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Effect of pH Value of Milk and Tomato Paste on The Quality and Properties of Mozzarella Cheese

Mohamed Mohamed El-Metwally, Sherif Abd El-Khalek Osman and Monira Mahmoud Basiony

Dairy Technology Department, Animal Production Research Institute, Agricultural Research Center, Egypt

*** Corresponding author**
Monira Mahmoud Basiony

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Abstract

To study the effect of adding tomato paste (as a natural acidulant) to Mozzarella cheese milk on the yield, chemical composition, texture profile, and organoleptic properties of the resultant cheeses. Four treatments were applied: cheese made with a starter culture (control), and the rest three treatments were acidified by tomato paste to pH 6.0, 5.8, and 5, 6, respectively. The resultant cheese of all treatments was evaluated when fresh and after 60 days of storage. Results showed that the addition of tomato paste increased the yield slightly, when fresh and at the end of the storage period, compared with the control one. A direct relationship was noticed between the gross chemical composition of Mozzarella cheese and both the combined action of pH milk and tomato paste added. Texture profile results showed that the control cheese had higher values in all parameters than in the tomato paste treatments except for cohesiveness and springiness values either when fresh or after 60 days of storage. Control cheese had organoleptic properties lower than the tomato paste treatments during storage and adding the tomato paste to cheese milk to reach pH 5.6 gave the best organoleptic properties of Mozzarella cheese.

Key words: Mozzarella, tomato paste, Texture profile, natural acidulant

Introduction

Mozzarella cheese is a soft, un-ripened variety belong to the Pasta-filata family, **(kosikowski, 1982)**. It made by a special plasticizing and kneading process that gives the finished cheese its distinctive fibrous structure, melting, and stretching capabilities **(Kindstedt et al., 1992)**. Most types of pizza, Lasagna, or dishes with sliced tomatoes and basil employ different types of Mozzarellas, (Anonymous, 2009). Fresh Mozzarella is a sliceable curd cheese that originated in Italy and is also considered one of the healthier cheeses due to its low fat and sodium content. Traditionally it derived from the milk of water buffalo, not North American buffalo or bison, and its delicate, milky flavor is widely coveted. Water cow's milk Mozzarella is less nutritious than buffalo's milk Mozzarella, had lower concentrations of calcium, protein, and iron, as well as being higher in cholesterol. Most Mozzarella is now produced from cow's milk.

Tomatoes are available in Egypt around the year at acceptable prices, and a part of the crop is processed into tomato paste or juice. Tomato has a high concentration of lycopene (antioxidant), reduces power activities, and plays a critical role in decreasing the risk of some cancer types of diseases. Because tomatoes are rich in active components, such as polyphenols and carotenoids as well as several rutins and naringenins, tomatoes can be considered as a functional vegetable **(Alsuhaibani, 2018).**

Few literatures were found about the use of tomato paste or tomato juice in the field of cheese making. **Abd El-Aziz and Refaey, (2017),** studied the effect of adding tomato juice to cheese milk for the processing of Mozzarella cheese. They found that, the best cheese was obtained with tomato juice as compared with the control cheese made by the starter culture.

Tomato paste is made from fresh, healthy, ripe tomato fruits that are mechanically harvested and are essentially free from any undesirable materials that can impact the fruit's quality. The product is prepared by thermal treatment and is completely free from any additives, pathogenic microorganisms, and other hazards. The chemical composition of tomato paste was (g/100g), 19 carbohydrates, 4.3 protein, 0.5 fat, and 0.0 cholesterol; minerals (mg/100 g), 36 calcium, 42 magnesium, 3 iron as well as sodium and potassium, and vitamins, (mg/ 100g), 21.9 C, 0.2 B6 and D. Acidity, min. 2.0 ± 1.0 (as anhydrous citric acid w / w), and pH at 20°C is 3.60 – 4.5.

The objective of this study was to investigate the possibility of using tomato paste (as a natural acidulant) to pre-acidification cheese milk, to pH 6.0, 5.8, and 5.6, and compare the resultant cheeses with the control one made by the starter culture, from the view of physicochemical, texture profile and organoleptic properties, when fresh and after 60 days of storage period.

