MENOUFIA JOURNAL OF
FOOD AND DAIRY SCIENCES

https://mjfds.journals.ekb.eg

EVALUATION OF MOZZARELLA CHEESE QUALITY MADE FROM DIFFERENT MILK TYPES AND STORED AT DIFFERENT TEMPERATURES

Kebary, K.M.K.[(1)]; Hussein, S.A.[(1)]; Badawi, R.M. .[(1)]; Hatem, H.E.A.[(2)]; Eid, Mai H.M.[(1)*] and Elham A.M. El-Den

[(1)] Department of Dairy Sci. and Techno., Faculty of Agriculture, Menoufia University, Shibin El-Kom, Egypt.

[(2)] Head Researcher, Animal Production Research Institute, Dokki – Giza

Received: Apr. 16, 2025 Accepted: Apr. 26, 2025

ABSTRACT: The quality of mozzarella cheese was assessed based on storage temperature and milk type. Two batches of mozzarella cheese were produced using 3% fat cow's milk (C_1); one was stored at 5±1 °C, while the other was stored at -18±2 °C (C_2). Another 5 batches were made from 3.0% fat buffalo's milk, one was stored at 5±1 °C (B_1) and the second was stored at -18±2 °C (B_2). The remaining three batches were maintained at 5±1 °C for 7, 14, and 21 days, respectively, before being stored at -18±2 °C for 120 days (T_1, T_2, and T_3). Acidity, fat, total protein and ash content, meltability, stretchability, oiling off, and texture parameter (Hardness, Adhesiveness, Cohesiveness, Springiness, Gumminess, Chewiness, and Modulus) increased throughout the storage period, while moisture content decreased. The effect of storage at 5±1 °C was more evident than stored at -18±2 °C. Mozzarella cheese made from cow's milk contained lower total protein and ash content and higher moisture, meltability, and stretchability than cheese treatments made from buffalo's milk. Total scores of organoleptic properties increased as the storage period proceeded and reached their maximum at the 14th day, then declined slightly for cheese treatments stored at 5±1 °C. At the same time, total scores for cheese treatments stored at -18±2 °C reached their maximum at the 90th day of storage, then decreased until the end of storage. The most acceptable cheese was treatment 2, which was made from buffalo's milk, which was stored at 5±1 °C for 14 days, then stored at -18±2 °C for 120 days.

Keywords: Mozzarella cheese, cow's milk, buffalo's milk, meltability, stretchability, texture parameters.

INTRODUCTION

Mozzarella cheese belongs to the pasta filata group. It was initially made from buffalo's milk in the Battipaglia region of Italy (Citro, 1981). Now it is made in many countries from cow's milk. Mozzarella cheese is soft, white, unripened, with a shiny surface, and it possesses special properties such as meltability and stretchability.

The global popularity of mozzarella cheese, including in Egypt, has recently surged, resulting in increased production and consumption. The demand for mozzarella cheese is significantly rising due to the increased global consumption of pizza and other food items. Mozzarella cheese is one of the most popular cheese varieties worldwide because of its primary use as a pizza topping. Its usage is growing as the global demand for pizza and other foods that use mozzarella. Mozzarella cheese belongs to the category of stretched or pasta filata cheese. Curd stretching is a process employed in the production of mozzarella cheese (Kosikowski, 1982; Fox *et al.,* 2000). Mozzarella cheese has a unique property called stretchability. It allows it to form fibers or strings when hot, depending on its pH and the proportion of colloidal calcium phosphate removed (Ghosh and Singh, 1996 b). The worldwide market for Mozzarella cheese is expected to grow at a CAGR of roughly 5.3% over the next five years (Adroit Market Research ©2019 and Research and Markets).

Moreover, the instability of some physical properties, such as melting capacity and

*Corresponding author: maieid880@yahoo.com

stretchability, and the seasonality of milk production have led large-scale consumers and producers to freeze the cheese for storage (Alvarez, 1986; Pilcher and Kindstdt, 1990). The low temperatures suspend or reduce biochemical modifications during freezing storage.

As Mozzarella cheese is considered to have a short storage life, a freezing scheme was designed to study its effect on the functional properties and shelf-life of the resultant cheese. The freezing schemes for the above experimental EPS and non-EPS cheeses were as follows: a) Cheese ripening for 14 days at 4 ºC before freezing at -20 ºC for 60 days, then again ripening at 4 ºC for 14 days, and b) Cheese freezing immediately after manufacturing at -20ºC for 60 days, then ripening at 4 ºC for 28 days.

Few studies have been conducted to investigate the effects of freezing and thawing conditions on Mozzarella cheese. In studies conducted with Mozzarella, immediately after thawing, the cheese showed high fat leakage, low cohesiveness, free-surface moisture, bleached discoloration, and poor melting (Dahlstrom, 1978). All these alterations were reverted after three wk. of refrigerated storage at 4.4 ºC. Tunick *et al.* (1991) froze Mozzarella cheese at –20 ºC for 8 weeks. After thawing, they tempered the cheese at 4ºC for 3 weeks. They observed a greater melting capacity than that of the nonfrozen control. Bertola *et al.* (1996) reported that frozen Mozzarella produced with a thermophilic starter and tempered for 14 to 21 days at –20 ºC showed the same quality as refrigerated cheese.

The objectives of this study were to evaluate the best storage conditions to improve the quality of buffalo's milk mozzarella cheese, study the effect of milk type on cheese quality, and monitor changes in cheese quality during storage.

MATERIALS AND METHODS

Materials

Fresh cow's and buffalo's milk were sourced from a private farm in Quoter, Al-Gharbia Governorate, Egypt. Both milk samples were standardized to contain 3.0% fat. The yoghurt starter culture, comprising Streptococcus thermophilus and Lactobacillus bulgaricus, was sourced from Cairo Mircen, Ain Shams University, Egypt. Rennet was derived from calf sources. Dry coarse commercial sodium chloride was obtained from El-Nasr Salines Company, Egypt.

Manufacture of Mozzarella cheese

Mozzarella cheese treatments were made according to the method described by Kosikowski (1982). With some modification (Figure 1). After standardizing the fat content to 3%, milk was heated to 65 °C for 30 min, then cooled to 37 °C, and then yoghurt starters and $CaCl_2$ were added to the milk at the rate of 1.0 % and 0.02% respectively. Rennet was added at the rate of 1 g/20 kg of milk. The curd was cut into cubes using American knives, the whey was drained when its pH reached 5.5, and the curds were gently collected and kept in the warm cheese vat (38±2°C) until the curd pH reached 5.2. The string test gives a rope of 3 meters. At this stage, the curd block was diced into small fragments, heated to 80–85 °C, and adequately blended for approximately 5–10 minutes. Utilizing a wooden paddle until a homogeneous plastic mass is achieved and molded into blocks. The cheese is salted in a 5% cold brine solution for 24 hours. The cheese blocks were extracted from the brine, dried on muslin, and packaged in polyethylene bags. The resultant cheese was analyzed fresh and during storage at 5±1 °C and -18±2 °C for chemical, rheological, and sensory evaluation. The whole experiments were duplicated.

Methods of analysis

Chemical analysis

Moisture, ash, and total protein content were determined according to A.O.A.C. (2012). For fat determined by the original Gerber's method according to A.O.A.C. (2010). The estimation of Titratable acidity (TA) was determined and expressed as lactic acid percent according to Ling (2008).

Rheological properties

The meltability (mm) of cheese was measured in duplicate using the melting test tube as described by Olson and Price (1958), which was modified by Rayan *et al*. (1980). Sabikhi and

Kanawjia (1992) evaluated the mozzarella cheese's stretchability test (cm).

Oiling-off (ratio): Ghosh and Singh's (1992) method was used to determine the oiling-off percentage (fat leakage).

