JSAES

Journal of Sustainable Agricultural and Environmental Sciences

Print ISSN : 2735-4377
Online ISSN : 2785-9878
Homepage: https://jsaes.journals.ekb.eg/

Research Article

Quality Characteristics of Mozzarella Cheese from Cow's Milk Using Different Acidulates

Nabeel Elgaml [1*], Ashraf Bakr [2], Mohamed EL- Hawary [2], and Mohamed Abo gamihe [2]

[1]Dairy Chem. Dept., Animal Production Res. Inst., Agric. Res. Center, Giza, Egypt

[2]Food Science and Technology Department, Tanta University, Egypt.

[*] Correspondence: elgamlnabeel71@gmail.com

Keywords:

Mozzarella cheese, acidulates, meltability, Rheological properties

Abstract:

The effect of cow's milk acidification with different acidulates starter acidification; GDL acidification (glucono D-lactone), and acidification with citric acid on the yield, composition and rheological properties of Mozzarella cheese was determined. Cheese was made from cow's milk using yoghurt starter (control) treatment T1 GD treatment T2 and citric acid treatment T3. The resultant cheese was determined for chemical rheological, and organoleptic properties when fresh and during a storage period at -18°C for 30 days. GDL cheese had higher acidity, TS, fat and TN values than the other treatments. Acidification of milk with GDL decreased the yield, DM, fat/DM, TN, ash/DM, salt/DM, calcium and oiling off values of resultant cheese while increasing WSN, TVFA and meltability values of the cheese. Treatment T2 (GDL) gained the highest scores points for all types of milk treatments.

1. Introduction

Mozzarella cheese has a soft-to-firm texture. However, when melted, the texture of Mozzarella cheese becomes smooth and creamy. The casein proteins in Mozzarella are in such a form that the cheese is very elastic and has a high degree of stretchability. The pH of the curd is the critical factor in determining stretchability as pH influences the state of the casein molecules. The Italian legal standard for Mozzarella cheese requires a minimum 45% fat in dry-matter and moisture content of 52% to 55% and often closer to 60% (Kosikowvski 1982).

Mozzarella cheese is the most important (Abd-El-Gawad et al., 2012). It was originated in Italy from buffalo milk which had widespread around the world and become the second cheese type in USA. In Egypt, a specification was set for full cream Mozzarella cheese (Egyptian Standards Specification, 2000). Full fat Mozzarella cheese must contain F/DM not less than 45 % and moisture not more than 54%. Mozzarella cheese functional properties (e.g., meltability, stretchability, browning, blister formation and oiling off) are important mainly due to their ability as a food raw material or food additive during the preparation of different food products such as pizza, pasta, salads, and bakery. Thus the production of such type cheese could be controlled of these characteristics.

Egyptian Organization for Standardization and Quality Control (ES 1008-14/2005) has defined Mozzarella cheese as the fresh soft cheese obtained after coagulation of fresh milk or retentate. Mozzarella cheese can be also obtained from coagulation of a mixture of fresh milk products, dried or pasteurized. In Egypt, there is a shortage in fresh milk production since there is a challenge between wheat production and forage growing. Prices of fresh milks are annually increasing, most of buffalo milk was consumed for drinking, while a part of cow milk is processing into soft white, and Ras cheese the rest is not enough for Mozzarella cheese production. Also, milk adulteration led to decrease of the final dairy products quality. Hence, the present work focused on the production of mozzarella cheese which could be used for different products such as pizza, pasta, salads in home, hotels, and restaurants. It will be prepared form substitute materials as alternative for the high price liquid milk with vegetable oil as a replacement of natural milk fat.

Thus, the present work aimed to produce mozzarella cheese from cow milk using three types acidulates including starter culture, GDL, and acetic acid. The mozzarella cheese making, on the quality, chemical, physical, sensorial, texture profile characteristics, and calcium content were investigated.

2. Materials and Methods

Raw materials and chemicals:

Morning cow milk obtained from the Friesian herd of Sakha Animal Production Station was used for mozzarella cheese experiments. Yoghurt starter culture was obtained from CHR-HANSEN Company Copenhagen, Denmark. Local calf rennet 0.5 N was obtained from Kafr El-Shiekh Governorate was used during the investigation work. Sodium chloride salt brought from EL-Nasr Company, Alexandria for cheese salting. Acetic acid was obtained from El-Gomhoria Chemicals Company. L

2.1 Mozzarella cheese production

Mozzarella cheese made from fresh standardized cow milk contained 3.00% fat, 3.18% protein, 4.46% lactose, 8.10% solid not fat, and 11.34% total solids (milko-scan, model 133B, which acidified by added1% yoghurt starter culture as a control (T1) as described by Kosikowski (1982). The other treatments acidified with GDL (T2) and citric acid (T3) to reach pH5.4 as a direct acidification procedure. The cheese curd was cut into blocks and slices. The slices were kneaded into hot water at 75±2 °C for 5 min to prepare the homogeneous paste which is formed into balls, directly thrown into the cold brine, left three hours. The salted cheese was left to dry on the open air, then rubbed with 3% solution of potassium sorbate; and then left on dried cloth for 6 hours, packed in polyethylene bags. Finally, the cheese curd left for 24 hours at 5±1 °C, then stored at -18 °C for 30 days.

