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IMPROVING THE TEXTURAL PROPERTIES OF MOZZARELLA CHEESE MADE FROM UF- BUFFALO MILK RETENTATE

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SUMMARY

Mozzarella cheese was made from standardized buffalo milk (~3 % fat) and UF-buffalo and cow milk retentates. The effect of using brine as stretching solution, and incorporation of *Bifidobacteria Bb-12* on the texture and meltability of Mozzarella cheese from different treatments was investigated. The resultant cheese was analyzed when fresh and after one month of storage at $\simeq$ 5 °C for chemical, rheological and organoleptic quality. Mozzarella cheese stretched with brine had higher moisture than the traditional one. On the other hand, Mozzarella cheese made from UF retentate without using brine as stretching solution had lower moisture content than the control treatment. UF- buffalo Mozzarella cheese had total protein (TP) content higher than those of cow's treatments. Slight variations were observed in TP content of buffalo cheese. Soluble Nitrogen (SN) and SN/ Total Nitrogen (TN) increased in all treatments after storage period. Significant differences were recorded in SN for various treatments. UF-Mozzarella cheese had higher ash, Ca^{++} and P^{++} content than traditional one which increased during storage in all treatments. Stretching the curd in brine and using *bifidobacteria* lowered the calcium and phosphorus contents in the resultant cheese. Acidity development of UF-cow Mozzarella cheese was higher than all other treatments and increased during storage period in all treatments. Mozzarella cheese from UF-cow milk and standardized buffalo milk had the highest lactose content, which decreased after storage. UF-Mozzarella cheese had higher TVFA, tyrosine and tryptophan contents which, increased in all treatments after storage period. Using brine as stretching solution and adding *Bifidobacteria* increased the meltability of UF-buffalo milk cheese, and cheese stretched with 2 % brine solution had the highest meltability. Also, the texture was improved by stretching the curd in brine solution. UF-Mozzarella cheese showed high oiling off; particularly that made from cow milk. The oiling off increased in all treatments after storage. The sensory evaluation indicated that Mozzarella cheeses stretched with brine gained higher scores for flavour, body & texture, and appearance. The chemical composition of whey and stretching solution was discussed.

Key wards: Mozzarella cheese, UF-milk retentate, texture properties, buffalo milk

INTRODUCTION

Mozzarella is an Italian cheese made from water buffalo or cow milk, the second one is used for most types of pizza or served with sliced tomatoes and basil in Caprese. Low moisture Mozzarella cheese (45 – 52% moisture) (Egyptian legal standards, 2005) tends to have longer shelf-life. Therefore, it is more common and popular for making pizza. Mozzarella cheese can be made from both cow and buffalo milks and their UF- retentates. However, UF-Mozzarella cheese was characterized by some cheese texture defects; *e.g.* decreasing in meltability rate which affected the properties of Mozzarella cheese made from buffalo milk and its UF-concentrates. (El-Batawy, *et al.*, 2004).

The composition and physical characteristics of Mozzarella cheese are influenced by a number of variables, and the rate of acid production by lactic starter cultures is considered to be the most important one. *Bifidobacteria* exhibited a high β- galactosidase activity (Desjardins *et al.*, 1991). One of the requirements for effective growth of *Bifidobacteria* is maintenance of pH ≥ 5.5. Therefore, the high buffering capacity of UF-milk retentate would be beneficial for the growth and activity of *Bifidobacteria.* Also, the aroma and taste can be enhanced with the organic acids produced by *Bifidobacteria* spps especially acetic acid.

The aim of this work is to overcome texture and meltability defects with buffalo milk for Mozzarella cheese production by reducing the calcium content in the curd using a brine solution as a stretching water; and to develop some of the flavour compounds by incorporating *Bifidobacteria Bb-12* as an adjunct starter to produce Mozzarella cheese in order to improve the quality and flavour of the cheese.

MATERIALS AND METHODS

Materials:

Fresh Buffalo and cow milks were obtained from EL-Gemmeza Animal Production Research Station herd (Gharbiea Governorate), Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt. Starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*; in addition to *Bifidobacteria* coded Bb–12 (multiple strain cultures of *Bifidobacteria* species), Direct Vat Set (DVS), and animal rennet powder (HA-LA) was obtained from Chr. Hansen's Lab., Copenhagen, Denmark. Commercial grade fine salt was purchased from the local market, produced by El- Nasr Company, Alexandria, Egypt.

Methods:

Cheese Milk Concentration for Mozza-rella Cheese Making:

Raw buffalo and cow milks were standardized to ≃ 3 % fat, heated up to 50 °C and ultrafiltered to ≃ 20 % total solids, using Carbo- sep ultrafiltration unit (SFEC, France) surface area of 6.8 m^2 of inorganic (Zerconium Oxide) tubular membrane. The unit was operated using an inlet pressure of ≃ 5 bars and outlet pressure of ≃ 3 bars. The concen-tration factor (CF) was 1.75:1 according to that given by Fernandez and Kosikowski (1986 b)

Mozzarella Cheese Manufacture:

Mozzarella cheese was made as described by Kosikowski (1982). Six treatments were employed.