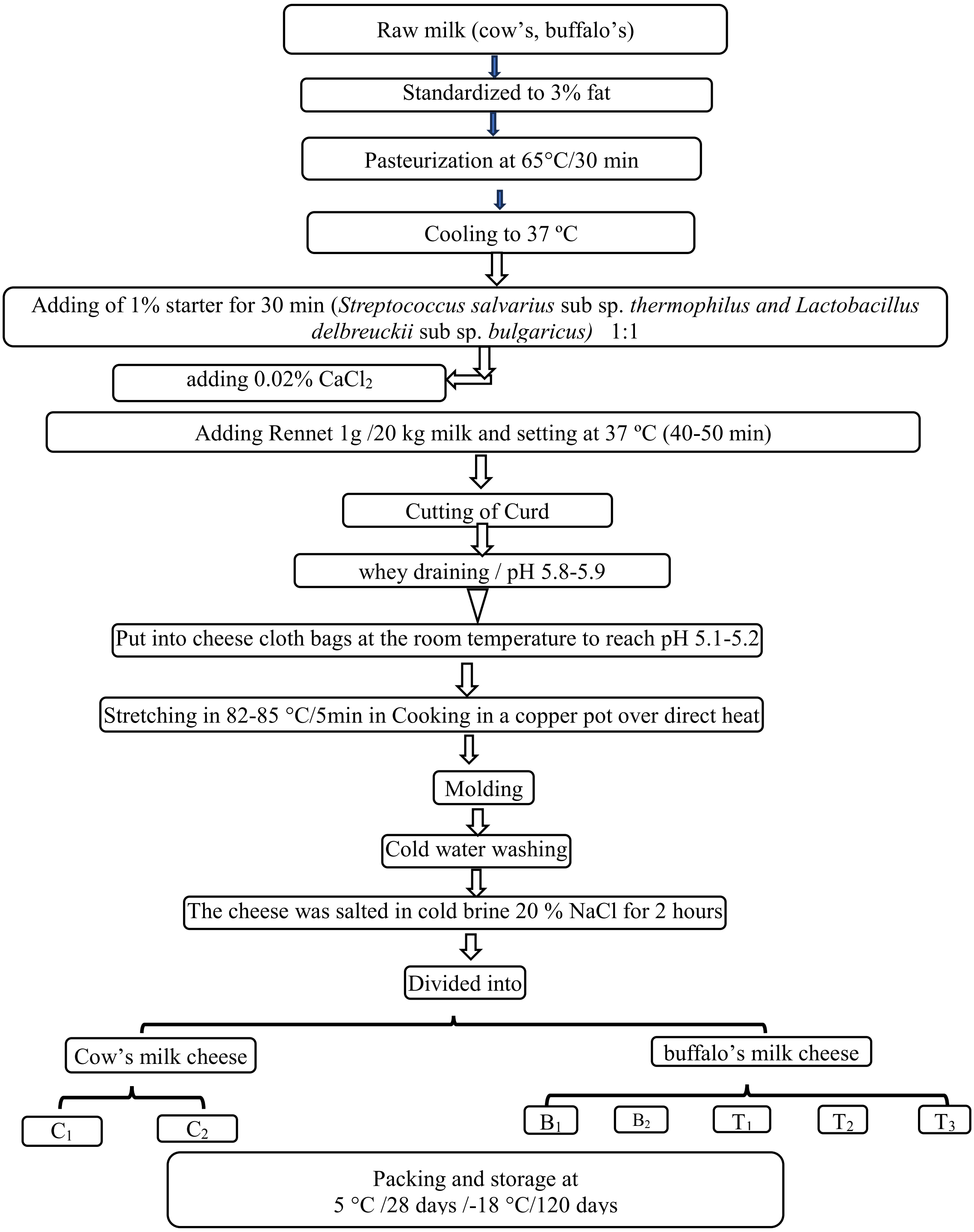

Figure 1: Flow sheet of Mozzarella cheese manufacture.

Texture profile analysis (TPA)

The texture properties of Mozzarella cheese samples were evaluated using texture profile analyzer, using a universal Testing Machine (MS-Pro), Food Technology Corporation, Sterling, Verginia, USA Cheese samples equipped with 1000 N (250 1b) load cell and connected to a computer programmed with Texture Pro^{TM} texture analysis software (program, DEV TPA with holding time between cycle two second). A flat rod probe (49.95 mm in diameter) uniaxially compresses the Mozzarella cheese samples with the following parameters: conduction to 50% of their original height was taken from cheeses, when fresh and after 14 days and 28 days of storage, and measured immediately. Cheese samples were cut into cubes 2x2x2 cm and kept at 25°C for 1 h before analysis. Cheese samples were tested at the following conditions: Speed of 1.95 mm/s, trigger force 2.25 lb., deformation 50%, holding time between cycles 2 sec, and temperature testing at room 25±2 °C. Each sample was subjected to two subsequent cycles (bites) of compression-decompression.

Data were collected on a computer, and the texture profile parameters were calculated from the TMS-Pro texture analyzer and computer interface. The Calculation described by Szczesniak *et al*. (1963) and Bourne 1978) was used to obtain the following texture profile parameters.

Organoleptic properties

Ten panelists from the staff and graduate students at the Department of Dairy Science and Technology and the Department of Food Science and Technology, Faculty of Agriculture, Menoufia University assessed the organoleptic properties of Labneh treatments, according to the scoring sheet described by Salem *et al*. (2007), for flavor (60 points), body and texture (30 points), and appearance (10 points).

Statistical analysis

Data were analyzed using a 2 × 3 factorial design. Newman-Keuls' Test was used to make the multiple comparisons (Steel and Torrie, 1980) using the CoStat Software program, Version 6.4 (2008). Significant differences were determined at $P \leq 0.05$.

RESULTS AND DISCUSSIONS

Table 1 shows the changes in Titratable acidity of all cheeses during storage. Titratable acidity of fresh mozzarella cheese made from cow's milk (C_1) and buffalo's milk (B_1) were 0.69 and 0.48% respectively, while the corresponding values at 28 days were 1.64 and 1.44% in the same order (Table 1). These results revealed that the titratable acidity of mozzarella cheese treatment increased pronouncedly ($p \leq 0.05$) as the storage period proceeded. The results agree with those found by Ghosh and Singh (1992), Abd El-Hamid *et al.* (2001), and Awad (2008). On the other hand, cheese treatment made from cow's milk had higher titratable acidity than mozzarella cheese made from buffalo's milk. Similar trends were reported by El-Abbassy *et al.* (1991), and El-Zoughby (1994) found that the acidity of buffalo's milk cheese was less than that of cow's and goat's milk cheese. The acidity of such cheese during storage was slower than that of cow's and goat's milk cheese. These results might be because buffalo's milk cheese has a higher buffering capacity than cow's milk (Abdel-Kader 1993).

It is evident that mozzarella cheese treatments stored at -18±2 °C contained lower acidity than those of mozzarella cheese treatments stored at 5±1 °C, which might be due to the differences in microbial growth, metabolic activity, and ability to ferment lactose into lactic acid. The results indicated that mozzarella cheese treatments made from cow's milk (C_2) contained higher acidity than those made from buffalo's milk (B_2) (Table 1). These results are based on those of El-Zoughby (1994), who found that the acidity of buffalo's milk cheese was less than that of cow's and goat's milk cheese, and also the development of acidity of such cheese during storage was slower than that of cow's and goat's milk cheese. The results could be because buffalo's milk cheese possesses a higher buffering capacity than cow's milk (Abdel-Kader 1993).

Mozzarella cheese treatments T_3 that stored at 5±1 °C for the most extended storage period (21 days) then stored at -18±2 °C for 120 days had the highest titratable acidity followed by cheese treatment T_2, T_1 those stored at 5±1 °C for 14 and 7 days respectively, while cheese treatment B_2 that stored directly at -18±2 °C for 120 days had the lowest acidity (Table 1). These results could be attributed to the higher microbial growth and higher ability to ferment lactose to lactic acid during storage at 5±1 °C than during storage at -18±2 °C.

