

**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**

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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<sub>1</sub>); one was stored at 5±1 °C, while the other was stored at -18±2 °C (C<sub>2</sub>). Another 5 batches were made from 3.0% fat buffalo's milk, one was stored at 5±1 °C (B<sub>1</sub>) and the second was stored at -18±2 °C (B<sub>2</sub>). 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<sub>1</sub>, T<sub>2</sub>, and T<sub>3</sub>). 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 14<sup>th</sup> 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 90<sup>th</sup> 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

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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 °C before freezing at -20 °C for 60 days, then again ripening at 4 °C for 14 days, and b) Cheese freezing immediately after manufacturing at -20°C for 60 days, then ripening at 4 °C 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 °C. Tunick *et al.* (1991) froze Mozzarella cheese at -20 °C for 8 weeks. After thawing, they tempered the cheese at 4°C 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 °C 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<sub>2</sub> 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).

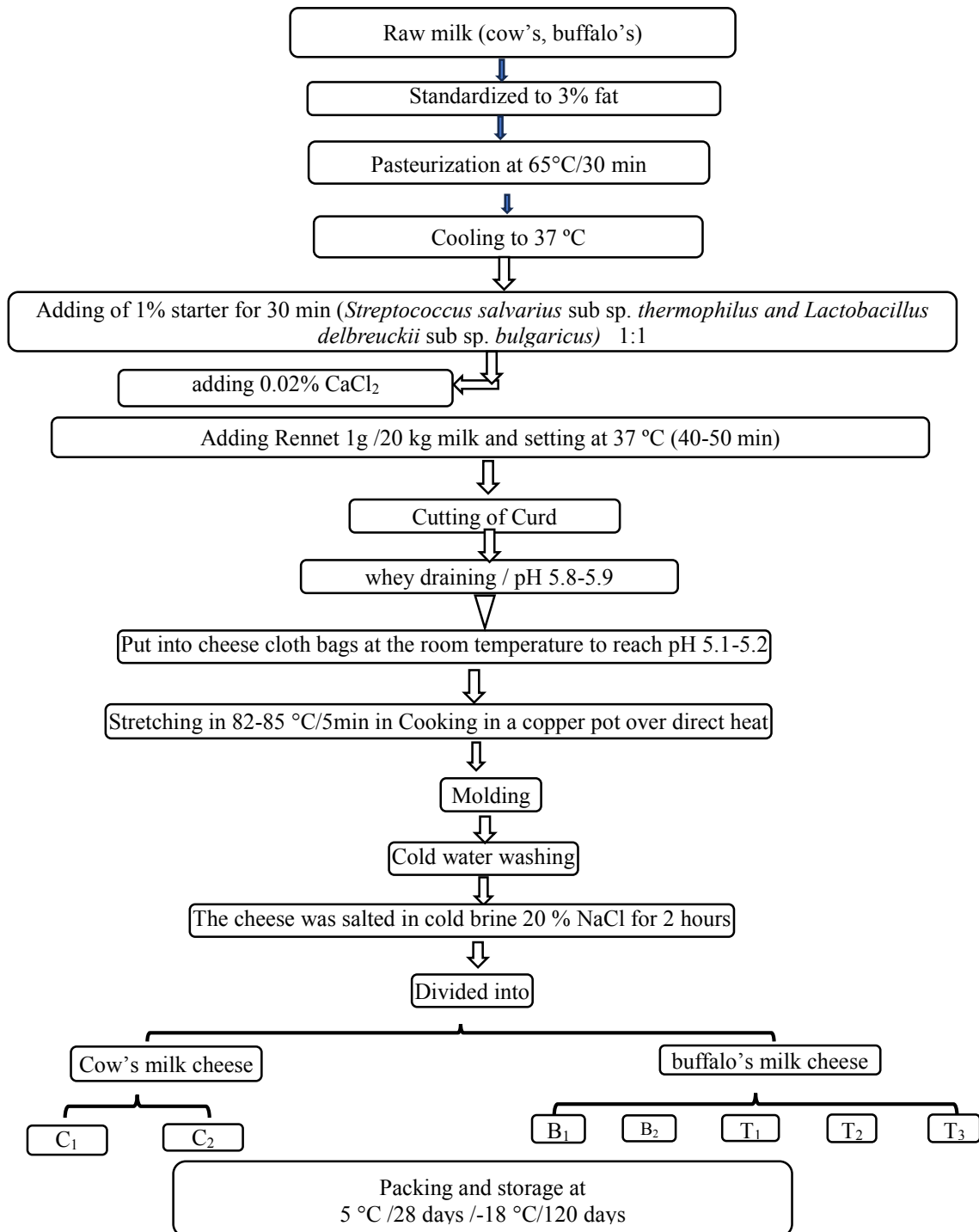


Figure 1: Flow sheet of Mozzarella cheese manufacture.

### 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, Virginia, USA Cheese samples equipped with 1000 N (250 lb) load cell and connected to a computer programmed with Texture Pro™ 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

Samples from fresh and stored Mozzarella cheese were organoleptically evaluated according to the scheme described by Nelson and Trout (1956). The scoring sheet for Mozzarella cheese was follows: Flavour (50 points), Body & texture (35 points), and Appearance (15 points). The evaluation was carried out by regular scoring panel (8-10 panelists) of staff members at Food Science Department, Faculty of Agriculture, Ain Shams University and Dairy Research Dept., Food Technology Research Institute, Agricultural Research Center.