(T1) Traditional Mozzarella cheese was made from pasteurized standardized buffalo milk 3% fat (Control) using activated starter culture containing *Streptococcus. thermophilus* and *Lactobacillus delbreuckii* subsp. *bulgaricus* (1:1) at a ratio of 1.5 %.

(T2) UF- Mozzarella cheese made from cow milk retentate.

(T3) UF- Mozzarella cheese made from buffalo milk retentate.

The stretching conditions of T1 to T3 is a normal condition of Mozzarella cheese making as mentioned by Kosikowski (1982).

(T4) As treatment T3 with using 1% brine as a stretching solution .

(T5) As treatment T3 with using 2% brine as a stretching solution.

(T6) As treatment T3 with using 3% brine as a stretching solution.

All cheese treatments from T2 to T6 were manufactured using the activated yoghurt starter culture (1.5 %) + (0.75 %) *Bifidobacteria Bb-12*. Resultant cheese was stored at ≃ 5 °C and analysed when fresh and after one month for chemical, rheological and organo-leptic properties. Also, the whey and stret-ching water were analysed. The yield of the cheese was calculated.

Chemical Analysis:

Moisture contents of milk, UF-retentate, whey, permeate, stretching water, and cheese were determined according to the method described by AOAC (1990) and CODEX STANDARD (1978), and moisture on-a-fat-free basis (MFFB) was calculated. Fat and ash contents and titratable acidity of milk, UF retentate, RO retentate, whey, permeate, stretching water, and cheese were determined according to the method described by International Dairy Federation (IDF) (1991a) and AOAC (1990). pH value of milk, UF-retentate, whey, permeate, stretching solution, and cheese were measured using JENWAY Digital pH meter model 3310. Salt content (NaCl) of Mozzarella cheese was determined by the method described by BSI (1989). Calcium content of milk, UF–retentate, whey, permeate, and stretching water was determined as described by Francesco and Raffaello (1980), and calcium content of Mozzarella cheese was determined as described by Roadsveld and Klomp (1971). The total phosphorus contents of milk, UF-retentate, whey, permeate, stretching water were determined according to Snell and Snell (1949) and in cheese using the method of IDF (1987). The total nitrogen and non- protein nitrogen of milk, UF- retentate, RO retentate, stretching water, and cheese were determined according to IDF (1991b) while the soluble nitrogen of cheese was determined as described by Kosikowski (1982). Soluble tyrosine and tryptophan of cheese were determined according to the method of Vakaleris and Price (1959). The total volatile free fatty acids were determined by the distillation method of Kosikowski (1982). Lactose content of milk, UF- retentate, RO retentate, whey and permeate was calculated by deference.

Physical Properties of Mozzarella cheese:

The meltability of Mozzarella cheese was determined using the method described by Olson and Price (1958) modified by Rayan *et al.* (1980). The method described by Kindstedt and Fox (1991) was used to express the oiling off for the produced cheeses. The distribution of cheese milk constituents between permeate, whey, stretching water and cheese was calculated according to the method of Rao and Renner (1988).

Sensory Evaluation:

The organoleptic properties of the Mozzarella cheese were evaluated for: flavour out of 50 points, Body & texture out of 35 points, and Appearance out of 15 points

Textural Properties:

Hardness, cohesiveness, springniess, gumminess and chewiness of Mozzarella cheeses were measured using Instron Universal Testing Machine (Model 4302, Instron Corporation, Canton M.A) according to the procedure of Bourne (1978) using load cell of 100 N under the following conditions:

- Load range:	20 %
- Cross-head speed:	25 mm/min
- Chart recorder speed:	50 mm/min
- Cross-head speed: Chart recorder speed:	1:2
- Depth:	10 mm
- Test temperature	15 °C ± 1 °C.

Statistical Analysis:

The general liner models procedure of SAS was used to analyze the data. Analysis of variance was carried out according to the method described by Clarke and Kempson (1997). Trials of all the treatments were replicated for three times.

RESULTS AND DISCUSSION

Chemical composition of different types of Mozzarella cheese:

Data presented in Table (1) show that fresh UF- cows' Mozzarella cheese (T2) contained the highest moisture than other treatments. This may be due to the ability of cow milk casein to bind more water than buffalo milk casein which attributed to the characteristic of casein micelles and mineral salts of buffalo milk. This is in agreement with the results given by Abdel-Kader (1993) and Abd El-Gawad (1998).