Table 1: Effect of storage temperature on Titratable acidity (%) content of Mozzarella cheese.

Mozzarella Treatments*	**Storage period (days) at 5±1 °C**					**Means****
	Fresh	7	14	21	28	
C_1	0.69	0.91	1.20	1.43	1.64	1.174^a
B_1	0.48	0.97	0.95	1.21	1.44	1.01^b
Means**	0.585^e	0.94^d	1.075^c	1.32^b	1.54^a	
Mozzarella Treatments*	**Storage period (days) at -18±2 °C**					Means**
	Fresh	30	60	90	120	
C_2	0.69	0.81	0.86	0.92	1.02	0.86^d
B_2	0.48	0.59	0.71	0.79	0.92	0.698^e
T_1	0.79	0.84	0.91	0.98	1.18	0.94^c
T_2	0.95	1.03	1.12	1.18	1.32	1.12^b
T_3	1.21	1.33	1.41	1.48	1.57	1.4^a
Mean**	0.824^e	0.92^d	1.002^c	1.07^b	1.202^a	

C_1*: Control cheese from cow's milk storage at 5±1 °C
B_1*: Control cheese from buffalo's milk storage at 5±1 °C
C_2: Control cheese from cow's milk storage at -18 °C
B_2: Control cheese from buffalo's milk storage at -18 °C
T_1: Mozzarella cheese from buffalo's storage at 5 °C for 7 days and then 90 days at -18 °C
T_2: Mozzarella cheese from buffalo's storage at 5 °C for 14 days and then 90 days at -18 °C
T_3: Mozzarella cheese from buffalo's storage at 5 °C for 21 days and then 90 days at -18 °C
● For each effect, the letters in the same row mean the multiple comparisons are different; letter A is the highest mean, followed by B, C, etc.
* Significant at 0.05 level ($p \leq 0.05$)

Moisture content

Moisture content of all cheese treatments decreased significantly ($P \leq 0.05$) throughout the storage period. Table (2) Similar trends were reported by Ghosh and Singh (1992), who reported that cheese weight loss during storage was due to the loss of its moisture content due to curd contraction and water expulsion. Similarly, O'Connor (1994) added that cheese loses its moisture during storage if not adequately wrapped, thus reducing its yield. These results might be due to acidity, which enhances the curd contraction and expels whey (Ghosh and Singh, 1992).

Mozzarella cheese treatments C_1 and C_2, made from cow's milk, contained higher moisture content than corresponding cheese treatments B_1 and B_2, which were made from buffalo's milk. (Table 2). Similar trends were reported by Helal (2006), Razig (2000), El-Sheikh (1997), Sameen *et al*. (2010), Zedan *et al*. (2014), and Bhat *et al.* (2022). These results might be due to the higher total solids content of buffalo's milk than that of cow's milk (Ahmed *et al*., 2008 and Sameen *et al*., 2010) and or the higher casein content of buffalo's milk that enhances the shrinkage of the curd and consequently whey synereses (Kebary *et al*. 1991) Abd El-Kader (1993) and El-Zoughby, (1994) who found buffalo's milk cheese had higher calcium content and /or cow's milk casein contain lower calcium content, which increases the ability of cow's milk casein to bind water more than buffalo's milk casein Abdou *et al.* (2000); Nasr(2015)The moisture content of all Mozzarella cheese treatments (C_2, B_2, T_1, T_2, and T_3) those stored at -18±2 °C decreased slightly ($P \leq 0.05$) during frozen storage (Table 1) The rates of moisture reduction of Mozzarella cheese treatments those stored at -18±2 °C were relatively lower than those of Mozzarella cheese treatments those stored at 5±1 °C (Table 2). These results might be due to the higher acidity of cheese storage at 5±1 °C than those of cheese stored at -18±2°C, which enhances the contraction of curd that helps to expel the whey (Ghosh and Seigh, 1992 and Kebary *et al.*, 1996).

Mozzarella cheese treatment B_2, which was stored directly at -18±2 °C, had the highest moisture content, followed by treatments T_1, T_2, and finally cheese treatment T_3, which was stored at 5±1 °C for 21 days and then at -18±2 °C for 120 days (Table 2). These results might be due to the rapid reduction of cheese moisture content during storage at 5±1 °C rather than storage at -18±2 °C.

Table 2: Effect of storage temperature on the Moisture content of Mozzarella cheese.

Mozzarella Treatments*	Storage period (days) at 5±1 °C					Means**
	Fresh	7	14	21	28	
C_1	51.09	50.36	49.53	49.02	48.62	49.724^{a}
B_1	48.16	47.52	46.79	46.31	46.63	47.082^{b}
Means**	49.625^{a}	$48.94a^{b}$	48.16^{b}	47.665^{b}	47.625^{b}	
Mozzarella Treatments*	**Storage period (days) at -18±2 °C**					**Means****
	Fresh	30	60	90	120	
C_2	51.09	50.83	50.52	50.31	49.85	50.52^{a}
B_2	48.16	47.89	47.57	47.22	47.01	47.57^{b}
T_1	47.52	46.61	47.12	46.92	46.73	$46.98b^{c}$
T_2	46.79	46.51	46.36	46.17	46.01	$46.368b^{de}$
T_3	46.31	46.15	45.88	45.73	45.56	45.926^{e}
Mean**	47.974^{a}	47.598^{ab}	47.49^{abc}	47.27^{abc}	47.032^{c}	

* See the legend of table (1)

Fat content

The fat content of all mozzarella cheese treatments increased slightly ($p \leq 0.05$) as the storage period advanced (Table 3), which might be due to the loss of moisture content during the storage period. These results agree with those reported by El-Zoughby (1994), Helal (2006), Amer *et al.* (1998), and Zedan *et al.* (2014).

The increases of fat content of mozzarella cheese treatments those stored at 5±1 °C either made from cow's or buffalo's milk (C_1 and B_1) were more evident than these stored at -18±2 °C directly (C_2 and B_2), which might be due to the higher loss of moisture of cheese treatments stored at 5±1 °C than those of cheese treatments those stored at -18±2 °C (Table 3). Similar trends were reported by Kumar and Jha (1997) and Abd El-Hamid *et al.* (2001), who found that fat content increased in all cheese samples due to the loss of moisture content during storage.

Mozzarella cheese treatments which made from cow's milk those stored at 5±1 °C or -18±2 °C (C_1 and C_2) (Table 3) contained higher fat content than the corresponding mozzarella cheese treatments those made from buffalo's milk (Helal, 2006 and Zedan *et al.*, 2014), which might be due to the higher losses of fat during cheese making (Zedan *et al.*, 2014).

Mozzarella cheese treatments (T_3) stored at 5±1 °C for 21 days at -18±2 °C contained the highest fat content, followed by cheese treatments T_2, T_1, and B_2, and finally storage directly at -18±2 °C. These results might be due to the pronounced losses of moisture during storage at 5±1 °C compared to storage at -18±2 °C, which caused a marked increase in the fat content of cheese stored at 5±1 °C (Table 3).

Table 3: Effect of storage temperature on the Fat content of Mozzarella cheese.