2.2 Chemical characterization of Mozzarella cheese

Cheese yield: Cheese yield=kg of cheese / kg of milk×100. Moisture, fat, and ash contents of milk, and cheese samples were determined according to AOAC (2016). Salt content of cheese was determined using the modified Volhards procedure as described by (Kosikowski 1982). Protein content of milk, and cheese were estimated using the semi micro-Kjeldahl procedure according to Ling (1963). Water soluble nitrogen (WSN), and non-protein nitrogen (NPN) were determined in cheese samples as described by Ling (1963). Total volatile fatty acids (TVFA) of cheese samples were determined according to Kosikowiski (1982) with 0.1 N NaOH. Calcium content of cheese samples were determined as described by Hankinson (1975) using Atomic absorption spectrophotometer No. 3300 (PerkinElmer, US instrument Division Norwalk, CT, USA). Calcium content by flam photometer carried out according to Cottenie et al., (1982)

2.3. Titratable acidity and pH of Mozzarella cheese

The titratable acidity and pH of milk and cheese samples were determined using NaOH (N/9) and phenolphthalein as an indicator according to Ling (1963). The pH of the cheese samples was measured using a pH-meter (Hanna Instruments Model 170300, Ingold, Knick, Germany).

2.4. Physical properties mozzarella cheese

The physical properties of Mozzarella cheese were measured during storage for 30 days as follows: melt ability (mm) of cheese was measured in duplicate by using the melting test tube as described by Olson and Price (1958) with the modification of Rayan et al. (1980). Stretch ability test (cm) of cheese was evaluated as described by Sabikhi and Kanawjia (1992) method. The fat leakage method as described by Ghosh and Singh (1992) was used to determine the oiling off ratio. Oiling off was recorded by compared the area of fat leakage with the area around the original disk. The fat leakage was reported as a ratio of A/B where, A= Area of fat ring, B = Area of original disc.

2.5. Rheological properties of Mozzarella cheese

Texture profile analyses (TPA) of Mozzarella cheese samples during storage for 30 days' ware measured at 23ºC as described by Kosikowski (1982). Using an Instron Universal Tasting Machin model 1195, StableMicro system. (SMS) LTD., Godalming, UK, loaded with Dimension software SMS program. Likwise, Penetration.

2.6. Organoleptic properties

The organoleptic properties of the resultant cheese were assessed by a test panel of 15 persons in Sakha Animal Production Research Station, Animal Production Research Institute according to the scheme described by Nelson and Trout (1981).

2.7. Statistical Analysis

Results were statistically analyzed design to study the effect of treatment using SAS (2004). However, the significant differences among means were tested using Duncan's Multiple Range Test Duncan (2004).

3. Results

Cheese yield:

It is clear from Figure (1) the yield % was increased in fresh cheese as compared with period storage. It is also observable that the yield of treatment control (T1) was higher than other treatments in fresh and the end period storage, which contained 10.85, 10.5, and 10 from control T1, T2 and T3, respectively. During storage, the yield of cheese was decreased in all treatments with advanced storage, may be due to changes in the moisture content.

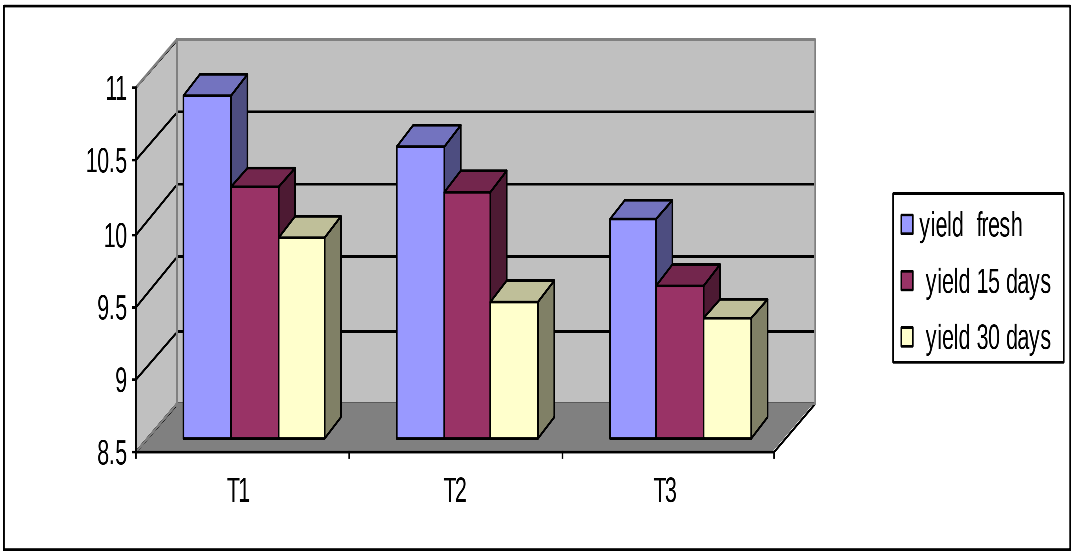

Fig: (1). The yield of mozzarella cheese from cow milk using different acidulates during storage for 30 days.

