (1:1)	0.17	6.50	14.89	5.5	3 49
Cow□s and goat□s milk (1:1)	0.18	6.51	12.39	4.1	3.24

Glucono delta lacton (GDL) has lysactone name as a commercial product was produced by Roquette Freres company, Lille- France. It was added to the milk as a powder at a rate of 0.37 and 0.75%.

Methods:

Mozzarella cheese manufacture:

Fresh buffaloe□s, cow□s and goat□s milk were used for manufacture of 9 treatments of Mozzarella cheese as shown in Table (2).

Table(2):Code letters of the different Mozzarella cheese treatments.

Treatments	Appreviation	Type of milk			Type of acidificatin	
		Buffaloe□s milk	Cow□s milk	Goat□s milk	yoghurt starter %	GDL %
A(control)	BC (starter)	1	1	-	0.5	-
B	BC(GDL)	1	1	-	-	0.75
C	BC (stareter+GDL)	1	1	-	0.25	0.37
D	BG (starter)	1	-	1	0.5	-
E	BG(GDL)	1	-	1	-	0.75
F	BG (stareter+GDL)	1	-	1	0.25	0.37
G	CG (starter)	-	1	1	0.5	-
H	CG(GDL)	-	1	1	-	0.75
I	CG (stareter+GDL)	-	1	1	0.25	0.37

B: Buffaloe□s milk C: Cow□s milk G: Goat□s milk

The nine batches of milk were made into Mozzarella cheese as described by Kosikowski (1982). The resultant cheese were freeze storaged at -18°C and analyzed when fresh and after 15,30,45 and 60 days of storage period.

Methods of analysis:

Milk and whey samples were analyzed for titratable acidity (TA), total solids (TS), fat and total protein contents according to Ling (1963). The pH values were estimated using a pH meter type CG 710. Cheese was analyzed for total solids (TS), titratable acidity (TA), pH, fat, total nitrogen (TN), water soluble nitrogen (WSN) and ash contents according to Ling (1963). Salt contents of Mozzarella cheese were estimated using Volhard method according to Richardson (1985). Calcium was determined using calcin as indicator by the method described by Graham *et al.*, (1962) and as modified by Abdel-Kader (1993). Total volatile fatty acids (TVFA) was determined as described by Kosikowski (1978), and expressed as ml of 0.1N NaOH, 100 g-1 cheese. Meltability and oiling off were determined as described by Kindsted and Rippe (1990). The cheese samples were scored for flavor (50 points), body and texture (40 points) and appearance and color (10 points) by ten panelists in El-Serw Animal Production Research Station.

The obtained results were statistically analyzed using a software package (SAS, 1991) based on analysis of variance. When F-test was significant, least significant difference (LSD) was calculated according to Duncan (1955) for the comparison between means. The data presented, in the Tables, are the mean (± standard deviation) of 3 experiments.

RESULTS AND DISCUSSION

Chemical composition of cheese whey:

The gross composition of whey from different cheese treatments was shown in Table (3). As it is expected, adding GDL to different types of cheese milk increased the acidity value of whey and the increase rate was proportional to the amount of GDL. On the other hand, no pronounced differences in whey acidity values were observed between mixtures of buffaloe□s and cow□s milk (treatment A), buffaloe□s and goat□s milk (treatment D), or cow□s and goat□s milk (treatment G). pH values had an opposite trend of acidity.

Also, the addition of GDL to cheese milk slightly increased fat contents of whey, while it had no significant effect on TS and TN contents. TS, fat and TN contents of cheese whey of treatments A, D and G were similar to each other.

Obtained results of the acidity, pH, TS, fat and TN contents of Mozzarella cheese whey were within the range obtained by El-Zoghby (1994) who used different milks in Mozzarella cheese making.

Table (3): Chemical composition of cheese whey:

Treatments	Acidity %	PH	TS %	Fat %	TN %
A	0.34	4.75	6.72	0.6	0 20
B	0.44	4.53	7.45	0.8	0 20
C	0.36	4.69	7.11	0.6	0 20
D	0.31	4.80	6.83	0.6	0.21
E	0.42	4.57	7.49	0 8	0 22
F	0.35	4.71	7.21	0 7	0 21
G	0.32	4.74	6.70	0 6	0 17
H	0.43	4.52	7.39	0.9	0 17
I	0.36	4.68	7.11	0.6	0.18

Yield and chemical composition of Mozzarella cheese:

The yield values of resultant cheese as affected by adding GDL and types of milk were illustrated in Table (4). Addition of 0.75% GDL to the milk prior to coagulation led to a decrease in cheese yield reaching 1.98, 3.53 and 4.30% for (buffaloe□s and cow□s milk), (buffaloe□s and goat s milk) and (cow□s and goat□s milk) admixtures respectively.