Materials And Methods

Materials

Fresh cow's milk which obtained from El-Serw Station, Animal Production Research Institute, Agriculture Research Center, Egypt, had TS 11.1%, fat 3.5%, protein 3.32%, and casein 2.8%. Commercial animal liquid rennet was bought from the local market (added at 25 ml /100 kg milk). Yoghurt starter culture containing *Streptococcus thermophilus and Lactobacillus delbrueckii subsp bulgaricus* was obtained from Egyptian Microbial Culture Collection (MIRCEN), Ain Shams University, Egypt. Tomato paste was purchased from Kaha Company for foods and additives, Egypt, and used as a natural acidulant.

Methods

Mozzarella Cheese Manufacture

Mozzarella cheese was made mainly from cow's milk by using the method described by **Scott (1981)**.

Four Treatments Were Done as Follows

cow's milk + 0.5 % yoghurt starter until pH reached 6.2 (control), cow's milk + Tomato paste until pH reached 6.0 (T_1), cow's milk + Tomato paste until pH reached 5.8 (T_2) and cow's milk + Tomato paste until pH reached 5.6 (T_3). The resultant cheese of all treatments was stored for 60 days, and three replicates of each treatment were carried out.

Methods Of Analysis

Chemical Analysis

Total solids, fat and total nitrogen (determined by the semi-micro Kjeldahl method) contents of milk, whey, and cheese samples were determined according to **AOAC (2000)**. Titratable acidity (estimated as lactic acid), and ash contents of milk, cheese and whey were done as **Ling (1963)**. pH value was measured using a glass electrode pH meter, Janway 3019 – England. Salt content as described by **(Richardson 1985)**.

Casein Calculation

Casein content represents 79.0% of the total cow protein contents **(Wong et al. 1988).**

Cheese Yield

Cheese yield was calculated as kg of fresh cheese per 100 kg of milk used.

Rheological Analyses

Texture profile of Mozzarella cheese was measured at 23ºC as described by Bourne (1982**),** using an Instron Universal Testing Machine model 1195, Stable Micro System (SMS) LTD., Godalming, UK, loaded with Dimension software SMS program. Likewise, Penetration values measured as mentioned by **Bourne (1982**).

Organoleptic Evaluation

Samples of cheese were organoleptically scored by the staff members of El-Serw Station, Animal Production Research Institute, Ministry of Agriculture. The score points were 30 for color and appearance, 30 for body and texture and 40 for flavor.

Statistical Analysis

The results were statistically analyzed using SAS, 2004. However, the significant differences among means were tested using Duncan's Multiple Range Test, 1955.

Results And Discussion

Table (1) shows that as the pH value of the milk decreased the total solids (TS), fat, protein, casein, and ash contents were increased. This increase in TS and protein values was due to the addition of tomato paste, which contains approximately 28-30 % TS and 4.30 % protein. Decreasing the pH value may also play a role in that. Treatment T_3 (pH 5.6) recorded the highest significant ($p < 0.05$) values of TS and protein being 13.2 and 3.6 %, respectively, compared with the control treatment, 11.1 and 2.80 %, made with the starter culture (control). Values of F/ TS and P/TS were found nearly similar among all treatments.

Table (1): Gross chemical composition (%) of the control and cheese milk with different pH values, fortified by tomato paste (Average of 3 replicates) *.

Treatments	T.S%	Fat %	F/TS %	Protein %	P/ DM%	Casein%	Ash %	SE
Control	**11.1^{c}**	**3.30^{b}**	**29.70^{c}**	**2.80^{c}**	**25.22^{b}**	**2.2^{b}**	**0.81^{b}**	0.17
T1	**11.7^{c}**	**3.35^{b}**	**33.30^{b}**	**3.00**^{b}	**25.64^{b}**	**2.4^{b}**	**0.92^{a}**	0.13
T2	**12.4^{b}**	**3.55^{b}**	**34.80^{b}**	**3.20^{b}**	**25.81^{b}**	**2.5^{b}**	**0.96^{a}**	0.09
T3	13.2^{a}	3.62^{b}	36.40^{a}	3.60^{a}	27.27^{a}	2.8^{a}	0.99^{a}	0.15

T_1 = cow's milk +T. paste till pH 6 T_2 = cow's milk +T. paste till pH 5.8 T_3 = cow's milk +T. paste till pH 5.6.
a, b, c: Means with same letter among treatments in the same pickling period are not significantly different

Table (2) revealed that TS, fat, protein, and ash were lost in the whey as the pH value of the cheese milk decreased and the rate of tomato paste increased. The rate of loss was directly correlated with the pH value of the milk and the amount of the tomato paste added. The collected whey contained a significant ($p < 0.05$) high rate of loss was found in control treatment, free from tomato paste (control), as compared with whey resulted from the rest treatments (T_1- T_2 and T_3). These results were near to that found by **Metzger et al. (2000)**, which were 6.6 % for TS and 0.86 % for protein.