Table 1. Chemical changes of mozzarella cheese from cow milk using different acidulates during storage for 30 days

Parameter	Storage (day)	Cheese treatment			Mean ± SE
		Control) T1	T2	T3	
Dry matter (DM) %	Fresh	45.83±0.21	44.50±0.2	44.40±0.21	44.91±0.12^{c}
	15	46.80±0.2	45.23±0.21	45.42±0.2	45.82±0.12^{b}
	30	47.84±0.2	46.65±0.21	46.58±0.2	47.02±0.12^{a}
	Mean ± SE	46.82±0.12^{A}	45.46±0.12^{B}	45.47±0.12^{B}	
Fat/DM %	Fresh	46.91±0.28	45.41±0.28	44.23±0.3	45.52±0.16^{b}
	15	46.37±0.28	48.20±0.28	45.42±0.3	46.66±0.16^{a}
	30	46.40±0.3	47.44±0.28	45.72±0.28	46.52±0.16^{a}
	Mean ± SE	46.56±0.16^{A}	47.02±0.16^{A}	45.12±0.16^{B}	
Ash/DM %	Fresh	8.00±0.05	7.90±0.05	8.06±0.05	7.989±0.03^{a}
	15	7.94±0.05	7.61±0.05	7.87±0.05	7.806±0.03^{b}
	30	7.90±0.05	7.48±0.05	7.67±0.05	7.686±0.03^{C}
	Mean ± SE	7.95±0.03^{A}	7.66±0.03^{B}	7.87±0.03^{A}	
Protein/DM%	Fresh	46.20±0.5	43.11±0.5	41.55±0.5	43.62±0.5^{b}
	15	48.23±0.5	44.63±0.5	42.87±0.5	45.25±0.5^{a}
	30	47.55±0.5	45.96±0.5	43.67±0.5	45.73±0.5^{a}
	Mean ± SE	47.33±0.5^{A}	44.57±0.5^{B}	42.70±0.5^{C}	
Salt/DM %	Fresh	2.50±0.03	2.49±0.03	2.83±0.03	2.61±0.03^{c}
	15	2.62±0.03	2.68±0.03	2.87±0.03	2.72±0.03^{b}
	30	2.82±0.03	2.85±0.03	2.97±0.03	2.88±0.03^{a}
	Mean ± SE	2.65±0.03^{B}	2.67±0.03^{B}	2.89±0.03^{A}	

(Control) **T1,** starter acidification; **T2**, GDL acidification; **T3**, direct acidification with citric acid. All parameters are represented as mean of replicates ±standard error. Means with different superscript letters are significantly different at *p* ≤0.05

Table 2. Titratable acidity and pH changes of mozzarella cheese from cow milk using different acidulates during storage for 30 days.

Parameter	Storage (day)	Cheese treatment			Mean ± SE
		(Control) T1	T2	T3	
Titratable acidity %	Fresh	0.65±0.02	0.65±0.03	0.76±0.03	0.75±0.03^{c}
	15	0.89±0.03	0.89±0.03	0.95±0.02	0.92±0.03^{b}
	30	1.11±0.02	1.11±0.03	1.04±0.03	1.06±0.03^{a}
	Mean ± SE	0.88±0.01$^{\beta}$	0.93±0.01$^{\Lambda}$	0.92±0.01$^{\Lambda\beta}$	
pH	Fresh	5.63±0.06	5.65±0.06	6.17±0.05	5.82±0.01^{a}
	15	5.05±0.05	4.95±0.06	4.98±0.06	4.99±0.01^{b}
	30	4.69±0.05	4.68±0.05	4.66±0.06	4.68±0.01^{c}
	Mean ± SE	5.12±0.03$^{\beta}$	5.09±0.03$^{\beta}$	5.27±0.03$^{\Lambda}$	

(Control) **T1,** starter acidification; **T2**, GDL acidification; **T3**, direct acidification with citric acid. All parameters are represented as mean of replicates ±standard error. Means with different superscript letters are significantly different at *p* ≤0.05

Chemical properties of cheese

The results of the chemical composition of all experimental of mozzarella cheese in fresh are shown in Table (1). Cheese from (Control) T1 had a higher significant differences (P<0.05) in DM, fat/DM, Ash /DM, and Protein /DM content than other treatments. These results are mainly attributed to add type of acidification in milk cheese. The Salt / DM in treatments (Control) T1 andT2 were lower than treatment T3. During storage, the Salt / DM content of all treatments increased until the end of period storage, but the DM in all treatments were increased. Differences in the moisture content ran parallel that of the cheese yield which indicate that the change in yield was related to change in moisture content.

Data presented in Table (2) showed that the Titratable acidity and pH changes of mozzarella cheese from cow milk using different acidulates during storage for 30 days at -18 °C. T2 was higher significant differences ($P<0.05$) in titratable acidity and the pH was lower in this treatment were mainly due to add GDL acidification in milk cheese than other treatments. The addition of GDL to cheese milk decreased markedly the dry matter, ash and salt/DM contents of the resultant cheese. The acidity percentages of GDL cheese treatments were higher than that other treatments cheese. the acidic properties of GDL. The observed differences in cheese acidity and pH between the treatments may be related to a difference in cheese buffering capacities. The acidity of cow's milk cheese by starter acidification was lower than other treatments.