In contrary, adding 0.25% yoghurt starter and 0.37% GDL had no effect on cheese yield.

From the other side, the yield of cheese increased when buffaloe□s milk mixed with cow□s or goat□s milk whereas yield of Mozzarella cheese made from (cow□s and goat□s milk) was the lowest one.

From Table (4) it is observed that the addition of GDL resulted in an increase the titratable acidity and a decrease in pH values. This is due to the acidic properties of GDL. Concerning the effect of type of milk on cheese acidity, cow□s and goat□s milk cheese had higher acidity values than buffaloe□s and cow□s milk or buffaloe□s and goat□s milk cheese. This could be explained by the fact that buffaloe□s milk cheese possesses a higher buffering capacity than those of cow□s milk (Abdel-Kader 1993). Although cheese stored at -18°C, the titratable acidity of all cheese treatments increased significantly (P< 0.001), while the pH values of all samples decreased significantly (P< 0.001).

Table (4): Yield abd chemical composition of Mozzarella cheese.

Treatments	Storage period (days)	Yield %	Acidity %	pH	TS %	Ash %	Salt %	Calcium %
A	0	13.10	0.62	5.58	54.19	3.43	1.83	0.837
	15	-	0.66	5.52	55.02	3.66	1.98	0.859
	30	-	0.68	5.49	55.74	3.79	2.09	0.870
	45	-	0.71	5.43	56.36	3.90	2.17	0.882
	60	-	0.74	5.37	57.08	4.04	2.28	0.889
B	0	12.84	0.65	5.51	49.65	3.36	1.65	0.648
	15	-	0.68	5.48	50.31	3.58	1 83	0.675
	30	-	0.73	5.40	51.11	3 61	1 92	0 683
	45	-	0.76	5.35	51.65	3 74	2 03	0 694
	60	-	0.80	5.30	52.19	3.82	2 15	0 710
C	0	13.11	0.64	5.53	52.79	3.39	1 81	0 822
	15	-	0.67	5.49	53.51	3.64	1 98	0 848
	30	-	0.71	5.44	54.15	3.77	2.07	0.861
	45	-	0.74	5.39	54.68	3.89	2.14	0.870
	60	-	0.78	5.30	55.21	4.03	2.25	0.879
D	0	13.75	0.60	5.62	54.93	3.51	1.87	0.928
	15	-	0.64	5.56	55.48	3.78	2.04	0.946
	30	-	0.67	5.52	56 11	3 91	2 13	0.955
	45	-	0.69	5.48	56.77	4.06	2 25	0.968
	60	-	0.72	5.42	57.24	4.19	2 33	0 977
E	0	13.09	0.63	5.53	50.42	3 42	1 79	0 749
	15	-	0.67	5.49	51.39	3.67	1 98	0 772
	30	-	0.71	5.42	52.15	3.81	2.11	0.781
	45	-	0.75	5.38	52.74	3.90	2.22	0.789
	60	-	0.78	5.32	53.26	4.03	2.30	0.796
F	0	13.40	0.61	5.56	53.35	3.48	1 82	0.894
	15	-	0.65	5.50	54.11	3.73	2.01	0.918
	30	-	0.68	5.47	55.02	3.89	2.14	0 929
	45	-	0.71	5.42	55 63	4.04	2.24	0.940
	60	-	0.74	5.36	56.14	4.16	2.32	0.950
G	0	11.63	0.67	5.51	51.19	3.69	1.93	0.641
	15	-	0.71	5.45	51.74	3.93	2 19	0.667
	30	-	0.74	5.40	52.55	4.10	2.31	0.680
	45	-	0.76	5.35	53.08	4.27	2 42	0.692
	60	-	0.78	5.30	53.81	4.36	2.51	0.706
H	0	11.13	0.69	5.46	46.98	3.56	1.84	0.483
	15	-	0.74	5.40	47.61	3.82	2 03	0.511
	30	-	0.78	5.33	48 21	3.94	2.16	0.520
	45	-	0.80	5.29	48.80	4.08	2 28	0.531
	60	-	0.83	5.25	49 62	4 21	2.39	0.539
I	0	11.61	0.68	5.45	50.15	3.65	1.90	0.622
	15	-	0.72	5.40	51.11	3.92	2.15	0.645
	30	-	0.75	5.34	51.79	4.04	2.28	0.658
	45	-	0.79	5.26	52.37	4.17	2 39	0.667
	60	-	0.81	5.23	53 16	4.30	2.49	0.675