After 1 month of refrigirated storage, there was a noticeable decrease in moisture content of all Mozzarella cheese samples, Using the brine as a stretching solution, increased the moisture content of cheese (T4, T5 and T6). In general, the moisture content of all fresh cheeses met the Egyptain Legal Standards (2005) for low moisture partialy skimmed Mozzarella cheese and agree with that of El-Batawy *et al.* (2004).

The changes in MFFB content among all treatments were highly significant ($P< 0.0001$) and it ranged from 54.97 to 61.36 % and this fall within semi hard cheeses (54-69%) in the classification scheme of the Codex Standards (1978) for cheeses.

From the results it could be observed that F/DM% increased after storage period ($P< 0.0001$). This may be due to the gradual loss of moisture during storage period (El-Zoghby, 1994 and Anis, 1979). The F/DM results are in accordance with the findings of Saleh, (1997) and El-Batawy *et al.* (2004). Also, F/DM of all treatments lie within the Egyptain Legal Standards (2005) for partialy skimmed (3/4 Fat) Mozzarella cheese.

The changes in salt content and salt–in–moisture (S/M %) of Mozzarella cheese cleared that the salt content increased after cheese storage in all treatments. There was a significant variation between treatments in salt content and S/M %. The results are within the range given by Nilson and LaClair (1976) who observed a wide range of salt content from 1.0 to 4.5 % in Mozzarella cheese. These variations can be attributed to the different methods of brining. This agree with Fernandez and Kosikowski (1986c).

Concerning the ash content, it can be seen that UF-buffalo cheese had the highest ash content when fresh, followed by treatments T6, T5, T4, T1 and T2, respectively, and increased significantly ($P < 0.0001$) after storage period. Such increase could be attributed to moisture loss during storage as a result of evaporation (Geurts *et al.*, 1980). These results agree with that of El-Batawy *et al.* (2004). Also, it was observed that ash content of Mozzarella cheese stretched in hot brine (treatments T4, T5 and T6) was lower than the control. This is in accordance with Fernandez and Kosikowski (1986a &b).

The results revealed significant differences ($P < 0.0001$) in lactose content between treatments either when fresh or after the storage period, as lactose was metabolized during storage by the starter bacteria, which differed among different treatments.

The total protein content was lower in UF-cow Mozzarella cheese than that in traditional and UF-buffalo cheeses ($P < 0.0001$) This is due to the high concentration of casein in buffalo milk. Similar results were obtained by El-Batawy *et al.* (2004). A significant ($P < 0.0001$) increase was observed in total protein of cheese from different treatments after 1 month of storage due to the decrease of the moisture content. These results confirmed that obtained by El-Batawy *et al.* (2004).

The changes of soluble nitrogen (SN) and SN/TN % of different treatments reflects the rate of proteolysis; generally it was significantly ($P < 0.0001$) increased after 1 month of storage. The results revealed that SN content and SN/TN % were higher in UF-Mozzarella cheese treatments than that of traditional one. The protein degradation in UF-Mozzarella cheese treatments was significantly ($P < 0.0001$) greater than in the traditional one, which may be due to the addition of the modified starter containing *Bifidobacteria*, which may be increase the proteolysis.

Calcium, and phosphorus contents:

It was clear that Mozzarella cheese made from cow or buffalo milk retentates had the highest Ca and P contents as they were retained with casein during ultrafiltration process (Glover, 1985; Shmidt and Both, 1987).

Concerning to the other treatments they had Ca and P contents less than the controls which may be attributed to the partial replacement of Ca with Na when brine was used as stretching solution in such treatments. Due to the decreases of cheese moisture Ca and P increased after 30 days of storage. The Ca and P contents of cheeses were significantly affected by replication, treatment and storage period ($P < 0.0001$).

Ripening indices:

The titratable acidity (Table 2) of traditional and all UF–Mozzarella cheeses increased significantly ($P < 0.0001$) after storage period, while the pH was decreased. This could be attributed to the activity of starter cultures which cause lactose fermentation and production of lactic acid during storage.

Wide significant ($P < 0.0001$) differences could be observed in the TVFA among all treatments. UF-Mozzarella cheese had higher content of TVFA than the traditional one which may be due to the difference in the used starter culture. The quantitative differences in volatile compounds were observed in the cheese harbouring *Bifidobacteria* most notably acitic acid (McBrearty *et al.*, 2001). The TVFA content of all cheeses significantly ($P < 0.0001$) increased during storage, which may be attributed to the growth of the starter culture. This agree with Hassan and Abdel-Kader, (2000) and Badawi *et al*, (2004 b).

It was obvious that soluble tyrosine and tryptophan contents were the lowest in traditional cheese. This may be attributed to the difference in the type of starter cultures used which, increased the protein hydrolysis and produced smaller molecules of amino acids. On the other hand, the soluble tyrosine and tryptophan increased by stretching the curd in brine (T4, T5 and T6).