### 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<sub>1</sub>) and buffalo's milk (B<sub>1</sub>) 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<sub>2</sub>) contained higher acidity than those made from buffalo's milk (B<sub>2</sub>) (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<sub>3</sub> 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<sub>2</sub>, T<sub>1</sub> those stored at 5±1 °C for 14 and 7 days respectively, while cheese treatment B<sub>2</sub> 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 <sub>1</sub>	0.69	0.91	1.20	1.43	1.64	1.174 <sup>a</sup>
B <sub>1</sub>	0.48	0.97	0.95	1.21	1.44	1.01 <sup>b</sup>
Means**	0.585 <sup>c</sup>	0.94 <sup>d</sup>	1.075 <sup>c</sup>	1.32 <sup>b</sup>	1.54 <sup>a</sup>	
Mozzarella Treatments*	Storage period (days) at -18±2 °C					Means**
	Fresh	30	60	90	120	
C <sub>2</sub>	0.69	0.81	0.86	0.92	1.02	0.86 <sup>d</sup>
B <sub>2</sub>	0.48	0.59	0.71	0.79	0.92	0.698 <sup>e</sup>
T <sub>1</sub>	0.79	0.84	0.91	0.98	1.18	0.94 <sup>c</sup>
T <sub>2</sub>	0.95	1.03	1.12	1.18	1.32	1.12 <sup>b</sup>
T <sub>3</sub>	1.21	1.33	1.41	1.48	1.57	1.4 <sup>a</sup>
Mean**	0.824 <sup>e</sup>	0.92 <sup>d</sup>	1.002 <sup>c</sup>	1.07 <sup>b</sup>	1.202 <sup>a</sup>	

C<sub>1</sub>\*: Control cheese from cow's milk storage at 5±1 °C

B<sub>1</sub>\*: Control cheese from buffalo's milk storage at 5±1 °C

C<sub>2</sub>: Control cheese from cow's milk storage at -18 °C

B<sub>2</sub>: Control cheese from buffalo's milk storage at -18 °C

T<sub>1</sub>: Mozzarella cheese from buffalo's storage at 5 °C for 7 days and then 90 days at -18 °C

T<sub>2</sub>: Mozzarella cheese from buffalo's storage at 5 °C for 14 days and then 90 days at -18 °C