However, Mozzarella cheese stored at -18°C, the titratable acidity of all cheese treatments increased significantly ($P< 0.001$), while the pH values of all samples decreased significantly ($P< 0.001$) during storage. The increase in pH may be associated with the gradual increase in para-casein hydration and the increased availability of various protein residues (e.g., ε- and α-carboxyl groups of aspartic and glutamatic acids), which combine with H^+ during storage and thereby reduce the hydrogen ion activity of the moisture phase of the cheese.

Table 3 shows different variation in TN whereas slight increase was found (Control) T1 when added yoghurt starter while added GDL and citric acid were decrease.TN, WSN/TN, NPN/TN and Total volatile fatty acids (TVFA) contents in Treatment (Control) T1 was significantly higher than that of the other treatments. The concentrations of fat and TN increased significantly in all cheese during storage at -18°C for 30 days. The changes in WSN, WSN/TN and TVFA contents of cheese between different treatments and within storage are shown in Table (3). Treatments had a large impact on both WSN and TVFA. Age (during storage for 30days) also had an effect on WSN and TVFA. The treatment (Control) T1 had higher water soluble N, WSN/TN and TVFA than the other samples of cheeses.

As storage time increased, both WSN and TVFA significantly ($P< 0.001$) increased in all cheese treatments. The rate of increase in proteolysis during storage occurred faster in cheese made using GDL, yoghurt starter. and direct acidification with lactic acid to produce cheeses at pH 5.9 (by direct acidification) and pH 5.5 (directs acidification and culture addition) and observed greater stretch ability and flow ability of the pH 5.5cheese even though both had similar calcium levels. However, because of adding culture, the pH 5.5 cheese had higher protein breakdown during 30 days of storage.

Results in Table (4) show that Calcium content of mozzarella cheese was affected by acidification treatment, and storage periods The acidified treatments had less calcium content than the treatments at all times, and this was correlated with lower cheese pH. Pre acidification with GDL caused a larger decrease in calcium than other acidification. Generally, the observed decrease in cheese calcium content and increase in whey calcium content with acidification was expected. The addition of acid to milk causes an increase in no micellar calcium.

Table 3. Ripening indices properties of mozzarella cheese from cow milk using different acidulates during storage for 30 days.

Parameter	Storage (day)	Cheese treatment (Control) T1	T2	T3	Mean ± SE
Total Nitrogen (TN%)	fresh	45.83±0.21	44.50±0.2	44.40±0.21	44.91±0.12^{c}
	15	46.80±0.2	45.23±0.21	45.42±0.2	45.82±0.12^{b}
	30	47.84±0.2	46.65±0.21	46.58±0.2	47.02±0.12^{a}
	Mean ± SE	46.82±0.12^{A}	45.46±0.12^{B}	45.47±0.12^{B}	
WSN/TN %	fresh	46.91±0.28	45.41±0.28	44.23±0.3	45.52±0.16^{b}
	15	46.37±0.28	48.20±0.28	45.42±0.3	46.66±0.16^{a}
	30	46.40±0.3	47.44±0.28	45.72±0.28	46.52±0.16^{a}
	Mean ± SE	46.56±0.16^{A}	47.02±0.16^{A}	45.12±0.16^{B}	
NPN/TN%	fresh	8.00±0.05	7.90±0.05	8.06±0.05	8.02±0.05^{a}
	15	7.94±0.05	7.61±0.05	7.87±0.05	7.806±0.05^{b}
	30	7.90±0.05	7.48±0.05	7.67±0.05	7.686±0.05^{c}
	Mean ± SE	7.95±0.05^{A}	7.66±0.05^{B}	7.87±0.05^{A}	
Total volatile fatty acids (TVFA) %	fresh	7.37±0.06	6.53±0.06	6.72±0.06	6.88±0.06c
	15	15.26±0.06	12.50±0.06	14.59±0.06	14.12±0.06b
	30	20.10±0.06	18.52±0.06	19.48±0.06	19.37±0.06a
	Mean ± SE	14.25±0. 06^{A}	12.52±0. 06^{C}	13.60±0. 06^{B}	

(Control) T1, starter acidification; **T2**, GDL acidification; **T3**, direct acidification with citric acid. All parameters are represented as mean of replicates ±standard error. Means with different superscript letters are significantly different at $p \leq 0.05$

Table 4. Calcium content of mozzarella cheese from cow milk using different acidulates during storage for 30 days.

Parameter (mg/100g)	Storage (day)	Cheese treatment			Mean ± SE
		(Control) T1	T2	T3	
Calcium	Fresh	0.60±0.001	0.58±0.002	0.65±0.001	0.61±0.001[c]
	15	0.63±0.002	0.59±0.001	0.68±0.001	0.63±0.001[b]
	30	0.64±0.001	0.60±0.001	0.71±0.002	0.65±0.001[a]
	Mean ± SE	0.62±0.001[B]	0.59±0.001[C]	0.68±0.001[A]	

(Control) **T1,** starter acidification; **T2**, GDL acidification; **T3**, direct acidification with citric acid. All parameters are represented as mean of replicates ±standard error. Means with different superscript letters are significantly different at $p \leq 0.05$.

Table 5. Physical changes of mozzarella cheese using different acidulates during storage for 30 days.