It is clear that, tyrosine and tryptophan contents significantly ($P < 0.0001$) increased in all treatments after 1 mo. of storage period at $\simeq 5$ °C. These results are in line with those found by Hassan and Abdel-Kader (2000) and Badawi *et al.* (2004b). Concerning to tryptophan content no significant differences were found between T2 and T5; and T6.

Physical properties of Mozzarella cheese:

The differences in the physical and chemical properties between cow and buffalo milk such as higher Ca, P and ash contents in buffalo milk than cow milk; and the high concentration of salts in UF-retentate play an important role in the rheological properties of Mozzarella cheese (Amer *et al.*,1978). Table 3 indicates the meltability, fat leakage and oiling off for different Mozzarella cheese treatments.

Table (1): Chemical composition, nitrogen fractions, Ca, and P%, of Mozzarella cheese from different treatments.

Treatments		Moisture %	Moisture MFFB %	Fat/ DM%	T P %	S.N %	SN/ TN %	Ca %	% P	salt %	salt S/M %	Ash	Lactose %
T1	Fresh	45.88	58.08	38.80	27.58	0.152	3.52	0.759	0.732	1.22	2.66	2.95	2.59
T2		48.78	61.36	40.02	24.47	0.235	6.13	0.819	0.786	1.23	2.52	3.01	3.24
T3		45.03	56.78	37.66	27.75	0.164	3.77	0.854	0.828	1.27	2.82	3.21	3.31
T4		46.43	58.48	38.45	27.41	0.184	4.28	0.582	0.667	1.14	2.46	3.08	2.48
T5		46.58	58.59	38.37	27.39	0.228	5.31	0.568	0.653	1.17	2.51	3.12	2.41
T6		46.87	58.88	38.39	27.34	0.207	4.83	0.557	0.637	1.19	2.54	3.13	2.26
T1	30 days	43.94	56.12	38.71	30.08	0.271	5.75	0.779	0.745	1.37	3.12	3.31	0.97
T2		46.13	58.54	39.99	28.37	0.339	7.62	0.832	0.799	1.41	3.06	3.21	1.09
T3		43.15	54.97	37.82	30.55	0.278	5.80	0.877	0.839	1.41	3.27	3.54	1.26
T4		44.21	56.25	38.36	30.28	0.319	6.72	0.596	0.687	1.21	2.74	3.51	0.6
T5		44.36	56.37	38.28	30.29	0.345	7.27	0.581	0.669	1.24	2.80	3.53	0.52
T6		44.51	56.56	38.39	30.01	0.338	7.19	0.572	0.649	1.29	2.90	3.57	0.61
LSD for treatments		0.361	0.448	2.054	0.044	0.018	0.504	0.009	0.004	0.086	0.179	0.133	0.059
LSD for storage		0.209	0.259	1.187	0.025	0.011	0.291	0.006	0.003	0.049	1.103	0.077	0.035

Table (2): Ripening Indices of Mozzarella cheese from different treatments

Treatments		Titratable acidity	pH	TVFA *	Tyrosine (mg/100g cheese)	Tryptophan (mg/100g cheese)
T1	Fresh	0.74	5.20	5.67	4.19	3.03
T2		0.73	5.23	8.03	6.97	4.03
T3		0.65	5.32	6.27	5.72	3.62
T4		0.64	5.34	6.83	6.19	3.78
T5		0.62	5.43	7.77	7.28	4.01
T6		0.60	5.48	7.67	7.18	3.90
T1	30 days	0.95	5.11	14.40	38.49	31.04
T2		1.06	4.81	20.03	43.85	39.53
T3		0.99	5.05	15.73	40.65	33.77
T4		1.05	4.91	18.35	42.47	36.33
T5		[illegible].07	4.73	20.67	45.16	39.37
T6		[illegible]	4.96	20.18	44.51	38.80
LSD for treatments		[illegible]	0.068	1.477	1.939	2.777
LSD for storage		0.032	0.039	0.853	1.119	1.603

* ml NaOH 0.1 N / 100 g cheese.

Utilization of brine as a stretching solution improved the melting properties of the resultant cheeses This may be due to the low Ca and P contents of these cheeses through the mineral exchange between Ca and Na and solubilization of calcium phosphate during stretching. This conclusion conform those reported by Anis and Ladkani (1988) and Kindstedt (1993), who reported that as curd Ca and P levels decreased, meltability increased and the cheese was visibly softer (Metzger *et al.* 2001a). Moreover, using *Bifidobacteria* as an adjunct starter may contribute to ripening espicially in the formation of low molecular mass peptides. This can explain the significant increase of meltability of T4, T5 and T6 than the controls (T1 and T3).