Data for TS, ash, salt and calcium contents of fresh cheese and during freezed storage period were recorded in Table (4). From these results it is clear that the addition of GDL to cheese milk decreased markedly the total solids, ash, salt and calcium contents of the resultant cheese. Similar results were found by Jensen *et al.* (1987) who used GDL or acetic acid for Mozzarella cheese making from ultrafiltered milk. They found that the preacidification to pH 5.8 increased fat losses and cheese moisture.

The TS content of cheese as well as the ash, salt and calcium values were varied due to the type of milk used in making Mozzarella cheese. Results found in Tables (1 and 4) showed that high TS, ash and calcium contents in the blending of buffaloe□s milk and cow□s or goat□s milk caused an obvious increase in TS, ash and calcium contents in the corresponding cheese. Generally, TS, ash, salt and calcium contents of cheese significantly (P< 0.001) increased as storage period progressed. These results are in agreement with El-Batawy, *et al* (2004).

Analysis of variance (Table 8) showed that the differences in TS, ash, salt and calcium values between treatments and the effect of storage time were highly significant (P< 0.001).

Fat, TN and some ripening indices of cheese:

As a TS of cheese decreased, fat, Fat/DM and TN contents decreased when GDL was added to cheese milk. Addition of 0.75% GDL increased the rate of fat, Fat/DM and TN decrease whereas slight decrease was found when 0.25% yoghurt starter + 0.37% GDL added. TN/DM values were similar in different treatments.

On the other hand, the average of fat, Fat/DM and TN contents of Mozzarella cheese made from buffaloe□s milk mixed with cow□s or goat□s milk were higher than that made from cow□s and goat□s milk. The differences in the fat, Fat/DM and TN values between treatments as well as the effect of storage time (Table 8) were highly significant (P< 0.001).

As indicated in Table (5), although the cheese was kept at - 18°C, the WSN and TVFA contents increased significantly (P< 0.001) as time of storage was advanced. Direct acidification with GDL enhanced protein breakdown as measured by WSN content. Also, WSN/TN values were higher in GDL cheese than that of other treatments. This is in accordance with the results of Abdel-Kader (1993). TVFA behaved similarly to WSN. GDL Mozzarella cheese either for fresh or stored cheese contained higher TVFA than that of control one.

Results in Table (5) show that the addition of buffaloe□s milk to cow□s or goat□s milk led to slow the protein decomposition of resultant cheese (Treatments A and D) .Also, the TVFA content of Mozzarella cheese made from admixture of cow□s and goat□s milk was higher than that made from either buffaloe□s and cow□s milk or buffaloe□s and goat□s milk mixtures.

Meltability and oiling off of Mozzarella cheese:

Values of meltability and oiling off of different treatments were illustrated in Table (6). Addition of GDL increased the meltability of Mozzarella cheese. This may be attributed to dissolving and removing a part of calcium into whey and kneading water during cheese making due to the acidification of cheese milk resultant in higher meltability of resultant cheese than control (El-Zoghby 1994, Sheehan 2004 and Guinee and Joshi et al 2004). Also, meltability of

Mozzarella cheese increased during storage period which could be related to the protein breakdown occurred in the cheese matrix (Abd El-Hamid 2004).

Table (5): Fat, TN and some ripening indices of Mozzarella cheese.