T<sub>3</sub>: 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<sub>1</sub> and C<sub>2</sub>, made from cow's milk, contained higher moisture content than corresponding cheese treatments B<sub>1</sub> and B<sub>2</sub>, 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<sub>2</sub>, B<sub>2</sub>, T<sub>1</sub>, T<sub>2</sub>, and T<sub>3</sub>) those stored at -18±2 °C decreased slightly (P≤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<sub>2</sub>, which was stored directly at -18±2 °C, had the highest moisture content, followed by treatments T<sub>1</sub>, T<sub>2</sub>, and finally cheese treatment T<sub>3</sub>, 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 <sub>1</sub>	51.09	50.36	49.53	49.02	48.62	49.724 <sup>a</sup>
B <sub>1</sub>	48.16	47.52	46.79	46.31	46.63	47.082 <sup>b</sup>
Means**	49.625 <sup>a</sup>	48.94 <sup>ab</sup>	48.16 <sup>b</sup>	47.665 <sup>b</sup>	47.625 <sup>b</sup>	
Mozzarella Treatments*	Storage period (days) at -18±2 °C					Means**
	Fresh	30	60	90	120	
C <sub>2</sub>	51.09	50.83	50.52	50.31	49.85	50.52 <sup>a</sup>
B <sub>2</sub>	48.16	47.89	47.57	47.22	47.01	47.57 <sup>b</sup>
T <sub>1</sub>	47.52	46.61	47.12	46.92	46.73	46.98 <sup>b</sup> <sup>c</sup>
T <sub>2</sub>	46.79	46.51	46.36	46.17	46.01	46.368 <sup>b</sup> <sup>de</sup>
T <sub>3</sub>	46.31	46.15	45.88	45.73	45.56	45.926 <sup>c</sup>
Mean**	47.974 <sup>a</sup>	47.598 <sup>ab</sup>	47.49 <sup>abc</sup>	47.27 <sup>abc</sup>	47.032 <sup>c</sup>	

\* See the legend of table (1)

### Fat content

The fat content of all mozzarella cheese treatments increased slightly (p≤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<sub>1</sub> and B<sub>1</sub>) were more evident than these stored at -18±2 °C directly (C<sub>2</sub> and B<sub>2</sub>), 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<sub>1</sub> and C<sub>2</sub>) (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  $5 \pm 1$  °C for 21 days at  $-18 \pm 2$  °C contained the highest fat content, followed by cheese treatments  $T_2$ ,  $T_1$ , and  $B_2$ , and finally storage directly at  $-18 \pm 2$  °C. These results might be due to the pronounced

losses of moisture during storage at  $5 \pm 1$  °C compared to storage at  $-18 \pm 2$  °C, which caused a marked increase in the fat content of cheese stored at  $5 \pm 1$  °C (Table 3).

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

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

\* 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  $5 \pm 1$  °C and  $-18 \pm 2$  °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  $5 \pm 1$  °C ( $C_1$  and  $B_1$ ) was higher than that of cheese treatments stored at  $-18 \pm 2$  °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  $-18 \pm 2$  °C, contained the lowest protein content, followed by  $T_1$ ,  $T_2$ , and finally  $T_3$ , which was first stored at  $5 \pm 1$  °C for 21 days and then at  $-18 \pm 2$  °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 <sub>1</sub>	22.91	23.25	23.93	24.26	24.69	23.808 <sup>b</sup>
B <sub>1</sub>	23.89	24.57	25.03	25.61	25.95	25.01 <sup>a</sup>
Means**	23.4 <sup>d</sup>	23.91 <sup>cd</sup>	24.48 <sup>bc</sup>	24.935 <sup>ab</sup>	25.32 <sup>a</sup>	
Mozzarella Treatments*	Storage period (days) at -18±2 °C					Means**
	Fresh	30	60	90	120	
C <sub>2</sub>	22.91	22.98	23.05	23.21	23.46	23.122 <sup>d</sup>
B <sub>2</sub>	23.89	23.95	24.21	24.65	24.78	24.296 <sup>c</sup>
T <sub>1</sub>	24.57	24.76	24.92	24.99	25.32	24.912 <sup>bc</sup>
T <sub>2</sub>	25.03	25.37	25.52	25.36	25.81	25.418 <sup>ab</sup>
T <sub>3</sub>	25.61	25.82	25.91	25.99	26.32	25.93 <sup>a</sup>
Mean**	24.402 <sup>c</sup>	24.576 <sup>bc</sup>	24.722 <sup>ab</sup>	24.84 <sup>a</sup>	25.138 <sup>a</sup>	