Mozzarella Treatments*	**Storage period (days) at 5±1 °C**					**Means****
	Fresh	7	14	21	28	
C_1	21.6	22.0	22.5	23.1	23.6	**22.56^{a}**
B_1	20.1	22.9	21.5	21.9	22.3	**21.74^{a}**
Means**	20.85^{b}	21.45^{ab}	22^{ab}	22.5^{ab}	22.95^{a}	
Mozzarella Treatments*	**Storage period (days) at -18±2 °C**					**Means****
	Fresh	30	60	90	120	
C_2	21.6	21.9	21.9	22.2	22.4	22^{a}
B_2	20.1	20.3	20.3	20.6	20.5	20.36^{d}
T_1	20.9	21.1	21.1	21.3	21.7	21.22^{c}
T_2	21.5	21.6	21.8	21.7	21.9	21.7^{b}
T_3	21.9	22.0	22.3	22.5	22.8	22.3^{a}
Mean**	21.2^{c}	21.38^{bc}	21.48^{ab}	21.66^{a}	21.86^{a}	

* See the legend of table (1)

Protein and ash contents

Changes in Protein and ash content of mozzarella cheese treatments are illustrated in Tables 4 and 5. A slight increase in total protein content of all mozzarella cheese treatments, those stored at 5±1 °C and -18±2 °C, was noticed. These results are consistent with Sameen *et al.* (2010) and Zedan *et al.* (2014). These results might be due to the moisture loss throughout the storage period and subsequent increase in total solids (Zedan *et al.*, 2014).

The increase in total protein and ash of mozzarella cheese stored at 5±1 °C (C_1 and B_1) was higher than that of cheese treatments stored at -18±2 °C (C_2 and B_2), which could be attributed to the differences in the rate of moisture losses during storage at different temperatures.

Buffalo's milk mozzarella cheese treatments (B_1 and B_2) contained higher protein and ash content than those of cow's milk mozzarella cheese treatments (C_1 and C_2) (Table 4) (El-Zoghby, 1994; Abbas, 2003; Sameen *et al.*, 2010; Zedan *et al.*, 2014) and Bhat *et al.* (2022). The previous results might be due to the higher protein content of buffalo's milk and the slow decomposition of buffalo's milk protein compared to cow's milk protein (Abbas,2003, and Zedan *et al.*, 2014)

Mozzarella cheese and ash treatment B_2, which was stored directly at -18±2 °C, contained the lowest protein content, followed by T_1, T_2, and finally T_3, which was first stored at 5±1 °C for 21 days and then at -18±2 °C for 120 days. T_3 contained the highest protein and ash content (Table 4). These results might be due to the differences in the rate of moisture loss during storage at different temperatures.

Table 4: Effect of storage temperature on the protein content of Mozzarella cheese.

Mozzarella Treatments*	**Storage period (days) at 5±1 °C**					**Means****
	Fresh	7	14	21	28	
C_1	22.91	23.25	23.93	24.26	24.69	23.808[b]
B_1	23.89	24.57	25.03	25.61	25.95	25.01[a]
Means**	23.4[d]	23.91[cd]	24.48[bc]	24.935[ab]	25.32[a]	
Mozzarella Treatments*	**Storage period (days) at -18±2 °C**					Means**
	Fresh	30	60	90	120	
C_2	22.91	22.98	23.05	23.21	23.46	23.122[d]
B_2	23.89	23.95	24.21	24.65	24.78	24.296[c]
T_1	24.57	24.76	24.92	24.99	25.32	24.912[bc]
T_2	25.03	25.37	25.52	25.36	25.81	25.418[ab]
T_3	25.61	25.82	25.91	25.99	26.32	25.93[a]
Mean**	24.402[c]	24.576[bc]	24.722[ab]	24.84[a]	25.138[a]	

* See the legend of table (1)

Table 5: Effect of storage temperature on Ash content of Mozzarella cheese.

Mozzarella Treatments*	**Storage period (days) at 5±1 °C**					**Means****
	Fresh	7	14	21	28	
C_1	2.35	2.71	2.93	3.03	3.22	2.848[b]
B_1	2.61	2.81	3.05	3.36	3.52	3.07[a]
Means**	2.48[e]	2.76[d]	2.99[c]	3.195[b]	3.37[a]	
Mozzarella Treatments*	**Storage period (days) at -18±2 °C**					**Means****
	Fresh	30	60	90	120	
C_2	2.35	2.41	2.48	2.61	2.73	2.516[e]
B_2	2.61	2.68	2.72	2.79	2.98	2.756[d]
T_1	2.71	2.78	2.85	2.93	3.09	2.872[c]
T_2	3.05	3.16	3.25	3.36	3.41	3.246[b]
T_3	3.36	3.45	3.49	3.57	3.66	3.506[a]
Mean**	2.816[e]	2.896[b]	2.958[b]	3052[b]	3.174[a]	

* See the legend of table (1)

Effect of storage temperature on rheological properties of mozzarella cheese

Meltability of cheese

The Data in Table 6 indicated that the meltability of all cheese treatments, either stored at 5±1 °C or stored at -18±2 °C, increased as the storage period proceeded (Ghosh and Singh 1992; Amer *et al*., 1998, and Zedan *et al.,* 2014). The increase of meltability throughout the storage period may be attributed to the proteolysis and breakdown of protein in the cheese matrix and /or solubilization of calcium by the developed acidity. The changes in meltability values among treatments could be a function of several factors such as moisture, pH, calcium content, and the nature of proteins (Tunick *et al.* 1991; McMahon & Oberg, 1998; Metzger *et al*., 2001, and Abd El-Hamid *et al.,* 2001). The meltability of mozzarella cheese treatments stored at -18±2 °C were lower than corresponding mozzarella cheese treatments stored at 5±1 °C and also the rate of increasing meltability of cheese treatments during stored at -18±2°C were relatively lower than those of cheese treatments stored at 5±1°C (Table 6) These results might be due to the differences of the rate of proteolysis during storage at different temperature. These results are following Oberg *et al.* (1991, 1992), Ghosh *et al.* (1992), and Kanawjia *et al.* (1996).

Mozzarella cheese treatments made from buffalo's milk (B_1 and B_2) exhibited lower meltability than those of mozzarella cheese treatments made from cow's milk (C_1 and C_2), which could be attributed to a storage protein network and reduced ability of fat and protein phases to move. The results agree with those that Kindstedt *et al.* (2004) and Guinee *et al.* (2002) reported.

Mozzarella cheese treatment T_3, stored at 5±1 °C for 21 days and then stored at -18±2 °C, had the highest meltability, followed by T_2, T_1, and B_2 (Table 6). The difference in proteolysis rates during storage at 5±1 °C and -18±2 °C may contribute to the increased meltability of cheese.

Table 6: Effect of storage temperature on the Meltability of Mozzarella cheese.

Mozzarella Treatments*	Storage period (days) at 5±1 °C					Means**
	Fresh	7	14	21	28	
C_1	76	85	93	112	146	102.4^a
B_1	22	38	47	53	66	45.2^b
Means**	49^e	61.5^d	70^c	82.5^b	106^a	
Mozzarella Treatments*	**Storage period (days) at -18±2 °C**					**Means****
	Fresh	30	60	90	120	
C_2	76	79	88	95	98	87.2^a
B_2	22	26	31	38	47	32.8^e
T_1	38	41	47	55	59	48^d
T_2	47	53	55	59	66	56^c
T_3	53	57	62	67	71	62^b
Mean**	47.2^e	51.2^d	56.6^c	62.8^b	68.2^a	

* See the legend of table (1)

Stretchability of cheese

Stretchability values of all mozzarella cheese treatments increased significantly ($P \leq 0.05$) as storage period advanced (Table 7) (Guinee *et al.*, 2001 and Zedan *et al.*, 2014). Stretchability of Mozzarella cheese treatments stored at 5±1 °C (C_1 and B_1) was relatively higher than those stored at -18±2 °C (C_2 and B_2) (Table 7). The improved functionality (Stretchability) during mozzarella cheese aging may be partly attributed to the age-related reduction in concentration of intact para-casein and the increased water-binding capacity of the casein. An increase in the water binding capacity of the para-casein is expected to enhance functionality as it is conductive to greater retention of moisture during baking of the Pizza, which limits defects associated with excessive dehydration, such as burning, crusting, and poor flowability.