Parameter	Storage (day)	Cheese treatment			Mean ± SE
		(Control) T1	T2	T3	
Meltability (mm)	fresh	116.00±2.17	115.00±2.17	120.67±2.17	117.22±2.17[c]
	15	147.00±2.17	135.67±2.17	145.00±2.17	142.56±2.17[b]
	30	173.00±2.17	168.33±2.17	157.33±2.17	166.22±2.17[a]
	Mean ± SE	145.33±2.17[A]	139.67±2.17[A]	141.00±2.17[A]	
Stretchability (cm)	fresh	75.33±0.55	70.08±0.55	75.00±0.55	73.47±0.55c
	15	97.67±0.55	96.90±0.55	92.00±0.55	95.52±0.55[b]
	30	116.33±0.55	116.97±0.55	113.00±0.55	115.43±0.55[a]
	Mean ± SE	96.44±0.55[A]	94.65±0.55[B]	93.33±0.55[B]	
Oiling off	fresh	2.45±0.05	1.48±0.05	2.30±0.05	2.08±0.05c
	15	4.73±0.05	3.10±0.05	3.48±0.05	3.77±0.05[b]
	30	5.27±0.05	4.43±0.05	4.36±0.05	4.69±0.05[a]
	Mean ± SE	4.15±0.05[A]	3.01±0.05[C]	3.38±0.05[B]	
fat leakage (cm^2)	fresh	34.67±0.57	34.67±0.57	33.33±0.57	34.22±0.57c
	15	36.67±0.57	38.00±0.57	36.00±0.57	36.89±0.57[b]
	30	42.00±0.57	42.00±0.57	41.00±0.57	41.67±0.57[a]
	Mean ± SE	37.78±0.57[A]	38.22±0.57[A]	36.78±0.57[A]	

(Control) **T1,** starter acidification; **T2**, GDL acidification; **T3**, direct acidification with citric acid. All parameters are represented as mean of replicates ±standard error. Means with different superscript letters are significantly different at $p \leq 0.05$

Meltability, oiling off and fat leakage of Mozzarella cheese:

In a statistical analysis of all of the data for days fresh, 15, and 30 days combined, the cheese meltability and oiling off were affected ($P < 0.001$) by acidification treatment and day of storage.

Table (5) presents the changes in meltability of Mozzarella cheeses over 30 days of storage at -18°C. The treatment T2 made with adding GDL to cheese milk displayed the lowest meltability. Cheeses containing GDL and citric acid (Treatments 2 and 3) were expected to show greater meltability resulting from the combined effects of acidification that reduced the calcium–casein interactions and stimulated primary proteolysis by starter. This occurred in cow's milk cheese, meltability increased by 117.22, 142.56 and 166.22% at the end of storage for (Control) T1, T2, and T3 respectively. These results establish the impact of calcium reduction on meltability of cheese.

Reducing the calcium causes increased interaction of proteins with surrounding serum, causing more hydration of proteins and better melting of the cheese. As moisture is absorbed from fat serum channels into the protein matrix, the proteins become more hydrated. This allows the proteins to flow more easily when heated and results in improved meltability. The microstructure of reduced calcium cheeses also showed that such cheeses had more fat particles entrapped in the protein matrix compared with the control cheese, which might have contributed in better melting. Casein in the reduced calcium curd better emulsifies fat so that less fat oozes out when the cheese is heated, resulting into better melting. During storage, an increase in melt area of the cheeses was observed (Table5). However, improvement in meltability of high calcium cheeses (Control) T1was more noticeable upon storage compared with that of the low calcium other treatments.

Table 6. Rheological characteristics of mozzarella cheese from cow milk using different acidulates during storage for 30 days at 5 °C.

Parameter	Storage (day)	Cheese treatment			Mean ± SE
		(Control) T1	T2	T3	
Hardness (kg)	Fresh	0.60±0.01	0.58±0.01	0.58±0.01	0.59±0.01[a]
	15	0.42±0.01	0.44±0.01	0.48±0.01	0.45±0.01[b]
	30	0.41±0.01	0.41±0.01	0.42±0.01	0.41±0.01c
	Mean ± SE	0.47±0.01B	0.48±0.01B	0.50±0.01A	
Chewiness (kg/mm)	Fresh	4.28±0.02	4.26±0.02	4.20±0.02	4.25±0.02c
	15	5.44±0.02	5.34±0.02	5.26±0.02	5.35±0.02[b]
	30	6.263±0.02	6.14±0.02	6.25±0.02	6.22±0.02[a]
	Mean ± SE	5.33±0.02A	5.25±0.02B	5.24±0.02B	
pringiness (mm)	Fresh	13.57±0.11	12.87±0.11	12.87±0.11	13.11±0.11c
	15	14.51±0.11	13.94±0.11	13.84±0.11	14.10±0.11[b]
	30	15.27±0.11	14.83±0.11	14.56±0.11	14.89±0.11[a]
	Mean ± SE	14.45±0.11A	13.88±0.11B	13.76±0.11B	
Cohesiveness (ratio)	Fresh	0.45±0.01	0.44±0.01	0.46±0.01	0.45±0.01c
	15	0.53±0.01	0.47±0.01	0.49±0.01	0.50±0.01[b]
	30	0.58±0.01	0.55±0.01	0.53±0.01	0.55±0.01[a]
	Mean ± SE	0.52±0.01A	0.49±0.01B	0.49±0.01B	

(Control) **T1,** starter acidification; **T2**, GDL acidification; **T3**, direct acidification with citric acid. All parameters are represented as mean of replicates ±standard error. Means with different superscript letters are significantly different at $p \leq 0.05$.