\* 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 <sub>1</sub>	2.35	2.71	2.93	3.03	3.22	2.848 <sup>b</sup>
B <sub>1</sub>	2.61	2.81	3.05	3.36	3.52	3.07 <sup>a</sup>
Means**	2.48 <sup>c</sup>	2.76 <sup>d</sup>	2.99 <sup>c</sup>	3.195 <sup>b</sup>	3.37 <sup>a</sup>	
Mozzarella Treatments*	Storage period (days) at -18±2 °C					Means**
	Fresh	30	60	90	120	
C <sub>2</sub>	2.35	2.41	2.48	2.61	2.73	2.516 <sup>c</sup>
B <sub>2</sub>	2.61	2.68	2.72	2.79	2.98	2.756 <sup>d</sup>
T <sub>1</sub>	2.71	2.78	2.85	2.93	3.09	2.872 <sup>c</sup>
T <sub>2</sub>	3.05	3.16	3.25	3.36	3.41	3.246 <sup>b</sup>
T <sub>3</sub>	3.36	3.45	3.49	3.57	3.66	3.506 <sup>a</sup>
Mean**	2.816 <sup>c</sup>	2.896 <sup>b</sup>	2.958 <sup>b</sup>	3.052 <sup>b</sup>	3.174 <sup>a</sup>	

\* 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  $5\pm 1$  °C and also the rate of increasing meltability of cheese treatments during stored at  $-18\pm 2$  °C were relatively lower than those of cheese treatments stored at  $5\pm 1$  °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  $5\pm 1$  °C for 21 days and then stored at  $-18\pm 2$  °C, had the highest meltability, followed by  $T_2$ ,  $T_1$ , and  $B_2$  (Table 6). The difference in proteolysis rates during storage at  $5\pm 1$  °C and  $-18\pm 2$  °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 $5\pm 1$ °C					Means**
	Fresh	7	14	21	28	
$C_1$	76	85	93	112	146	102.4 <sup>a</sup>
$B_1$	22	38	47	53	66	45.2 <sup>b</sup>
Means**	49 <sup>c</sup>	61.5 <sup>d</sup>	70 <sup>c</sup>	82.5 <sup>b</sup>	106 <sup>a</sup>	
Mozzarella Treatments*	Storage period (days) at $-18\pm 2$ °C					Means**
	Fresh	30	60	90	120	
$C_2$	76	79	88	95	98	87.2 <sup>a</sup>
$B_2$	22	26	31	38	47	32.8 <sup>c</sup>
$T_1$	38	41	47	55	59	48 <sup>d</sup>
$T_2$	47	53	55	59	66	56 <sup>c</sup>
$T_3$	53	57	62	67	71	62 <sup>b</sup>
Mean**	47.2 <sup>c</sup>	51.2 <sup>d</sup>	56.6 <sup>c</sup>	62.8 <sup>b</sup>	68.2 <sup>a</sup>	