Treatments	Storage period (days)	Fat %	Fat/DM %	TN %	TN/DM %	WSN %	WSN/TN %	TVFA*
A	0	27.9	51.48	4.11	7.58	0.196	4.77	4.6
	15	28.6	51.98	4.23	7.69	0.234	5.53	5.6
	30	29.1	52.21	4.29	7.70	0 263	6 13	6.2
	45	29.6	52.52	4.32	7.66	0 301	3 97	6 8
	60	30.1	52.73	4 36	7.64	0.328	7 52	7 4
B	0	24.9	50.15	3.90	7.85	0 219	5 61	6 4
	15	25.6	50.88	4.03	8.01	0 262	6 50	7 0
	30	26.3	51.46	4.09	8.00	0.306	7 48	7 8
	45	26.9	52.08	4.14	8.02	0.337	8 14	8 6
	60	27.5	52.69	4.17	7.99	0.393	9 42	9.2
C	0	26.1	49.44	3.98	7.54	0.208	5.23	5.2
	15	26.9	50.27	4.11	7 68	0 241	5 87	6 6
	30	27.4	50.60	4.16	7.68	0 280	6 73	7 4
	45	27.8	50.84	4.21	7.70	0 323	7 67	8 2
	60	28.4	51.44	4.25	7 70	0 354	8 33	9.0
D	0	28.8	52.43	4.24	7 72	0 190	4 48	5.0
	15	29.5	53.17	4 33	7.80	0.225	5 20	6.6
	30	30.1	53.64	4.38	7.81	0.249	5 68	7 2
	45	30.9	54.43	4.42	7.79	0.287	6 49	7.8
	60	31.3	54.68	4.45	7.77	0.311	6 99	8.2
E	0	26.4	52.36	4.02	7.97	0.204	5 07	7 2
	15	27.2	52.93	4.13	8 04	0.248	6 00	8 4
	30	28.0	53.69	4.19	8.03	0.279	6 66	9 0
	45	28.5	54.04	4.23	8 02	0 315	7 45	9.6
	60	29.0	54.45	4.25	7.98	0.367	8.63	10 4
F	0	27.1	50.80	4.13	7.74	0.201	4.87	6.2
	15	27.8	51.38	4.22	7.80	0.237	5 62	7 6
	30	28.4	51.62	4.26	7.74	0.271	6 36	8.2
	45	28.9	51.95	4.31	7.75	0.303	7 03	8.8
	60	29.4	52.37	4.34	7.73	0.334	7 69	9.4
G	0	24.5	47.86	3.60	7.03	0 240	6 67	6.6
	15	24.9	48.13	3.71	7.17	0 274	7 38	7 8
	30	25.5	48.53	3.77	7 17	0.298	7 90	8.6
	45	26.1	49.17	3.80	7.16	0.346	9 11	9.4
	60	26.6	49.43	3.85	7.15	0.383	9 95	10.0
H	0	22.4	47.68	3.30	7.02	0.277	8 55	8.2
	15	23.2	48.79	3.36	7.06	0.303	9 02	9.6
	30	23.7	49.16	3.41	7.07	0.335	9 82	10.4
	45	24.0	49.18	3.44	7.05	0.382	11 10	11 0
	60	24.5	49.37	3.54	7.13	0 424	12 18	11.8
I	0	23.3	46.46	3 53	7.04	0.261	7 52	7.2
	15	24.0	46.96	3 61	7.06	0 292	8 09	8 8
	30	24.7	47.69	3.65	7.05	0.323	8 85	9.6
	45	25.1	47.65	3.70	7.06	0.362	9.86	10 2
	60	25.5	47.88	3.76	7.07	0.401	10 81	10 6

*** expressed as ml 0.1N NaOH 100g-1 cheese.**

On the other hand, meltability of cheese made from cow□s and goat□s milk mixture was higher than that of buffaloe□s and cow□s milk or buffaloe□s and goat□s milk admixtures either in GDL or traditional cheese.

Data presented in Table (6) showed that direct acidification significantly decreased (P< 0.001) the oiling off of the cheese especially that made from buffaloe□s and goat□s milk mixtures. This may be explained by added acids formed certain emulsifying system led to the retention and binding tightly the fat in the curd (El-Zoghby 1994).

Mozzarella cheese made from cow□s and goat□s milk mixture showed the lowest while that of buffaloe□s and goat□s milk mixture had the highest oiling off. This may be related to the size of fat globules of the milk. The bigger size of fat glouble in buffaloe□s milk led to more oiling off in the cheese product (Bikash *et al.*, 1996).