Changes in cheese structure due to protein breakdown play an important role in contributing to increase melting of cheese during storage. Proteolysis of casein allows fat globules, which are initially dispersed in the protein matrix, (Kiely et al., 1992; Tunick et al., 1997). An increase in the meltability of cheese during storage can be explained in terms of changes in water and protein status within the cheese. Data presented in Table (5) showed that the acidification significantly increased (P< 0.05) the Stretchability and oiling off values of the cheese. This may be explained by added acids formed certain emulsifying system led to the retention and binding tightly the fat in the curd (El-Zoghby 1994). From the obtained results were found that the type of acidification affected the values of oiling off, and stretchability in general the all cheeses showed the highest oiling off in all treatments. This may be related to the size of fat globules of the milk.

The rheological role of casein in cheese is to provide a continuous elastic framework for individual cheese granules. Cheese made from (T2) was lower significantly (P<0.05) in hardness, Chewiness, Springiness and Cohesiveness and chewiness than the other cheese, the gumminess is the product of hardness, cohesiveness a chewiness of cheese made from (T2) was less adhesiveness but more cohesive than others treatments. This property expressed mathematically as the product of gumminess the same trend of those property. Include those factors that affect the curd moisture content (as temperature of coagulate and drain whey) cheese composition, pH casein and serum protein Ca content, salt, fat and manufacturing of cheese for its many desirable functional and texture. In addition, increasing the moisturecontent might result in increase in the level of free moisture in cheese, this increased the hardness.

Table 7. Organoleptic properties of mozzarella cheese from cow milk using different acidulates during storage for 30 days.

Parameter	Storage (day)	Cheese treatment (Control) T1	T2	T3	Mean ± SE
Flavor (50)	Fresh	42.00±0.47	42.00±0.47	42.33±0.47	42.11±0.27 ^{a}
	15	41.33±0.47	43.67±0.47	42.00±0.47	42.33±0.27 ^{a}
	30	41.67±0.47	41.33±0.47	41.67±0.47	41.56±0.27 ^{a}
	Mean ± SE	41.67±0.27 ^{A}	42.33±0.27 ^{A}	42.00±0.27 ^{A}	
Body and texture (40)	Fresh	33.33±0.54	34.67±0.54	34.33±0.54	34.11±0.31 ^{a}
	15	32.67±0.54	33.33±0.54	34.67±0.54	33.56±0.31 ^{a}
	30	34.33±0.54	34.33±0.54	34.33±0.4	34.33±0.31 ^{a}
	Mean ± SE	33.44±0.31 ^{B}	34.11±0.31 ^{AB}	34.44±0.31 ^{A}	
Appearance (10)	Fresh	6.00±0.53	6.67±0.53	7.33±0.53	6.67±0.31 ^{a}
	15	7.67±0.53	6.00±0.53	6.00±0.53	6.56±0.31 ^{a}
	30	6.67±0.53	6.67±0.53	6.00±0.53	6.44±0.31 ^{a}
	Mean ± SE	6.78±0.31 ^{A}	6.44±0.31 ^{A}	6.44±0.31 ^{A}	
Overall acceptability (100)	Fresh	81.33±0.84	83.33±0.84	84.00±0.84	82.89±0.48 ^{a}
	15	81.67±0.84	83.00±0.84	82.67±0.84	82.44±0.48 ^{a}
	30	82.67±0.84	82.33±0.84	82.00±0.84	82.33±0.48 ^{a}
	Mean ± SE	81.89±0.48 ^{A}	82.89±0.48 ^{A}	82.89±0.48 ^{A}	

(Control) **T1,** starter acidification; **T2**, GDL acidification; **T3**, direct acidification with citric acid. All parameters are represented as mean of replicates ±standard error. Means with different superscript letters are significantly different at $p \leq 0.05$.

Organoleptic evaluation of Mozzarella cheese:

Test panel evaluation values were recorded in Table (7). Mozzarella cheese made using three types of different acidulates yoghurt starter and GDL and citric acid gained the highest score when it was fresh and also at the end of storage period. The sensory evaluation of all cheese treatments gradually improved during storage period reaching the highest score after 30 days of storage. So, from the previous study acceptable Mozzarella cheese can be made using GDL (T2), citric acid, and yoghurt starter.

4. Discussion

The yield of cheese during storage were decreased in all treatments with advanced storage, may be due to changes in the moisture content. These findings are partly in agreement with those reported by Salama et al. (1982). Differences in the moisture content ran parallel that of the cheese yield which indicate that the change in yield was related to change in moisture content. These results agree with those reported by various workers (Hofei et al., 1979; Mehanna and Rashed, 1990; Shehata et al., 1995).