Mozzarella cheese treatments made from buffalo's milk (B_1 and B_2) exhibited lower Stretchability than those of Mozzarella cheese made from cow's milk (C_1 and C_2) (Table 7) (Zedan *et al.*, 2014; Bhat *et al.*, 2022) Which might be due to lower calcium content of cow's milk which causes decrease in the structural strictness of the cheese matrix, which consequently enhancing the stretchiness Ghosh and Singh (1996) reported that the soft and delicate threads of cheese made from cow's milk could be due to lesser protein content.

Mozzarella cheese treatment T_3, which was stored at 5±1 °C for 21 days and then stored at -18±2 °C, exhibited the highest stretchability, followed by T_2, T_1, and finally B_2, which was stored directly at -18±2 °C. This may probably be due to the difference in the rate of proteolysis and development of acidity during storage at 5±1 °C and -18±2 °C.

Table 7: Effect of storage temperature on Stretchability(cm) of Mozzarella cheese.

Mozzarella Treatments*	Storage period (days) at 5±1 °C					Means**
	Fresh	7	14	21	28	
C_1	66	75	86	93	105	85^a
B_1	20	31	46	58	67	44.4^b
Means**	43^e	53^d	66^c	75.5^b	86^a	
Mozzarella Treatments*	**Storage period (days) at -18±2 °C**					**Means****
	Fresh	30	60	90	120	
C_2	66	69	75	79	86	75^a
B_2	20	25	33	39	45	32.4^e
T_1	31	36	39	44	49	39.8^d
T_2	46	51	58	62	66	56.6^c
T_3	58	63	71	75	83	70^b
Mean**	44.2^e	48.8^d	55.2^c	59.8^b	65.8^a	

* See the legend of table (1)

Oiling off %

Oiling off is regarded as a defect of this type of cheese when melted on the top of a pie. Excessive free oil in Mozzarella cheese is a significant quality problem (El-Zoghby, 1994; Abbas, 2003).

The results showed that oiling off percent increased gradually as the storage period advanced for all Mozzarella cheese treatments. (Table 8) These results agree with those reported by El-Zoghby (1994) and Abbas (2003). The oiling off increased as the storage period advanced, but lower oiling off occurred after 4 weeks (Ghosh and Singh, 1991). These results could be due to the increase in meltability and the change in the polymorphic structure of milk fat during the storage of mozzarella cheese

The increase in oiling off of mozzarella cheese treatments stored at 5±1°C (C_1 and B_1) was higher than that of Mozzarella cheese treatments stored at -18±2 °C (Table 8), which might be due to the higher protein breakdown.

Mozzarella cheese treatments made from cow's milk (C_1 and C_2) exhibited lower fat leakage than those of corresponding mozzarella cheese treatments made from buffalo's milk ($B_1$and B_2) (Table 8), which might be probably due to a coarse protein and fat distribution in the cheese (El-Batway *et al*., 2004).

Mozzarella cheese treatments T_3 (stored at 5±1 °C for 21 days and then at -18±2 °C for 120 days) had the highest oiling off, followed by T_2, T_1, and B_2 (stored at -18±2 °C). This could be due to the rapid changes in cheese texture at 5±1 °C versus -18±2 °C (Table 8).

Table 8: Effect of storage temperature on Oiling off (%) of Mozzarella cheese.

Mozzarella Treatments*	**Storage period (days) at 5±1 °C**					**Means****
	Fresh	7	14	21	28	
C_1	2.13	2.38	2.71	3.02	3.48	2.744^b
B_1	2.65	2.83	2.92	3.39	4.02	3.162^a
Means**	2.39^e	2.605^d	2.815^c	3.205^b	3.75^a	
Mozzarella Treatments*	**Storage period (days) at -18±2 °C**					**Means****
	Fresh	30	60	90	120	
C_2	2.13	2.14	2.28	2.51	2.76	2.364^e
B_2	2.65	2.74	2.81	2.88	3.17	2.85^d
T_1	2.83	2.91	3.03	3.16	3.25	3.036^c
T_2	2.96	3.07	3.18	3.25	3.47	3.186^b
T_3	3.39	3.51	3.56	3.69	3.81	3.592^a
Mean**	2.792^e	2.874^d	2.972^c	3.098^b	3.292^a	

* See the legend of table (1)

Texture analysis

Texture is one of the most important quality attributes of Mozzarella cheese. The texture parameters (Hardness, cohesiveness, springiness, Gumminess, and chewiness) of all mozzarella cheese treatments were determined.

The values of texture parameters of all mozzarella cheese treatments are presented in Table 9. These results revealed that all texture parameters followed similar trends (Table 9). Hardness and other texture parameters of all mozzarella cheese treatments increased significantly (P≤0.05) as the storage period proceeded (Mailam, 2015; Abdel-Hamid *et al.*, 2001; Nasr,2019). These results could be attributed to the increase of total solids and protein content and loss of moisture during storage (Abdel-Hamid *et al*., 2001; Mailam, 2015). Romeih (2006) and El-Zeini *et al.* (2007). Reported that the adhesiveness of cheese treatments increased throughout the storage period, possibly due to proteolysis during the storage period.

The increases of all Texture parameters of mozzarella cheese treatments that were stored at 5±1 °C (C_1, B_1) were more pronounced than those of cheese treatments stored at -18±2 °C (C_2, B_2), which might be due to the higher loss of moisture and greater increases of total solids and protein content.

Mozzarella cheese treatments made from buffalo's milk (B_1 and B_2) exhibited higher values of all texture parameters than those of corresponding cheese treatments made from cow's milk (C_1 and C_2) (Olson and Johnson 1990); Bhaskar Acharya and Shah, 1999 and Abhiyeat *et al*. 2017), who reported that these results may be probably due to the higher total solids and total protein content.

Mozzarella cheese treatments B_1 that storage at -18 ±2 exhibited the lowest values of hardness and the other texture parameters, while cheese treatments T_3 that stored at 5±1 °C for 21 days then stored at -18±2 °C exhibited the highest values of all texture parameters (Table 9), which might be due to the differences of the rate of moisture losses during stored at 5±1°C and -18±2°C and subsequently the difference of total solids and protein content of the resultant mozzarella cheese treatments.

Table 9: Effect of storage temperature on the rheological parameters of Mozzarella cheese.

Property	Treatments	Storage period (days) at 5±1 °C					
		Fresh	7	14	21	28	Means**
Hardness(g)	C_1	5.69	6.78	7.46	7.91	8.27	7.22^b
	B_1	8.93	9.28	9.75	10.11	10.43	9.7^a
	Means**	7.31^d	8.03^{cb}	8.605^c	9.01^b	9.35^a	
Cohesiveness (ratio)	C_1	0.462	0.471	0.479	0.482	0.491	0.477^b
	B_1	0.491	0.499	0.505	0.511	0.518	0.504^a
	Means**	0.4765^b	0.485^b	0.492^b	0.4965^b	0.5045^a	
Springiness(mm)	C_1	6.91	6.88	7.45	8.01	8.78	7.606^b
	B_1	8.86	9.45	10.01	10.47	10.86	9.93^a
	Means**	7.885^e	8.165^d	8.73^c	9.24^b	9.82^a	
Gumminess(N)	C_1	2.63	3.19	3.57	3.81	4.06	3.452^b
	B_1	4.38	4.63	4.92	5.17	5.40	4.9^a
	Means**	3.505^e	3.91^d	4.245^c	4.49^b	4.73^a	
Chewiness(g/mm.)	C_1	16.28	21.95	26.59	30.51	35.65	26.196^b
	B_1	38.81	43.75	49.24	54.13	58.64	48.914^a
	Means**	27.545^e	32.85^d	37.915^c	42.32^b	47.145^a	

Table 9: Continue.