Meltability of cheese made from cow milk retentate was higher than that of buffalo milk retentate. This confirmed the results of Ghosh and Singh, (1991) and El-Batawy *et al*., (2004a). It was clear that the meltability of traditional and UF-Mozzarella cheese significantly ($P < 0.0001$) increased after the storage period.

The increase in meltability of Mozzarella cheese during storage are thought to be due to proteolysis of casein during storage changing the moisture and protein status within the cheese structure. A dramatic increase in moisture holding capacity occurs during aging, concomitantly moisture migrates from the fat-serum channel into the protein matrix, thus the protein becomes more hydrated and results in an increase of meltability. These results coincide with those reported by Oberg *et al* (1992), Abd El- Rafee *et al.* (1998), Roweny *et al.* (1999) and Abd El-Hamid *et al.* (2001).

Excessive fat leakage and oiling off are considered to be serious defects that detracts from melted Mozzarella cheese appearance on pizza and related foods. Obtained data indicated that Mozzarella cheese made from UF-cow milk retentate showed the highest fat leakage and oiling off in fresh and after 1 mo. storage, These results could be ascribed to low protein content of cow milk leading to high F/DM in cheese, and more fat that can be released during melting. This agree with Kindstedt, (1993) and Abd El-Gawad, (1998). Also, Dalgleish (1981) reported that less casein incorporated into the cheese matrix, resulted in less fat entrapment. The fat in Mozzarella cheese coalesces during melting into pools that flow as the protein matrix collapses, consequently, high fat Mozzarella cheese produced more free oil (McMahon *et al.*, 1993).

Fat leakage and oiling off was decreased in cheese stretched in brine and the lowest figures was for that stretched with 2 % brine. From the results it is obvious that fat leakage and oiling off for traditional and UF-Mozzarella cheeses increased after storage. This increase may be partly related to the increased meltability and to the changes in the polymorphic structure of milk fat in Mozzarella cheese during storage, (Rowney *et al.*, 1998a). The results are in accordance with those reported by Kindstedt and Fox (1991) and El-Batawy *et al.* (2004).

Statistical analysis showed significant differences in meltability and oiling off between cheese samples affected by treatments, and storage period (P < 0.0001).

Textural Properties:

1-Hardness, Springiness and Cohesiveness:

Hardness is described to the panelist as the force required to penetrate the sample with the molar teeth (from soft to firm) (Lee *et al.*, 1978). From the obtained results (Table 4) storage of cheese increased significantly (P < 0.0001) the hardness of cheese for all treatments. Also, manufacture of cheese from UF-milk retentate caused high significant (P < 0.0001) increase in the cheese hardness. Hardness of cheese increased in treatments with high protein content. Moisture reduction resulted in a firmer texture due to alterations in the casein matrix. Also, lower moisture content in cheese, lower the level of proteolysis developing coarser and the stronger protein network which increase cheese hardness. After 1 month of storage the hardness of cheese increased .

Table (3): Some physical properties of Mozzarella cheese from different treatments.

Treatments		Meltability		Fat Leakage /cm^2	Oiling off %
		(tube mm)	(disc cm^2)		
T1	Fresh	11.78	41.00	43.60	3.36
T2		17.21	49.67	54.42	4.51
T3		11.60	38.00	49.01	3.59
T4		12.91	40.00	48.82	3.59
T5		15.91	44.93	44.19	3.55
T6		15.41	43.80	45.57	3.62
T1	30 days	32.88	126.3	89.70	4.56
T2		42.00	138.4	114.01	5.68
T3		34.29	100.0	113.87	4.82
T4		36.51	103.8	92.59	4.75
T5		42.46	134.3	89.92	4.74
T6		41.11	125.0	89.93	4.74
LSD for treatments		3.148	7.263	4.473	0.259
LSD for storage		1.818	4.193	2.583	0.149

The significant (P < 0.0001) differences in hardness of different Mozzarella cheese treatments can be attributed to the diffences in their composition. The results clear that UF-cow milk cheese recorded the lowest hardness as it had the highest moisture and lowest protein content. Also, UF-buffalo milk cheese was firmer than traditional cheese as it was lower in moisture and higher in protein content. Stretching the curd in brine lowered significantly (P < 0.0001) the Ca and increased the moisture contents of cheese,which may explain the hardness decrease for such treatments. The results are in accordance with El-Batawy *et al.* (2004)

Springiness is described to the panelists as bouncing property of the sample through several consicutive bites (from plastic to elastic). The obtained values of this property (Table 4) for fresh Mozzarella cheese from different treatments ranged from 10.50 to 13mm and reached to be from 10.75 to 14.75mm after 30 days of storage. Springiness took the same trend of hardness being higher in buffalo cheese than cow cheese. Also, it was reduced by stretching the curd in brine. Analysis of variance showed significant differences in springness of all Mozzarella cheese treatments ($P < 0.0001$). The results agree with those given by El-Batawy *et al.* (2004).