Titratable acidity and pH changes of mozzarella cheese from cow milk using different acidulates during storage for 30 days at -18 °C. T2 was higher significant differences (P<0.05) in titratable acidity, and the pH was lower in this treatment were mainly due to add GDL acidification in milk cheese than other treatments. The addition of GDL to cheese milk decreased markedly the dry matter, ash and salt/dm contents of the resultant cheese. Similar results were found by Jensen et al., (1987) The acidity percentages of GDL cheese treatments were higher than that other treatments cheese this attributed to the acidic properties of GDL. The observed differences in cheese acidity and pH between the treatments may be related to a difference in cheese buffering capacities as a result of different calcium levels (Metzger et al., 2001). The acidity of milk cheese by starter acidification was lower than other treatments. While the pH values of all samples decreased significantly (P< 0.001) during storage. The increase in pH may be associated with the gradual increase in para-casein hydration and the increased availability of various protein residues (e.g., ε- and α-carboxyl groups of aspartic and glutamatic acids), which combine with H+ during storage and thereby reduce the hydrogen ion activity of the moisture phase of the cheese. In turn, the increase in para casein hydration may be affected by changes in the equilibrium concentrations of soluble and colloidal calcium phosphate (Guo et al., 1997). During cheese manufacture, the micellar calcium in milk is retained in the cheese, while the no micellar calcium is lost in the whey. Therefore, as a result of acidification, the high level of no micellar calcium caused the observed decrease in cheese calcium content and increase in whey calcium content. Increased calcium content, decreased pH, and increased acidity of the whey resulting from acidification may have impacts on whey processing and whey product functionality (van Hooydonk et al, 1986 and Dalgleish and Law, 1988). shows different variation in TN whereas slight increase was found (Control) T1 when added yoghurt starter while added GDL and citric acid were decrease. Similar results were found by Fahey (2005) who acidified cheese milk with lactic acid and added GDL as a powder with salt to the curd.TN, WSN/TN, NPN/TN and Total volatile fatty acids (TVFA) contents in Treatment (Control) T1 was significantly higher than that of the other treatments. The concentrations of fat and TN increased significantly in all cheese during storage at 5°C for 30 days. These results are in agreement with El-Zoghby (1994). The changes in WSN, WSN/TN and TVFA contents of cheese between different treatments and within storage are shown in Table (3). Treatments had a large impact on both WSN and TVFA. Age (during storage for 30days) also had an effect on WSN and TVFA. The treatment (Control) T1 had higher water soluble N, WSN/TN and TVFA than the other samples of cheeses. This is in accordance with the results of Abdel-Kader (1993). As storage time increased, both WSN and TVFA significantly ($P< 0.001$) increased in all cheese treatments. The rate of increase in proteolysis during storage occurred faster in cheese made using GDL, yoghurt starter. and direct acidification with lactic acid, Sheehan and Guinee (2004) produced cheeses at pH 5.9 (by direct acidification) and pH 5.5 (directs acidification and culture addition) and observed greater stretchability and flowability of the pH 5.5 cheese even though both had similar calcium levels. Also, during storage the calcium content of cheese increased in all treatments. the type of acidification affected the values of oiling off, and stretchability in general the all cheeses showed the highest oiling off in all treatments. This may be related to the size of fat globules of the milk. The bigger size of fat globule. in milk led to more oiling off in the cheese product (Bikash et al., 1996). Also, Kindstedt (1993) mentioned that fat leakage was increased with increasing cheese fat on DM basis. The amount of free oil increases at higher cheese fat levels (Tunick, 1994; Tunick et al., 1997). and pH 5.5 (directs acidification and culture addition) and observed greater stretchability and flowability of pH 5.5 cheese even though both had similar calcium levels. However, because of adding culture, the pH 5.5 cheese had higher protein breakdown during 30 days of storage. Increased calcium content, decreased pH, and increased acidity of the whey resulting from acidification may have impacts on whey processing and whey product functionality (van Hooydonk et al., 1986; Dalgleish and Law, 1988). The stretchability and oiling off values of the cheese. This may be explained by added acids formed certain emulsifying system led to the retention and binding tightly the fat in the curd (El-Zoghby 1994). Changes in cheese structure due to protein play an important role in contributing to increase melting of cheese during storage. Proteolysis of casein allows fat globules, which are initially dispersed in the protein matrix, (Kiely et al., 1992). gumminess is the product of hardness, cohesiveness and chewiness of cheese made from (T2) was less adhesiveness but more cohesive than others, these results were in agreement with Kaminarides et al., (2000), and Awad (2011) who described the chewiness to be number of chews required to swallow a certain amount of sample. The sensory evaluation of all cheese treatments gradually improved during storage period reaching the highest score after 30 days of storage. So, from the previous study acceptable Mozzarella cheese can be made using GDL (T2), citric acid, and yoghurt starter.

5. Conclusions

The results of the present study for manufactured Mozzarella cheeses from additives of acidification to milk showed that cheese from (Control) T1 was higher in yield DM, fat/DM, Ash /DM, Protein /DM, water soluble N, WSN/TN and TVFA content than other treatments while T2 was lower in the pH, Ca, hardness, Chewiness, Springiness, Cohesiveness, and chewiness than others treatments. Mozzarella cheeses cheese made from meltability increased by 117.22, 142.56 and 166.22% at the end of storage for T1, T2, and T3 respectively.

Reference

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

Awad, S. (2011). Texture and Microstructure. In Practical Food and research. (Ed.Rui M,Cru S.), Nova Sci. publishers, Inc. pp.361-391.