Property	Treatments	Storage period (days) at -18±2 °C					
		Fresh	30	60	90	120	Means**
Hardness(g)	C_2	5.69	5.77	5.93	6.07	6.19	5.93^e
	B_2	8.92	9.02	9.18	9.25	9.38	9.15^d
	T_1	9.28	9.41	9.48	9.57	9.71	9.49^c
	T_2	9.75	9.88	9.69	10.05	10.18	9.91^b
	T_3	10.11	10.26	10.39	10.46	10.58	10.36^a
	Means**	8.75^d	8.868^{cb}	8.934^c	9.08^b	9.208^a	
Cohesiveness (ratio)	C_2	0.462	0.468	0.473	0.481	0.488	0.474^c
	B_2	0.491	0.498	0.503	0.512	0.518	0.504^b
	T_1	0.499	0.503	0.509	0.513	0.512	0.507^b
	T_2	0.505	0.512	0.518	0.524	0.532	0.518^a
	T_3	0.511	0.518	0.526	0.533	0.540	0.525^a
Means**	Means**	0.493^c	0.499^b	0.5058^a	0.5126^a	0.518^a	
Springiness(mm)	C_2	6.19	6.31	6.55	6.68	6.81	6.508^e
	B_2	8.86	8.94	8.99	9.08	9.15	9.004^d
	T_1	9.45	9.56	9.63	9.75	9.83	9.644^c
	T_2	10.01	10.09	10.17	10.22	10.28	10.154^b
	T_3	10.47	10.56	10.63	10.69	10.72	10.614^a
Means**	Means**	8.996^e	9.092^d	9.194^c	9.284^b	9.358^a	
Gumminess(N)	C_2	2.63	2.70	2.80	2.92	3.02	2.814^d
	B_2	4.38	4.49	4.62	4.74	4.86	4.618^c
	T_1	4.63	4.73	4.82	4.91	5.06	4.83^c
	T_2	4.92	4.99	5.16	5.27	5.42	5.152^b
	T_3	5.17	5.31	5.47	5.58	5.71	5.448^a
Means**	Means**	4.346^e	4.444^d	4.574^c	4.684^b	4.814^a	
Chewiness(g/mm.)	C_2	16.28	17.04	18.34	19.51	20.57	18.348^e
	B_2	38.81	40.10	41.53	43.04	44.47	41.59^d
	T_1	43.75	45.22	46.42	47.87	49.74	46.6^c
	T_2	49.25	50.35	52.48	53.86	55.72	52.332^b
	T_3	54.13	56.07	58.15	59.65	61.21	57.842^a
Means**	Means**	40.444^e	41.756^d	43.384^c	44.786^b	46.342^a	

* See the legend of table (1)

Sensory evaluation

The changes in Organoleptic properties scores (Flavour, appearance, body, texture, and total scores) during storage of mozzarella cheese are presented in Table 10. Total scores of mozzarella cheese stored at 5±1 °C increased during the first 14 days of the storage period and reached their maximum scores on the fourteenth day of the storage period, then declined slightly up to the end of the storage period (Table 10).

There were no significant differences between the scores of cheese treatments on the 14th and 21st day of the storage period (Table 10). These results agree with those of Amer *et al*. (1998), who reported that slight changes occurred after storage at 4 °C for 2 weeks, while after storage at 4 °C for 3 weeks, more changes in texture and odor appeared. More changes in texture have appeared for 3 weeks. Mozzarella cheese treatments stored at 5±1 °C C_1, B_1) gained higher total scores of Organoleptic properties than those of cheese treatments stored at -18±2 °C (C_2 and B_2) respectively (Table 11), which might be due to the higher hydrolysis of protein and fat of cheese stored at 5±1 °C than those of stored at -18±2 °C. Mozzarella cheese treatments made from cow's milk (C_1 and C_2) gained higher total stores of Organoleptic properties than corresponding cheese treatments made from buffalo's milk (B_1 and B_2), respectively (Bhat *et al*., 2022). On the other hand, the total scores for organoleptic properties of mozzarella cheese increased during storage and reached their maximum at 90 days of storage, then declined to the end of the storage period (Table 10). Cheese treatment that was stored at 5±1 °C for 14 days, then stored at -18±2 °C for 120 days, which was made from buffalo's milk, gained the highest total scores and was the most acceptable Mozzarella cheese among cheese made from buffalo's milk.

It could be concluded that acidity, fat, total protein, ash content, meltability, stretchability, oiling-off, and texture parameters increased, while moisture decreased during storage. These changes were more evident in cheese stored at 5±1 °C than in cheese stored at -18±2 °C. Mozzarella cheese made from cow's milk was more acceptable than that made from buffalo's milk. Cheese treatments that were made from buffalo's milk, which were stored at 5±1 °C for 14 days, then stored at -18±2 °C for 120 days, were the most acceptable cheese among cheeses made from buffalo's milk.

Table 10: Effect of cold storage (5±1 °C) on Organoleptic analysis of Mozzarella cheese.

Properties	Mozzarella Treatments	Storage period (days) at 5±1 °C					
		Fresh	7	14	21	28	Means**
Flavour (50)	C_1	43	44	46	44	42	43.8^a
	B_1	38	40	41	41	40	39.8^b
	Means**	40.5^c	42^b	43.5^a	42.5^a	41^b	
Body & texture (35)	C_1	31	32	33	33	33	32.4a
	B_1	27	28	30	30	28	28.4b
	Means**	29^c	30^b	31.5^a	31.5^a	30.5^b	
Appearance (15)	C_1	12	13	13	13	13	12.8^a
	B_1	13	13	13	12	13	12.6^a
	Means**	12.5^a	13^a	13^a	12.5^a	12^a	
Total (100)	C_1	86	89	92	90	88	90.4^a
	B_1	78	81	84	83.5	80	83^b
	Means**	82^c	85^b	88^a	86.75^{ab}	84^b	

Table 10: Continue.

Properties	Mozzarella Treatments	Storage period (days) at -18±2 °C±1					
		Fresh	30	60	90	120	Means
Flavour (50)	C_2	39	40	41	42	40	40.4[d]
	B_2	33	35	36	37	40	36.2[e]
	T_1	40	41	42	44	42	42[c]
	T_2	41	43	45	45	42	43.4[a]
	T_3	40	42	43	43	42	42.4[b]
	Mean**	38.8[c]	40.6[b]	41.4[b]	42.2[a]	41.2[b]	
Body & texture (35)	C_2	28	30	31	32	30	30.2[a]
	B_2	23	25	28	30	30	27.2[b]
	T_1	28	29	31	32	32	30.6[a]
	T_2	30	30	31	31	30	30.4[a]
	T_3	29	29	30	30	30	30.2[a]
	Mean**	27.6[c]	28.6[b]	30.2[a]	31[a]	30.4[a]	
Appearance (15)	C_2	12	13	13	13	13	12.8[a]
	B_2	12	12	13	13	12	12.4[a]
	T_1	13	13	13	13	12	12.8[a]
	T_2	13	13	12	13	12	12.6[a]
	T_3	13	13	13	12	12	12.6[a]
	Mean**	12.6[a]	12.8[a]	12.8[a]	12.8[a]	12.2[a]	
Total (100)	C_2	79	83	85	87	83	83.4[c]
	B_2	68	72	77	80	82	75.8[d]
	T_1	81	83	86	87	84	85.2[b]
	T_2	84	86	88	89	86	86.2[a]
	T_3	82	84	86	85	85	84[b]
Means**		78.8[d]	82.4[c]	84.6[b]	86[a]	84.46[c]	

* See the legend of table (1)

REFERENCES

Abdel- Kader, Y.I. (1993). Technological studies on the properties of Kachkaval-like cheese as affected by direct acidification. Ph. D. Thesis, Fac. Of Agric. Alex. Univ., Egypt.

Abdel-Razig, A. K. (2000). Quality attributes of braided cheese "Madaffra" as affected by the level of salt and storage temperature. Ph. D. Thesis, University of Khartoum, Sudan.