Table (6): Meltability and oiling off Mozzarella cheese.

Properties	Storage period (days)	Treatments								
		A	B	C	D	E	F	G	H	I
Meltability (%)	0	14.23	18.68	15.91	11.32	13.52	12.31	15.86	18 95	16.34
	15	18.85	24.95	20.56	16.14	19.14	17.20	21 04	24.46	21 91
	30	23.45	29.82	25.56	21.22	24.83	21.97	25.81	29.83	26.75
	45	29.95	33.91	30.67	26.18	29.16	26.49	30.53	33.81	31.04
	60	35.22	39.56	37.04	32.73	34.64	33.85	35.92	39.86	37.71
Oiling off (%)*	0	54.15	48.29	53.63	58.49	46.25	54 11	48.27	40 24	45 82
	15	60.38	54.25	59.15	65.33	50.91	58.15	53 26	46 19	51 29
	30	65.28	58.39	6343	70 39	55.39	65 87	60 30	50 26	56 41
	45	69.25	63.41	68.93	74.55	61.12	70.56	66 46	55 11	62.48
	60	77.29	67.38	73.80	80.29	65.59	76.22	72.48	61.39	69.08

* areia of fat diffusions.

Similarly to the meltability, oiling off percent significantly increased (P< 0.001) during cheese storage in all traetments but increasing meltability is a favourd property of the cheese but increasing oiling off is not a good property of the cheese and may be for this reason many people like to consume this varity of cheese very fresh. As a general, the increase in oiling off during storage period may be due to the protein degradation and weakness of casein network, which may led to demulsification and easy fat separation. These observations are in agreement with those of Yun *et al.*, (1998), Abd El-Hamid *et al.*, (2001) and Abd El-Hamed *et al.*, (2004).

Organoleptic evaluation of Mozzarella cheese:

Test panel evaluation values were recoded in Table (7). Mozzarella cheese made using 0.25% yoghurt starter and 0.37% GDL gained the highest score when it was fresh and also at the end of storage period. Also, buffaloe□s and cow□s milk mixture cheese had higher score than that of other treatments. The sensory evaluation of all cheese treatments gradually improved during storage period reaching the highest score after 60 days of storage.

So, from the previous study acceptable Mozzarella cheese can be made using 0.25% yoghurt starter and 0.37% GDL regardeless of the type of the milk.

Table (7):Organoleptic properties of Mozzarella cheese.

Properties	Storage period (days)	Treatments								
		A	B	C	D	E	F	G	H	I
Appearance & Color (10)	0	8	8	8	8	8	8	7	7	7
	15	7	8	8	8	8	7	6	7	6
	30	7	7	7	7	7	7	6	6	6
	45	6	7	6	7	7	6	5	6	5
	60	5	6	6	6	6	6	5	5	5
Body & Texture (40)	0	31	30	32	31	31	32	32	31	32
	15	33	32	34	33	32	34	34	32	34
	30	33	33	35	33	33	34	35	34	34
	45	34	33	35	34	34	35	36	35	36
	60	36	34	37	36	35	36	37	36	37
Flavour (50)	0	36	33	36	30	29	31	31	30	33
	15	38	33	38	30	30	32	33	31	35
	30	39	34	40	32	30	33	34	32	36
	45	40	35	41	33	31	34	34	34	36
	60	42	36	43	35	32	35	36	35	37
Total (100)	0	75	71	76	69	68	71	70	68	72
	15	78	73	80	71	70	73	73	70	75
	30	79	74	81	72	70	74	75	72	76
	45	80	75	82	74	72	75	75	75	77
	60	83	76	86	77	73	77	78	76	79