\* 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  $5\pm 1$  °C ( $C_1$  and  $B_1$ ) was relatively higher than those stored at  $-18\pm 2$  °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 conducive 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<sub>3</sub>, which was stored at 5±1 °C for 21 days and then stored at -18±2 °C, exhibited the highest stretchability, followed by T<sub>2</sub>, T<sub>1</sub>, and finally B<sub>2</sub>, 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 <sub>1</sub>	66	75	86	93	105	85 <sup>a</sup>
B <sub>1</sub>	20	31	46	58	67	44.4 <sup>b</sup>
Means**	43 <sup>e</sup>	53 <sup>d</sup>	66 <sup>c</sup>	75.5 <sup>b</sup>	86 <sup>a</sup>	
Mozzarella Treatments*	Storage period (days) at -18±2 °C					Means**
	Fresh	30	60	90	120	
C <sub>2</sub>	66	69	75	79	86	75 <sup>a</sup>
B <sub>2</sub>	20	25	33	39	45	32.4 <sup>c</sup>
T <sub>1</sub>	31	36	39	44	49	39.8 <sup>d</sup>
T <sub>2</sub>	46	51	58	62	66	56.6 <sup>c</sup>
T <sub>3</sub>	58	63	71	75	83	70 <sup>b</sup>
Mean**	44.2 <sup>e</sup>	48.8 <sup>d</sup>	55.2 <sup>c</sup>	59.8 <sup>b</sup>	65.8 <sup>a</sup>	

\* 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<sub>1</sub> and B<sub>1</sub>) 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<sub>1</sub> and C<sub>2</sub>) exhibited lower fat leakage than those of corresponding mozzarella cheese treatments made from buffalo's milk (B<sub>1</sub> and B<sub>2</sub>) (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<sub>3</sub> (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<sub>2</sub>, T<sub>1</sub>, and B<sub>2</sub> (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 <sub>1</sub>	2.13	2.38	2.71	3.02	3.48	2.744 <sup>b</sup>
B <sub>1</sub>	2.65	2.83	2.92	3.39	4.02	3.162 <sup>a</sup>
Means**	2.39 <sup>e</sup>	2.605 <sup>d</sup>	2.815 <sup>c</sup>	3.205 <sup>b</sup>	3.75 <sup>a</sup>	
Mozzarella Treatments*	Storage period (days) at -18±2 °C					Means**
	Fresh	30	60	90	120	
C <sub>2</sub>	2.13	2.14	2.28	2.51	2.76	2.364 <sup>e</sup>
B <sub>2</sub>	2.65	2.74	2.81	2.88	3.17	2.85 <sup>d</sup>
T <sub>1</sub>	2.83	2.91	3.03	3.16	3.25	3.036 <sup>c</sup>
T <sub>2</sub>	2.96	3.07	3.18	3.25	3.47	3.186 <sup>b</sup>
T <sub>3</sub>	3.39	3.51	3.56	3.69	3.81	3.592 <sup>a</sup>
Mean**	2.792 <sup>e</sup>	2.874 <sup>d</sup>	2.972 <sup>c</sup>	3.098 <sup>b</sup>	3.292 <sup>a</sup>	