Abd El-Hamid, L.B.; Hagrass, A.E.; Awad, R.A. and Zammar, O.A. (2001). Physical and sensory properties of reduced calorie mozzarella cheese with some food additives' 8th Egyptian Conf. Dairy Sci. and Techn., pp: 299–315.

Alvarez, R. J. (1986). Exopolysaccharides of Italian cheese in the pizza industry. Pages 130-138 in proc. 23rd Annu. Marshall Invt. Cheese Sem. Marschall products, Madison, WI. Marschall products, Division of Miles Laboratories, Inc., Madison, WI.

Amer, S. N.; Taha, S.H.; El-Assar, M.A. and Genena, M.H.M. (1998). Keeping quality of Mozzarella cheese during storage. Annals of Ac Agric. Sc., Moshtohor. 36(1): 377-390.

Abbas, K.A. (2003). Studies on Mozzarella cheese. M.Sc. Thesis, Fac. of Agric. Fayoum, Cairo Univ., Egypt.

Ahmed, S.I.; Gaucher, F.; Rousseau, E.; Beaucher; Piot, M.; Grongnet, J.F. and

Gaucheron, F. (2008). Effects of acidification on physico-chemical characteristics of buffalo milk: A comparison with cow's milk. Food Chem. 106: 11-17.

Awad, R.A. (2008). Yield improvement and production quality of mozzarella cheese from cow milk fortified with dried skim milk or dry milk protein concentrate. Annals of Agric. Sci., Moshtohor, 46(1):53–67.

AOAC (2012). Official Method of the Association of Analytical Chemists. 19th Ed. Published by the Association of Official Analytical Chemists, Washington, D.C. (USA).

A.O.A.C. (2010). Official Methods of Analysis of Association of Official Analytical Chemists. 18th Edition, Washington, DC. 6, No. 10.

Bourne, M.C. (1978). Texture profile analysis. Food Tech. 32: 62.

Barbano, D.M.; Yun, J.J. and Kindedt, P.S. (1994). Mozzarella cheese making by a stirred curd, no brine procedure. J. Dairy Sci., 77: 2687-2694.

Bertola, N.C.; Califano, A.N.; Bevilacqua, A.E. and Zaritzky, N.E. (1996). Effect of freezing conditions on functional properties of low moisture Mozzarella cheese. J. Dairy Sci. 79:185-190.

Bhaskaracharya, R.K. and Shah, N.P. (1999). Texture evaluation of commercial Mozzarella cheeses. Aust. J. Dairy Tech. 54:36.

Bourne, M.C. (2003). Food texture and viscosity: concept and measurement. Elsevier Press, New York/London.

Bhat, A. R.; Shah, A. H. and Ayoob, M. (2022). Chemical, rheological, and organoleptic analysis of cow and buffalo milk Mozzarella cheese. Ankara Üniversitesi Veteriner Fakültesi Dergisi, 69: 51–60.

Citro, V. (1981). Atypical local product obtained from buffalo milk: "la Mozzarella" Scienza-e-Tecnicalattiero-casearia, 32: 263-27.

Dahlstrom, D. G. (1978). Frozen storage of part skim Mozzarella cheese. Thesis, Univ. of Wisconsin, Madison.

El-Safty, M.S.; Nabil, M.M.; Nofal, A.A. and Ismail, A.A. (1976). Utilization of buffalo's milk in chedder cheese making. I-The use of sodium pyrophosphate and sodium citratr. Egyption J. of Dairy Sci., 4: 155–159.

El-Abbassy, M. Z.; Fayed, H. H. and Farag, A. A. (1991). The quality of mozzarella cheese is affected by certain enzyme preparations. Egyptian Journal of Applied Science, 6 (7).

El-Zoghby, Y.I. (1994). Studies on mozzarella cheese. Ph.D. Thesis, Fac. Of Agric Zagazig university., Egypt.

El-Sheikh, A.N. (1997). Production of Mudaffara cheese from cow's and goat's milk. M.Sc. Thesis, University of Khartoum, Sudan.

El-Batawy, M.A.; Galal, E.A.; Morsy, M.A. and Abbas, Kh.A. (2004). Effect of homogenization on some properties of mozzarella cheese. Egyptian J. Dairy Sci. 32: 315-326.

El-Zeini, H.M.; El-Aasser, M.A.; Anis, S.M.K. and Romeih, E.A.H. (2007). Influence of some processing treatments on chemical composition rheological properties and micro-structure of cast UF-white soft cheese. Egyptian. Dairy Sci., 35: 57.

Fox, P.F.; Guinee, T.P.; Cogan, T.M. and Mc-Sweeney, P.H. (2000). Fundamentals of cheese science. Aspen Pulishers, Inc. Maryland, USA.Ch.0. Cheese yield. Pp169-205.

Ghosh, B. C. and Singh, S. (1991). Effect of storage temperatures on sensory, chemical and rheological characteristics of Mozzarella cheese. J. Food Sci and Tech, 28:288.

Ghosh, B. C. and Singh, S. (1992). Storage studies of Mozzarella cheese, Part I- sensory and rheological characteristics. Indian J. Dairy Sci., 45: 199–202.

Ghosh, B.C. and Kulkarni, S. (1996). Low cholesterol Mozzarella cheese- technology Standardization. J. Food Sci. and Technology (Mysore), 33: 488-492.

Ghosh, B.C. and Singh, S. (1996 b). Effect of different levels of titratable acidity in curd from buffalo milk at stretching on mozzarella cheese. J. Food Sci. & Tech., 33 (1) 70-72.

Guinee, T.P.; Feeney, E.P. and Fox, F.P. (2001). Effect of ripening temperature on low moisture Mozzarella cheese.2. Texture and functionality. Lait, 81:475-485.

Gunasekaran, S. and Mehmet, M.AK. (2003). Cheese rheology and texture: CRC Press LLC, New York, USA, Chapter 9:377-397.

Helal, A.M.I. (2006). Manufacturing of Mozzarella Cheese from Cow's and Buffalo's Milk with Complete Substitution of Milk Fat with Vegetable Oils. Ph. D. Thesis, Fac. of Agric. (damanhour), Alex. Univ., Egypt.

Kindstedt, P. S. (1993). Effect of manufacturing factors, composition, and proteolysis on the functional characteristics of Mozzarella cheese. Crit. Rev. Food Sci. Nutr. 33(2): 167-187.

Mostafa, M. B. M.; Shahein, N. M.; Abdel-Kader, Y. I. and El-Zoghby, A. S. (1996). Properties of mozzarella cheese as affected by milk type. II- proteolysis, physical properties and organoleptic quality of cheese. Egyptian J. Dairy Sci, 24 (2): 289-296.

Kebary, K. M. K.; Hamed, M. K. and Frag, S. I. (1991). Influence of cold storage of milk on the chemical composition and quality of Domiati cheese. Minufiya J. of Agricultural Research, 16(2): 1811.

Kebary, K.M.K.; Khader, A.E.; Zedan, A.N. and Mahmoud, S.F. (1996). Accelerated ripening of low-fat Ras cheese by attenuated lactobacilli cells. Egyptian Journal of Dairy Science, 24: 219–229.

Kumar, S. and Jha, Y.K. (1997). Soymilk substitution on quality attributes of mozzarella cheese made from buffalo milk. J. Food Sci. and Tech, India, 43(2): 113-118.

Kosikowski, F.V. (1982). Cheese and fermented milk foods. 2nd ed. F.V. kowsikowski and Associates, Brooktonale, New York.

Kanawjia, S.K; Sabikhi, L. and Singh, S. (1996). Textura profile changes in Mozzarella cheese during storage. Korean. J. Dairy Sci.18(1):17-24. C.F. Dairy Sci.Abstr58:5997,1996.

Ling, E.R. (2008). “A Textbook of Dairy Chemistry”. Vol. II practical, Chapman and Hall. LTD, (London).