***Table (8)*: Statistical analysis of Mozzeralla cheese treatments.**

Analysis	Effect of cheese treatments									
	A	B	C	D	E	F	G	H	I	LSD
Yield	13.1^{bc}	12.8^{c}	13.4^{ab}	13.6^{a}	13.1^{bc}	13.4^{ab}	11.6^{d}	11 1^{e}	11.4^{de}	0 43***
Whey Acidity	0.34^{cd}	0.44^{a}	0.35^{cd}	0.31^{d}	0.41^{ab}	0.35^{cd}	0.33^{d}	0.43^{ab}	0 36^{bcd}	0.08*
Whey pH	4.75^{a}	4.53^{c}	4.69^{ab}	4.80^{a}	4.57^{bc}	4.71^{ab}	4.74^{ab}	4.52^{c}	4.68^{abc}	0.18*
Whey TS	6.72^{a}	7.45^{a}	7.11^{a}	6.83^{a}	7.49^{a}	7.21^{a}	6.71^{a}	7.39^{a}	7 11^{a}	1.10
Whey Fat	0.60^{d}	0.80^{ab}	0.65^{cd}	0.60^{d}	0.85^{ab}	0.70^{bcd}	0.60^{d}	0 90^{a}	0 55^{d}	0 15**
Whey TN	0.20^{ab}	0.20^{ab}	0.20^{ab}	0.21^{ab}	0.22^{a}	0 21^{ab}	0 17^{b}	0 17^{b}	0 18^{ab}	0 05
Cheese acidity	0.68^{cde}	0.73^{abc}	0.71^{bcde}	0.66^{e}	0.71^{bcd}	0.68^{de}	0 73^{ab}	0 77^{a}	0 75^{ab}	0 05***
Cheese pH	5.48^{a}	5.41^{ab}	5.44^{ab}	5.52^{a}	5.43^{ab}	4.96^{b}	5.41^{ab}	5 35^{ab}	5 34^{ab}	0 49
Cheese TS	55.7^{ab}	50.9^{e}	54.1^{c}	56.1^{a}	51.9^{de}	54.85^{d}	55 24^{ab}	48 2^{f}	51 8de	1 23***
Cheese Fat	29.1^{a}	26.2^{abcd}	27.3^{ab}	27.3^{abc}	27.9^{ab}	28.32^{ab}	25 5^{bcd}	24 1^{d}	24.5^{cd}	2.91*
Cheese TN	4.27^{a}	4.37^{a}	4.15^{a}	4.37^{a}	4.17^{a}	4 25^{a}	3 75^{b}	3.39^{c}	3 62^{bc}	0.27***
Cheese WSN	0.26^{ef}	0.30^{bcd}	0.28^{def}	0.25^{f}	0.28^{cde}	0.27^{ef}	0.30^{bc}	0.35^{a}	0 33^{ab}	0.03***
Cheese Ash	3.77^{cd}	3.62^{d}	3.74^{cd}	3.89^{abc}	3.77^{cd}	3.86^{bc}	4.07^{a}	3.92^{abc}	4.02^{ab}	0.20***
Cheese Salt	2.07^{bcd}	1.92^{d}	2.05^{cd}	2.12^{abc}	2.08^{bcd}	2.11^{abc}	2.27^{a}	2.14^{ab}	2 24^{ab}	0.18*
Cheese Ca	0.87^{b}	0.68^{d}	0.86^{b}	0.96^{a}	0.78^{c}	0.93^{a}	0.68^{d}	0.52^{e}	0 65^{d}	0 04***
Cheese TVFA	6.13^{h}	7.80^{ef}	7.28^{fg}	6.97^{g}	8.92^{bc}	8.03^{de}	8.47^{cd}	10 2^{a}	9.28^{b}	0.61***
Meltability	24.3^{c}	29.4^{a}	25.8^{b}	21.5^{d}	24.3^{c}	22.4^{d}	25.8^{b}	28.8^{a}	26 5^{b}	0.83***
Oiling off	65.3^{b}	58.4^{e}	63.8^{c}	69.8^{a}	55.8^{g}	64.9^{b}	60 2^{d}	50 6^{h}	57 0^{f}	0.66***
Appeance& color	6.90^{ab}	7.20^{a}	6.90^{ab}	7.30^{a}	7.00^{ab}	6.60^{b}	5.70^{c}	6.10^{c}	5 80^{c}	0 43***
Body& Texture	33.6^{bc}	32.5^{c}	34.9^{a}	33.9^{abc}	32.9^{bc}	34.40^{abc}	34 9^{a}	33.8^{abc}	34.6^{ab}	1 92
Flavor	39.1^{a}	34.2^{bc}	39.8^{a}	32.0^{de}	30.4^{e}	33.1^{cd}	33.7^{c}	32 6^{cd}	35 4^{b}	1 83***