\* 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 ( $P \leq 0.05$ ) 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<sub>1</sub>, B<sub>1</sub>) were more pronounced than those of cheese treatments stored at -18±2 °C (C<sub>2</sub>, B<sub>2</sub>), 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<sub>1</sub> and B<sub>2</sub>) exhibited higher values of all texture parameters than those of corresponding cheese treatments made from cow's milk (C<sub>1</sub> and C<sub>2</sub>) (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<sub>1</sub> that storage at -18 ±2 exhibited the lowest values of hardness and the other texture parameters, while cheese treatments T<sub>3</sub> 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 <sub>1</sub>	5.69	6.78	7.46	7.91	8.27	7.22 <sup>b</sup>
	B <sub>1</sub>	8.93	9.28	9.75	10.11	10.43	9.7 <sup>a</sup>
	Means**	7.31 <sup>d</sup>	8.03 <sup>cb</sup>	8.605 <sup>c</sup>	9.01 <sup>b</sup>	9.35 <sup>a</sup>	
Cohesiveness (ratio)	C <sub>1</sub>	0.462	0.471	0.479	0.482	0.491	0.477 <sup>b</sup>
	B <sub>1</sub>	0.491	0.499	0.505	0.511	0.518	0.504 <sup>a</sup>
	Means**	0.4765 <sup>b</sup>	0.485 <sup>b</sup>	0.492 <sup>b</sup>	0.4965 <sup>b</sup>	0.5045 <sup>a</sup>	
Springiness(mm)	C <sub>1</sub>	6.91	6.88	7.45	8.01	8.78	7.606 <sup>b</sup>
	B <sub>1</sub>	8.86	9.45	10.01	10.47	10.86	9.93 <sup>a</sup>
	Means**	7.885 <sup>c</sup>	8.165 <sup>d</sup>	8.73 <sup>c</sup>	9.24 <sup>b</sup>	9.82 <sup>a</sup>	
Gumminess(N)	C <sub>1</sub>	2.63	3.19	3.57	3.81	4.06	3.452 <sup>b</sup>
	B <sub>1</sub>	4.38	4.63	4.92	5.17	5.40	4.9 <sup>a</sup>
	Means**	3.505 <sup>c</sup>	3.91 <sup>d</sup>	4.245 <sup>c</sup>	4.49 <sup>b</sup>	4.73 <sup>a</sup>	
Chewiness(g/mm.)	C <sub>1</sub>	16.28	21.95	26.59	30.51	35.65	26.196 <sup>b</sup>
	B <sub>1</sub>	38.81	43.75	49.24	54.13	58.64	48.914 <sup>a</sup>
	Means**	27.545 <sup>c</sup>	32.85 <sup>d</sup>	37.915 <sup>c</sup>	42.32 <sup>b</sup>	47.145 <sup>a</sup>	

**Table 9: Continue.**

Property	Treatments	Storage period (days) at -18±2 °C					
		Fresh	30	60	90	120	Means**
Hardness(g)	C <sub>2</sub>	5.69	5.77	5.93	6.07	6.19	5.93 <sup>c</sup>