Cohesiveness known as the degree to which the cheese samples deforms before rupturing, therefore, cohesiveness value is a direct function of the work needed to overcome the internal bonds of the material. The data (Table 5) indicate non- significant differences in cohesiveness values between the treatments. This suggested that this property was not greatly affected by different treatments during cheese manufacture. However, there was a slight but non-significant increase in cohesiveness after the storage period. These results are in line with that of El-Batawy *et al.* (2004).

Gumminess and Chewiness:

Gumminess is expressed as the product of hardness and cohesiveness. It can be seen from the obtained data (Table 4) that the average gumminess of fresh Mozzarella cheeses were low and increased after 1 month of storage. Mozzarella cheese made from buffalo milk retentate (T3) showed the highest gumminess followed by the traditional one and the lowest for that made from cows' retentate (T2). Stretching the curd in brine decreased the gumminess. The results are in line with those given by El-Batawy *et al* (2004).

Chewiness is described to be the number of chews required to swallow a certain amount of sample (from tender to tough). Also, it can be measured by the time required to masticate the cheese sample at a constant rate of force application to reduce it to a consistencey suitable for swallowing. This property expressed mathematically as the product of gumminess & springiness. Therefore, it took the same trend of these properties. The differences for treatments and storage was highly significant in both properties.

In a conclusion, the use of brine as a stretching solution decrased Ca, and P contents of Mozzarella cheese which afected its textural properties as Ca plays an integral role in cheese texture. Lucey and Fox (1993), Cheng *et al.* (1997) and Metzger *et al.* (2001b) stated that, Ca and P promote cheese regidity as they are responsible for cross-linkages formation within the casein network. Cheese with a high mineral content will have a more completely cross-linked structure and be more riged.

Chemical composition of Mozzarella cheese whey:

The total solids content (Table 5) of whey from UF-cheeses contained more total solids than that from milk. These data agree with Fernandez and Kosikowski (1986b) and Lucey *et al.* (2005). Also the total solids of whey from UF-buffalo milk cheese was higher than that from UF-cow milk cheese. Similar results were obtained by Abd El-Gawad (1998) and Green, *et al.*, (1981). The fat content of whey from UF-cheeses was higher than that from traditional control cheese. This was probably due to the excessive recirculation needed in the UF-system used, which could have damaged some fat globules (Lucey *et al.*, 2005). Also, concentrated UF-retentates have relatively less casein directly involved in curd formation and incorporated into the curd matrix, resulting in less fat entrapment (Dalgleish, 1981). Green *et al.* (1981) observed a reduction in the degree of aggregation of the casein micelles proportional to retentate concentration. High fat losses observed from retentates may result from difficulties encountered in stirring concentrated retentates, leading to curd abrasion and subsequent release of fat globules (Bush *et al.*,1983). The total protein of whey obtained from the UF-retentate cheese was higher in total protein content than that obtained from control cheese. Also, total protein was higher in buffalo UF-cheese whey than that of cow UF-cheese whey. The ash content in the whey of all treatments took the same trend of total protein as well as Ca and P contents. These results were in accordance with those reported by Fernandez and Kosikowski (1986 a,b &c), Abd El-Gawad (1998).

Chemical composition of Mozzarella cheese stretching solution:

A high total solids (Table 5) content in stretching solution was observed for (T4, T5 and T6) which may be attributed to increase of ash content in these treatments. With regard to fat content (Table 5) it was reported (Fernandez& Kosikowsk,1986a) that stretching and molding the curd in hot water caused higher fat losses than in hot brine solution. This agree with the present results as fat content of stretching solution in treatments T5 and T6 was lower than T3.

On the other hand, stretching solution of UF-Mozzarella cheese treatments had a higher protein content than that of the traditional Mozzarella cheese (Table 5). Fernandez and Kosikowski (1986 a&b) reported that total protein lost in hot brine was not significantly different from that lost in hot water.

Table (4): Textural properties of Mozzarella cheese from different treatments.