McMahon, D. J. and Oberg, C. J. (1998). Influence of fat, moisture and salt on functional properties of Mozzarella cheese. Aust. J. Dairy Technol. 53:98-101.

Metzger, L.E.; Barbano, D.M. and Kindstedt, P.S. (2001). Effect of milk reacidification on low fat Mozzarella cheese. III. post-melt chewiness and whiteness. J. Dairy Sci., 84: 1357-1366.

Mailam, M.A. (2015). Studies on the use of milk concentrates in mozzarella cheese manufacture. Ph.D. Thesis, Faculty of Agric., Ain Shams Univ., Egypt.

Nasr, W.I.A. (2015). Effect of potassium chloride as A salt replaced on the quality of buffalo’s mozzarella cheese. J. Food Dairy Sci., Mansoura Univ., 6:697.

Olson, N.F. and Price, W.V. (1958). A melting test for pasteurized process cheese spreads.J. Dairy Sci. 41:999-1000.

Olson, N. J. and Johnson, M. E. (1990). Light cheese products: Characteristics and economics. Food Technol. 44:93-96.

O'Connor, C.B. (1994). Rural Dairy Technology: In ILRI Training Manual 1. ILRI, Addis Ababa, Ethiopia: pp133.

Oberg, C. J.; Merrill, R. K.; Moyes, L. V.; Brown, R. J. and Richardson, G. H. (1991a). Effects of *Lactobacillus helveticus* cultureon physical properties of Mozzarella cheese. J. Dairy Sci. 74:4101–4107.

Oberg, C. J.; Wang, A.; Moyes, L. V.; Brown, R. J. and Richardson, G. H. (1991). Effects of proteolytic activity of thermolactic cultures on physical properties of Mozzarella cheese. Journal of Dairy Science, 74(2): 389–397.

Pilcher, S.W. and Kindstedt, P.S. (1990). Survey of Mozzarella cheese quality at restaurant end use. J. Dairy Sci. 73: 1644.

Rayan, A.A.; Kalab, M. and Ernstrom, C.A. (1980). Microstructure and rheology of pasteurized process Cheese Scanning Electron Microscopy. N.O. 3: 635–643.

Romeih, E.A. (2006). Rheological assessment of UF-White cheese. Ph.D. Thesis, Faculty of Agric., Cairo Univ., Egypt.

Shegdoni, A.; Rettl, C. and Souzza, G.P. (1979). Manufacture of Mussarel Cheese [Fabricacaode Mussarela]. Revista do Institute de Laticinios Tostes, 34: 27-30.

Szczesniak, A.; Brandt, M. and Freidman, H. (1963). Development of standard rating scales for mechanical parameters and correlation between the objective and sensory texture measurements. Food Tech., 22:50.

Steel, R.G.D. and Torrie, J.H. (1980). Principles and procedures of statistics. A biometrical approach. 2nd Ed. Mc. Graw-Hill Book Co., New York.

Sabikhi, L. and Kanawjia, S. K. (1992). Effect of admixing of goat and buffalo milks on sensory, compositional, and textural characteristics of direct acid Mozzarella cheese. Indian J. Dairy Sci., 45(10):562-567.

Salem, M.M.E.; Abd El-Gawad, M.A.M.; Hassan, F.A.M. and Effat, B.A. (2007). Use of synbiotics for production of functional low fat Labneh. Polish J. of Food and Nutr. Sci., 57 (2): 151 – 159.

Sameen, A.; Anjum, F.M.; Huma, N. and Nawaz, H. (2008). Quality Evaluation of Mozzarella cheese from Different Milk Sources. Pakistan J. Nutri., 7(6): 753–756.

Sameen, A.; Anjum, F.M.; Huma, N. and Nawaz, H. (2010). Chemical composition and sensory evaluation of Mozzarella cheese: Influence by milk sources, fat levels, starter cultures and ripening period. Pak. J. Agri. Sci., 47(1): 26–31.

Teama, Z.Y.; El-Sadek, G.M.; Abd El-Kader, A.E. and El-Shabrawy, E.A. (1979). Manufacture of Kachkaval cheese from buffalo milk, II- Addition of sodium citrate. Egyptian Dairy Sci., 7: 199-208.

Tunick, M. H.; Mackey, K. L.; Smith, P. W. and Holsinger, V. H. (1991). Effects of composition and storage on the texture of Mozzarella cheese. Neth. Milk Dairy J. 45:117–125.

Zedan, I.A.; Abou-Shaloue, Z. and Zaky, S.M. (2014). Quality Evaluation of Mozzarella Cheese from Different Milk Types. Dairy Science and Technology, Faculty of Agriculture, Alexandria University, Egypt. 35: 162–177.

تقييم خواص جبن الموزاريلا المصنع من البان مختلفة والمخزنه على درجات حرارة مختلفة

خميس محمد كامل كعباري[1]، سامي عبد الرحمن حسين[1]، رجب محمد بدوي[1]، حامد السيد عبد الرازق حاتم[2] مى حسن محمد عيد، الهام امين محمد الدن[1]

[1] قسم علوم وتكنولوجيا الألبان كلية الزراعة - جامعة المنوفية

[2] معهد بحوث الإنتاج الحيواني - مركز البحوث الزراعية - الدقي - الجيزة

الملخص العربى

فى هذا البحث تم دراسة تأثير نوع اللبن ودرجات حرارة التخزين على خواص جبن الموزاريلا لذالك تم تصنيع معاملتين من اللبن البقرى المعدل نسبة الدهن فيه الى 3 % دهن واحدة تم حفظها على درجة حرارة 5±1 م°(C_1) والاخرى تم حفظها على درجة حرارة -18 ±2 م°(C_2) وتم تصنيع 5 معاملات من اللبن الجاموسى المعدل نسبة الدهن فيه الى 3 % واحده منهم تم حفظها على درجة حرارة 5±1 م°(B_1) والثانية على درجة حرارة -18 ±2 م°(B_2) اما المعاملات الثلاث الأخرى فقد تم حفظها على درجة حرارة 5±1 م° لمدة 7و14و21 يوم ثم تم نقلهم للحفظ على درجة حرارة -18 ±2 م° لمدة 120 يوم (T_3,T_2,T_1 على التوالى)

ولقد اوضحت النتائج المتحصل عليها مايلى:

- ازدات نسب الحموضة والدهن والبروتين الكلى والرماد وكذالك القابلية للانصهار والمطاطية وانفصال الدهن وخواص التركيب أثناء التخزين بينما انخفضت نسبة الرطوبة.
- كان تأثير الحفظ على درجه الحرارة 5±1 م° على الصفات السابقة اكثر وضوحا عنه عند التخزين على درجة حرارة -18 ±2 م°.
- تميزت الجبن المصنعة من اللبن البقرى بانخفاض نسبة البروتين الكلى والرماد بينما تميزت بارتفاع نسبة الرطوبة وزيادة القابلية للانصهار والمطاطية عن الجبن المصنعة من اللبن الجاموسى
- ازدادت درجات التحكيم الكلى اثناء تخزين الجبن ووصلت الى اعلى درجات التحكيم عند اليوم الرابع عشر ثم بدأت تقل بدرجة قليلة وذالك للجبن المخزن على درجات حرارة 5±1 م° فى حين حصلت الجبن المخزنة على -18 ±2 م° على اعلى درجات التحكيم بعد 90 يوم من التخزين.
- حصلت الجبن المصنعة من اللبن الجاموسى والمخزنه لمدة 14 يوم على درجة 5±1 م° ثم نقلها للتخزين على -18 ±2 م° لمدة 120يوم على اعلى درجات التحكيم وكانت اكثر معاملات الجبن قبولا.

الكلمات المفتاحية: جبنة موتزاريلا، حليب الأبقار، حليب الجاموس، قابلية الذوبان، قابلية التمدد، معايير القوام.