	B <sub>2</sub>	8.92	9.02	9.18	9.25	9.38	9.15 <sup>d</sup>
	T <sub>1</sub>	9.28	9.41	9.48	9.57	9.71	9.49 <sup>c</sup>
	T <sub>2</sub>	9.75	9.88	9.69	10.05	10.18	9.91 <sup>b</sup>
	T <sub>3</sub>	10.11	10.26	10.39	10.46	10.58	10.36 <sup>a</sup>
	Means**	8.75 <sup>d</sup>	8.868 <sup>cb</sup>	8.934 <sup>c</sup>	9.08 <sup>b</sup>	9.208 <sup>a</sup>	
Cohesiveness (ratio)	C <sub>2</sub>	0.462	0.468	0.473	0.481	0.488	0.474 <sup>c</sup>
	B <sub>2</sub>	0.491	0.498	0.503	0.512	0.518	0.504 <sup>b</sup>
	T <sub>1</sub>	0.499	0.503	0.509	0.513	0.512	0.507 <sup>b</sup>
	T <sub>2</sub>	0.505	0.512	0.518	0.524	0.532	0.518 <sup>a</sup>
	T <sub>3</sub>	0.511	0.518	0.526	0.533	0.540	0.525 <sup>a</sup>
	Means**	0.493 <sup>c</sup>	0.499 <sup>b</sup>	0.5058 <sup>a</sup>	0.5126 <sup>a</sup>	0.518 <sup>a</sup>	
Springiness(mm)	C <sub>2</sub>	6.19	6.31	6.55	6.68	6.81	6.508 <sup>c</sup>
	B <sub>2</sub>	8.86	8.94	8.99	9.08	9.15	9.004 <sup>d</sup>
	T <sub>1</sub>	9.45	9.56	9.63	9.75	9.83	9.644 <sup>c</sup>
	T <sub>2</sub>	10.01	10.09	10.17	10.22	10.28	10.154 <sup>b</sup>
	T <sub>3</sub>	10.47	10.56	10.63	10.69	10.72	10.614 <sup>a</sup>
	Means**	8.996 <sup>c</sup>	9.092 <sup>d</sup>	9.194 <sup>c</sup>	9.284 <sup>b</sup>	9.358 <sup>a</sup>	
Gumminess(N)	C <sub>2</sub>	2.63	2.70	2.80	2.92	3.02	2.814 <sup>d</sup>
	B <sub>2</sub>	4.38	4.49	4.62	4.74	4.86	4.618 <sup>c</sup>
	T <sub>1</sub>	4.63	4.73	4.82	4.91	5.06	4.83 <sup>c</sup>
	T <sub>2</sub>	4.92	4.99	5.16	5.27	5.42	5.152 <sup>b</sup>
	T <sub>3</sub>	5.17	5.31	5.47	5.58	5.71	5.448 <sup>a</sup>
	Means**	4.346 <sup>c</sup>	4.444 <sup>d</sup>	4.574 <sup>c</sup>	4.684 <sup>b</sup>	4.814 <sup>a</sup>	
Chewiness(g/mm.)	C <sub>2</sub>	16.28	17.04	18.34	19.51	20.57	18.348 <sup>c</sup>
	B <sub>2</sub>	38.81	40.10	41.53	43.04	44.47	41.59 <sup>d</sup>
	T <sub>1</sub>	43.75	45.22	46.42	47.87	49.74	46.6 <sup>c</sup>
	T <sub>2</sub>	49.25	50.35	52.48	53.86	55.72	52.332 <sup>b</sup>
	T <sub>3</sub>	54.13	56.07	58.15	59.65	61.21	57.842 <sup>a</sup>
	Means**	40.444 <sup>c</sup>	41.756 <sup>d</sup>	43.384 <sup>c</sup>	44.786 <sup>b</sup>	46.342 <sup>a</sup>	