Treatments		Hardness (N)	Springiness (mm)	Cohesiveness (cm)	Gumminess (N)	Chewiness (n-mm)
T1	Fresh	8.24	13.0	0.438	3.61	46.92
T2		4.75	10.50	0.550	2.61	27.49
T3		9.01	12.75	0.464	4.17	53.13
T4		7.91	12.0	0.442	3.45	41.47
T5		7.37	11.5	0.437	3.22	37.03
T6		7.20	11.5	0.426	3.07	35.33
T1	30 days	9.59	14.75	0.458	4.39	64.74
T2		5.13	11.75	0.580	2.98	34.72
T3		13.44	13.25	0.496	6.67	88.30
T4		10.36	12.5	0.452	4.69	58.82
T5		9.84	11.25	0.443	4.36	49.09
T6		9.42	10.75	0.430	4.05	43.59
LSD for treatments		0.642	0.733	0.021	0.353	0.362
LSD for storage		0.371	0.423	0.012	0.204	2.519

N: Newton mm: millimeter n-mm: Newton - millimeter

Table (5): Chemical composition and pH values of different Mozzarella cheese whey and Stretching water

Constituents	T1		T2		T3		T4		T5		T6	
	Whey	Stw*	Whey	Stw	Whey	Stw	Whey	Stw	Whey	Stw	Whey	Stw
Total solids %	5.74	4.29	6.15	4.44	6.25	4.44	6.25	5.32	6.25	6.34	6.25	7.45
Fat %	0.3	0.30	0.4	0.40	0.4	0.40	0.4	0.40	0.4	0.30	0.4	0.30
Ash %	0.55	3.76	0.63	3.87	0.72	3.88	0.72	4.76	0.72	5.81	0.72	6.89
Total protein %	0.49	0.089	0.55	0.102	0.67	0.115	0.67	0.102	0.67	0.108	0.67	0.115
Calcium %	0.049	0.097	0.052	0.099	0.056	0.108	0.056	0.123	0.056	0.131	0.056	0.139
Phosphorus %	0.036	0.073	0.041	0.077	0.045	0.080	0.045	0.092	0.045	0.098	0.045	0.108
Titratable acidity %	0.33	0.12	0.30	0.14	0.29	0.14	0.29	0.13	0.29	0.12	0.29	0.13
pH value	4.54	5.32	4.60	5.19	4.65	5.17	4.65	5.21	4.65	5.29	4.65	5.26

* Stretching water

Due to the increase of Ca and P contents of T4, T5 and T6 its stretching solution had high ash content than the other treatments..

Cheese yield:

Table (6) shows the yield of fresh Mozzarella cheese treatments, and percentage of increase compared with the traditional Mozzarella cheese. This accounts an increase of 0.7, 16.52, 17.81, 18.65 and 19.0 % for T1 to T6 in sequance. This increase is due to the greatest transfer rate of total solids, total protein and fat content beside the higher moisture in T4, T5 and T6 treatments.

Furthermore, the yield of Mozzarella cheese made from buffaloes' retentate was higher than that made from cows' retentate. These results are in agreement with those reported by Kosikowski (1982), Ghosh (1987) and Abd El-Gawad (1998).

Table (6): Yields and increase rate of yield for Mozzarella cheese from different treatments

Treatments	Yield %	Increase rate of yield %
Control standardized buffaloes' milk	13.49	---
UF- cows' retentate	13.58	0.70
UF-buffaloes' retentate	15.72	16.52
UF-buffaloes' retentate stretched in 1 % brine solution	15.90	17.81
UF-buffaloes' retentate stretched in 2 % brine solution	16.01	18.65
UF-buffaloes' retentate stretched in 3 % brine solution	16.06	19.00

Sensory properties:

Sensory properties of Mozzarella cheese samples were examined when fresh and after storage period up to 30 days (Table 7). The flavour of buffalo traditional Mozzarella cheese recorded the lowest scores. Moreover, the flavour of cow UF-cheese gained higher scores than buffalo UF cheese. This agree with El-Batawy *et al.* (2004). These results are also in accordance with McBrearty *et al.* (2001) who stated that during early ripening (even during manufacture) more extensive proteolysis and improved flavour were observed in the *Bifidobacteria* cheese compared with control cheese and quantitative differences in volatile compounds were observed in the cheeses harbouring *Bifidobacteria,* mostly acetic acid.

With regard to body and texture of Mozzarella cheese, it tended to be improved significantly ($P < 0.0001$) with increasing the storage period of Mozzarella cheese. Mozzarella cheese made from UF–cow's got higher scores than UF-buffaloes' cheese either when fresh or after storage. This may be due to that cows' casein is higher in breakdown than that of buffaloes. These results were in accordance with El-Batawy *et al.* (2004).

It was obvious from the data that using brine solution during stretching of cheese improved body and texture of the cheese (T4, T5 and T6) as it removes some calcium and phosphorus, increased the moisture and dec-reased the salt content which activate proteolysis of the starter culture activity. More starter culture activity cause more proteolysis and improve the body and texture of the cheese. Also, it enhanced the cheese stretchability, and meltability.

The appearance score of the cheeses slightly decreased non- significantly ($P < 0.0001$) after the storage period at $\simeq 5$ °C. This may be due to a slight loss of water and shrinkage of the cheese, these results are in line with the findings of El-Batawy *et al.* (2004). From The total score the best cheese was T5 which stretched in 2 % brine as it gained 93.0 and 94.8 in fresh and stored, respectively.