	Effect of storage time (days)					
	0	15	30	45	60	LSD
Cheese Acidity	0.65^{d}	0.68^{c}	0.72^{bc}	0.75^{ab}	0.79^{a}	0 034***
Cheese pH	5.53^{a}	5.48^{ab}	5.15^{bc}	5.37^{ab}	5.32^{ab}	0.366
Cheese TS	51.5^{d}	52.2^{cd}	52.9^{bc}	53.6^{ab}	54 2^{a}	0.920***
Cheese Fat	25.8^{bc}	24.9^{c}	· 27.1^{a}	27.6^{ab}	28.1^{a}	2.17*
Cheese TN	3.86^{bc}	4.03^{ab}	4.14^{c}	4.06^{a}	4 10^{a}	0.201*
Cheese WSN	0.22^{e}	0.26^{d}	0.29^{c}	0 33^{b}	0 36^{a}	0 02***
Cheese Ash	3.50^{d}	3.75^{c}	3.88^{bc}	4.01^{ab}	4.20^{a}	0 151***
Cheese Salt	1.83^{d}	2.02^{c}	2.14^{bc}	2.24^{ab}	2.34^{a}	0.137***
Cheese Ca	0.74^{c}	0.76^{bc}	0.77^{ab}	0.78^{ab}	0.79^{a}	0.029**
Cheese TVFA	6.29^{e}	7.54^{d}	8.28^{c}	8.93^{b}	9.55^{a}	0.458***
Meltability	15.14^{e}	20.5^{d}	25.4^{c}	30.1^{b}	36.1^{a}	0.618***
Oiling off	49.9^{e}	55.4^{d}	60.6^{c}	65.8^{b}	71.5^{a}	0.494***
Appeance& color	7.61^{a}	7.44^{a}	6.61^{b}	6.05^{c}	5 33^{d}	0.324***
Body& Texture	31.5^{d}	3.33^{c}	33.94^{bc}	34.78^{ab}	36.2^{a}	1.43***
Flavor	32.22^{d}	3.33^{cd}	34.61^{c}	35.33^{b}	36.9^{a}	1.37***

Significant different at $p <$ (*0.05, **0.01, ***0.001). For each effect the different letters in the means the multiple comparison are different from each. Letters a is the highest means followed by b, c .....etc.

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تأثير حمض الجلوكونودلتا لاكتون على الخواص الكيماوية و الريولوجيـة لجـبن الموزاريلا المصنع من ألبان مختلفة.

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صنعت جبن الموزاريلا من خليط لبن جاموسى و بقرى (١:١) و خليط لبن جاموسـى و ماعز (١:١) و حليط لبن بقرى و ماعز (١:١) و ذلك بأستخدام ٠,٥% بادئ زبـادى، ٠,٧٥% جلوكونودلتا لاكتون، ٠,٢٥% بادئ زبادى + ٠,٣٧% جلوكونودلتا لاكتون. و تم تخزين الجبن الناتج لمدة ٦٠ يوم على درجة حرارة -١٨°م. و تشير النتائج إلى أن إضافة الجلوكونودلتا لاكتون للبن الجبن ادى إلى أرتفاع نسب الحموضة و الدهن بشرش الجبن. كذلك أدت إضـافة ٠,٧٥% جلوكونودلتا لاكتون إلى أنخفاض قيم التصافى و المادة الصلبة و الدهن و النتـروجين الكلـى و الرماد و الملح و الكالسيوم و أنفصال الدهن و إلى زيادة محتوى الجبن من النتروجين الذائب فى الماء و الأحماض الدهنية الطيارة الكلية و المطاطية.

و قد أرتفعت قيم التصافى و المادة الصلبة و الدهن و النتروجين الكلـى و الكالسـيوم و أنفصال الدهن بينما أنخفضت قيم الحموضة و الرماد و الملح و النتروجين الذائب فـى المـاء و الأحماض الدهنية الكلية الطيارة و المطاطية بجبن الموزاريلا المصنع من خليط لبن جاموسـى و بقرى او خليط لبن جاموسي و لبن ماعز مقارنة بذلك المصنع من خليط لبن بقرى و لبن ماعز. و تشير نتائج التقييم الحسي إلى أن جبن الموزاريلا المصنع بأسـتخدام ٠,٢٥% بـادئ زبـادى و ٠,٣٧% جلوكونودلتا لاكتون قد سجل أعلى درجات التحكيم.