A.O.A.C (2007). Associaction of Official Analytical Chemists. Official Methods of Analysis, 15 Ed. Washington, D.C., pp.803-845

Bourne, M._(2002). Food Texture and Viscosity: Concept and Measurement .2nd ed. San Diego: Academic Press, p 415.

Dalgleish, D.G. and Law, A.J.R. (1988): pH-Induced dissociation of bovine casein micelles. I. Analysis of liberated caseins. J. Dairy Res. 55:529–538.

Duncan, D. B. (2004) Multiple Range and Multiple F-Test. *Biometrics*, 11, 1-42.

El-Zoghby, A.S. (1994): Studies on Mozzarella cheese. Ph.D. Thesis, Fac. of Agric. Zagaaig Univ., Egypt.

Fahey, JW. (2005). Moringa oleifera**:** A review of the medical and plant for its nutritional therapeutic and prophylactic properties. Part 1. In: trees for Live of Journal Beneficial Trees and Plants. Maryland. 1:1-5.

Guo, M.R.; Gilmore, J.K.A. and Kindstedt, P.S. (1997): Effect of sodium chloride on the serum phase of Mozzarella cheese. J. Dairy Sci. 80:3092–3098

Houghtby, G, A.; Maturin L.J. and Koening E.K. (1992). Microbiologi count methods In: R.T. marshal (Ed). Standard methods for the examination of dairy products (16 Ed.) American Public Health Association, Washington, D.C, USA. 213-246.

Joshi, N.S.; Muthukumarappan, K. and Dave, R. I. (2004): Effect of calcium on microstructure and meltability of part skim Mozzarella cheese. J. Dairy Sci., 87:1975-1985.

Kaminarides, S.; Ioannis, L.; Theophilos, M. and Aikaterini, G. (2015). The effect of cooking time on curd composition and textural properties of sheep Halloumi cheese. Small. Rumi. Res. 125: 106–114.

Kiely, L.J.; Kindstedt, P.S.; Hendricks, G.M.; Levis, J.E.; Yun, J.J. and Barbano, D.M. (1992). Effect of draw pH on the development of curd structure during the manufacture of Mozzarella cheese. Food Struct. 11:217–224

Lee, S.C.; Kim, J.H.; jeong, S.M.; Kim, D.R.; Ha, J.U. and Nam, K.C. (2003). Effect of far-infraraed radiation on the antioxidant activity of rice hulls, J. Agri. and food chemi. 51: 4400- 4403.

Lawson, P.A.; Papademas. P.; Wacher, C.; Falsen, E.; Robinson, R.K. and Collins, M.D. (2001). Lactobacillus cypricaseisp. nov., isolated from Halloumi cheese. Int. J. of Systematic and Evolutionary Microbiology. 51: 45–59**.**

McLean, E.; Cogswell, ME.; Egli, I.; Wojdyla, D.; de Benoist, B. and Mary, B. (2009). Worldwide prevalence of anemia, World Health Organization vitamin and mineral nutrition information syste19932005. Public Health Nutrit; 12:444-54.

Milci, S.; Goncu, A.; Alkent, Z. and Yaygın, H. (2005). Chemical, microbiological and sensory characterization of Halloumi cheese produced from ovine, caprine and bovine milk. Int. Dairy J. 15: 625-630.

McMahon, D.J.; Oberg, C.J. and McManus, W. (1993): Functionality of Mozzarella cheese. Aust. J. Dairy Technol. 48:99–104.

Nelson, J.A. and Trout, G.M. (1981). Judging of Dairy Products ,4th Ed. INC Westport, Academic Press, 345-567.

Nezhad, M.H. Duc.; Han, N.F. and Hosseinian F. (2013). Flaxseed soluble dietary fiber enhances Lactic acid bacterial survival and growth in kefir and possesses high antioxidant capacity. J. Food Res.2: 152-163.

SAS (2004)**.** SAS Institute Inc. SAS User's Guide, Statistics. Cary, NC.

Sheehan, J.J., and Guinee, T.P. (2004): Effect of pH and calcium level on the biochemical, textural and functional properties of reduced fat Mozzarella cheese. Int. Dairy J. 14:161 –172.

Tunick, M.H.; Cooke, P.H.; Malin, E.L.; Smith, P.W. and Holsinger, V.H. (1997): Reorganization of casein submicelles in Mozzarella cheese during storage. International Dairy J. 7 (2-3): 149-155.

van Hooydonk, A.C.M.; Boerrigter, I.J. and Hagedoorn, H. G. (1986): pH-induced physico-chemical changes of casein milk and their effect on renneting. 1. Effect of acidification on physico-chemical properties. Neth. Milk Dairy J. 40:281–296.

Author Contributions: Conceptualization, E.N., B.A., H.M., and G.M.;data curation,.G.M.and E.N; formal analysis, A.M. and E.N; funding acquisition E.N., B.A.; investigation, E.N.,B.A., H.M., and A.M.; methodology, E.N., and; resources, E.N. and A.G.; software ,E.N.; supervision, H.M., B.A. and E.N.; validation. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding"

Institutional Review Board Statement: Not applicable" for studies not involving humans or animals.

Acknowledgments: The research participants extend their thanks to the workers at Tanta University, the Animal Production Research Institute, and the Dairy Production Training Unit at the Agricultural Research Center.