From such a study it could be concluded that mozzaralla cheese can be made successfully from buffaloes retentate) and improved by stretching the curd in a brine solution especially that stretched in 2% brine solution.

Table (7): Sensory evaluation scores of Mozzarella cheese from different treatments.

Treatments		Flavour (50)	Body & Texture (35)	Appearance (15)	Total (100)
T1	Fresh	40.00	32.00	14.5	86.5
T2		44.00	33.00	15.0	92.0
T3		41.00	31.00	14.0	86.0
T4		42.00	32.00	14.5	88.5
T5		45.00	33.00	15.0	93.0
T6		42.00	32.00	14.5	88.5
T1	30 days	43.00	32.70	14.0	89.7
T2		47.00	33.30	14.5	94.8
T3		44.00	32.00	13.5	89.5
T4		44.00	33.00	14.0	91.0
T5		47.00	34.70	14.5	96.2
T6		45.00	34.00	14.0	93.0
LSD for treatments			0.924	0.801	2.444
LSD for storage			0.534	0.462	1.411

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تحسين خواص الجبن الموزاريلا المصنع من مركز اللبن الجاموسى بالترشيح الدقيق

أجريت هذه الدراسة للتغلب على بعض المشاكل التي تظهر في الجبن الموزاريلا المصنع من مركز اللبن الجاموسى وفيها تمت محاولة خفض نسبة الكالسيوم بالعجن في محلول ملحي (١، ٢، ٣%) واضافة بكتيريا *Bifidobacteria Bb- 12* مع البادئ المستخدم في الجبن لتسهل من عملية العجن في وقت كافي وكذلك لتحسين نكهة الجبن والنتائج المتحصل عليها فى هذا البحث يمكن تلخيصها فى النقاط التالية:

- معاملات الجبن الموزاريلا الناتج باستخدام الترشيح الفائق والمستخدم معها محلول ملحى لعملية العجن احتوت على نسبة من الرطوبة أقل عما فى جبن المقارنة .ومن ناحية أخرى فإن الجبن الناتج من استخدام الترشيح الفائق والمستخدم معها محلول ملحي لعملية العجن كان محتواها من الرطوبة أعلي من جبن المقارنة ولكنها تتفق مع المواصفات القياسية المصرية لجبن الموزاريلا المنخفض الرطوبة. احتوى جبن المقارنة على أعلى نسبة للدهن عن باقي المعاملات والتي كانت متقاربة في محتواها من الدهن وزادت نسبة الدهن بعد فترة التخزين، بالنسبة للدهن/المادة الجافة فقد تباينت النتائج بين المعاملات سواء في الجبن الطازج أو بعد فترة التخزين.

* احتوى جبن الموزاريلا الناتج من اللبن البقرى المركز بالترشيح الفائق على أقل نسبة من المواد النيتروجينية الكلية وزادت هذه النسبة بعد التخزين كما احتوت هذه المعاملة على أعلى نسبة من النيتروجين الذائب وقد تزايد هذا المحتوى أيضا من النيتروجين الذائب بعد التخزين فى كل المعاملات.
• احتوت جبن الـ U.F من اللبن الجاموسي علي نسبه من البروتين الكلى اعلي عن مثيلتها من الـ U.F البقري وكذلك المصنعة من اللبن .وقد زادت نسبة البروتين الكلى وكذلك النيتروجين الذائب اثناء التخزين وكان هناك فروق واضحة في نسبة النيتروجين الذائب فى الجبن .جبن الـــ U.Fكانت تحتوىعلى نسبة عالية من الكالسيوم والفوسفور عن المصنعة من اللبن .وقد لوحظ ان عجن الخثرة في محلول ملحى خفض.نسبة الكالسيوم والفوسفور فى الجبن كانت.نسبة الحموضة اعلي فى الجبن المصنع من البقرى عن الجاموسي وقد زادت الحموضة اثناء التخزين في جميع المعاملات .احتوي الجبن المصنع من الــU.F البقري والمصنع من اللبن الجاموسي علي نسب أعلي من الأحماض الطيارة والتيروزين والتربتوفان عن المصنعة من اللبن وكانت مرتفعة فىالجبن المعجون في محلول ملحي والمضاف اليه الــ *Bifidobacteria* فى جميع المعاملات زادت هذة الارقام بالتخزين.
• عجن الخثرة في محلول ملحى حسن كثيرا من الخواص الريولوجية والقوام وخاصة بعد التخزين كما حسن كثيرا من الخواص الحسية للجبن وكانت افضل المعاملات هو الجبن الذى تم فية عجن الخثرة فى محلول ماحى ٢% مع اضافة الــ *Bifidobacteria* وقد تمت مناقشة التركيب الكيميائي للشرش وماء العجن .