\* 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  $5\pm 1$  °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 14<sup>th</sup> and 21<sup>st</sup> 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  $5\pm 1$  °C ( $C_1$ ,  $B_1$ ) gained higher total scores of Organoleptic properties than those of cheese treatments stored at  $-18\pm 2$  °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  $5\pm 1$  °C than those of stored at  $-18\pm 2$  °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  $5\pm 1$  °C for 14 days, then stored at  $-18\pm 2$  °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  $5\pm 1$  °C than in cheese stored at  $-18\pm 2$  °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  $5\pm 1$  °C for 14 days, then stored at  $-18\pm 2$  °C for 120 days, were the most acceptable cheese among cheeses made from buffalo's milk.

**Table 10: Effect of cold storage ( $5\pm 1$  °C) on Organoleptic analysis of Mozzarella cheese.**

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

Table 10: Continue.

Properties	Mozzarella Treatments	Storage period (days) at $-18\pm 2$ °C $\pm 1$					
		Fresh	30	60	90	120	Means
Flavour (50)	C <sub>2</sub>	39	40	41	42	40	40.4 <sup>d</sup>
	B <sub>2</sub>	33	35	36	37	40	36.2 <sup>e</sup>
	T <sub>1</sub>	40	41	42	44	42	42 <sup>c</sup>
	T <sub>2</sub>	41	43	45	45	42	43.4 <sup>a</sup>
	T <sub>3</sub>	40	42	43	43	42	42.4 <sup>b</sup>
	Mean**	38.8 <sup>c</sup>	40.6 <sup>b</sup>	41.4 <sup>b</sup>	42.2 <sup>a</sup>	41.2 <sup>b</sup>	
Body & texture (35)	C <sub>2</sub>	28	30	31	32	30	30.2 <sup>a</sup>
	B <sub>2</sub>	23	25	28	30	30	27.2 <sup>b</sup>
	T <sub>1</sub>	28	29	31	32	32	30.6 <sup>a</sup>
	T <sub>2</sub>	30	30	31	31	30	30.4 <sup>a</sup>
	T <sub>3</sub>	29	29	30	30	30	30.2 <sup>a</sup>
	Mean**	27.6 <sup>c</sup>	28.6 <sup>b</sup>	30.2 <sup>a</sup>	31 <sup>a</sup>	30.4 <sup>a</sup>	
Appearance (15)	C <sub>2</sub>	12	13	13	13	13	12.8 <sup>a</sup>
	B <sub>2</sub>	12	12	13	13	12	12.4 <sup>a</sup>
	T <sub>1</sub>	13	13	13	13	12	12.8 <sup>a</sup>
	T <sub>2</sub>	13	13	12	13	12	12.6 <sup>a</sup>
	T <sub>3</sub>	13	13	13	12	12	12.6 <sup>a</sup>
	Mean**	12.6 <sup>a</sup>	12.8 <sup>a</sup>	12.8 <sup>a</sup>	12.8 <sup>a</sup>	12.2 <sup>a</sup>	
Total (100)	C <sub>2</sub>	79	83	85	87	83	83.4 <sup>c</sup>
	B <sub>2</sub>	68	72	77	80	82	75.8 <sup>d</sup>
	T <sub>1</sub>	81	83	86	87	84	85.2 <sup>b</sup>
	T <sub>2</sub>	84	86	88	89	86	86.2 <sup>a</sup>
	T <sub>3</sub>	82	84	86	85	85	84 <sup>b</sup>
Means**		78.8 <sup>d</sup>	82.4 <sup>c</sup>	84.6 <sup>b</sup>	86 <sup>a</sup>	84.46 <sup>c</sup>	

\* See the legend of table (1)

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## تقييم خواص جبن الموزاريلا المصنع من اللبن مختلفة والمخزنه على درجات حرارة مختلفة

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### الملخص العربي

فى هذا البحث تم دراسة تأثير نوع اللبن ودرجات حرارة التخزين على خواص جبن الموزاريلا لذلك تم تصنيع معاملتين من اللبن البقرى المعدل نسبة الدهن فيه الى 3 % دهن واحدة تم حفظها على درجة حرارة  $1 \pm 5^\circ\text{C}$  والآخرى تم حفظها على درجة حرارة  $18 \pm 2^\circ\text{C}$  وتم تصنيع 5 معاملات من اللبن الجاموسى المعدل نسبة الدهن فيه الى 3 % واحده منهم تم حفظها على درجة حرارة  $1 \pm 5^\circ\text{C}$  والثانية على درجة حرارة  $18 \pm 2^\circ\text{C}$  اما المعاملات الثلاث الأخرى فقد تم حفظها على درجة حرارة  $1 \pm 5^\circ\text{C}$  لمدة 7 و14 و21 يوم ثم تم نقلهم للحفظ على درجة حرارة  $18 \pm 2^\circ\text{C}$  لمدة 120 يوم ( $T_1, T_2, T_3$  على التوالى)

### ولقد اوضحت النتائج المتحصل عليها مايلى:

- ازدادت نسب الحموضة والدهن والبروتين الكلى والرماد وكذلك القابلية للانصهار والمطاطية وانفصال الدهن وخواص التركيب أثناء التخزين بينما انخفضت نسبة الرطوبة.
- كان تأثير الحفظ على درجه الحرارة  $1 \pm 5^\circ\text{C}$  على الصفات السابقة اكثر وضوحا عنه عند التخزين على درجة حرارة  $18 \pm 2^\circ\text{C}$ .
- 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 وذلك للجبن المخزن على درجات حرارة  $1 \pm 5^\circ\text{C}$  فى حين حصلت الجبن المخزنة على  $18 \pm 2^\circ\text{C}$  على اعلى درجات التحكيم بعد 90 يوم من التخزين.
- حصلت الجبن المصنعة من اللبن الجاموسى والمخزنه لمدة 14 يوم على درجة  $1 \pm 5^\circ\text{C}$  ثم نقلها للتخزين على  $18 \pm 2^\circ\text{C}$  لمدة 120 يوم على اعلى درجات التحكيم وكانت اكثر معاملات الجبن قبولا.

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