Table (2) Gross Chemical composition (%), acidity (%) and pH value of different Mozzarella cheese whey (Average of 3 replicates) *

Treatments	pH	Acidity%	TS%	Fat%	F/ DM%	Protein%	P/DM %	Ash%	SE
Control	5.6^{a}	0.32^{b}	5.6^{a}	0.30^{a}	5.35^{a}	1.02^{a}	18.21^{a}	0.46^{b}	0.023
T_1	5.4^{a}	0.36^{a}	5.2^{b}	0.24^{a}	4.62^{a}	0.88^{a}	16.92^{a}	0.38^{b}	0.027
T_2	5.2^{b}	0.38^{a}	5.1^{b}	0.26^{b}	5.10^{b}	0.79^{b}	15.49^{b}	0.44^{a}	0.13
T_3	5.1^{b}	0.39^{a}	5.00^{b}	0.25^{b}	5.00^{b}	0.72^{b}	14.40^{c}	0.49^{a}	0.018

*See legend to Table (1) for details.

Data in **Table (3)** showed that the minimum yield of fresh cheese (11.52%) was recorded for fresh control cheese, whereas the maximum one (13.21%) was for fresh cheese of (T_3). These results are not in agreement with **Abd -EL-Aziz and Refaey, (2017)**. During storage period, the yield of all cheese treatments was decreased as a result to the loss of the moisture content. The yields of 60 days cheese were as follows 10.15, 10.55, 10.86, and 11.43 for control, T_1, T_2, and T_3, respectively. The rate of loss in weight reached 11.9, 13.2, 15.7, and 13.5 % for the former treatments, respectively and control cheese recorded the lowest significant ($p < 0.05$) rate of loss.

Table (3): Yield (%) of cheese as affected by pH of milk and tomato paste, during storage (Average of 3 replicates) *

Treatments	Control	T1	T2	T3
Fresh cheese	11.52^{Aa}	12.16^{Aa}	12.88^{Aa}	13.21^{Aa}
Cheese (60 day)	10.15^{Bb}	10.55^{Bb}	10.86^{Bb}	11.43^{Bb}
Loss of weight %	11.9	13.2	15.7	13.5
SE	0.016	0.012	0.019	0.021

A, B, C: Means with same letter among treatments in the same pickling period are not significantly different.
a, b, c : Means with same letter for same treatment during pickling periods are not significantly different.

Results in **Table (4)** displays the values of pH, TS, fat, fat/DM, protein, TN/DM, WSN/TN, salt, salt/DM, and ash of Mozzarella cheese during the storage period. The pH values for all fresh cheese treatments were ranged between 5.0– 5.6. The variation in the pH values could be attributed to the different levels of tomato paste used to reach the required pH in different cheese treatments. It is clear, also, that the pH values of all cheese treatments were decreased with the progress of the storage period. The significant ($p < 0.05$) increase in TS content (47.44%) was obtained in fresh tomato paste Mozzarella cheese (T_3). The TS, fat and protein contents of all cheese treatments were increased as the storage period advanced. The highest fat percent (20.84%) was obtained in tomato paste Mozzarella cheese (T_3), whereas the lowest one (17.40%) was recorded in control Mozzarella cheese (CONTROL). The reduction of moisture content during the storage period may be responsible for that increase **(Kebary et al., 2006)**. These results are in agreement with those of **Karki and Ojha (2018),** who found that values of TS and protein were increased while fat content was slightly decreased, during storage.

Table (4): Gross chemical composition (%) and pH value (%) of cheese during storage as affected by pH of milk and tomato paste (Average of 3 replicates) *

Treatments	Ripening period (days)	pH	T.S%	Fat %	F/ DM%	Protein %	P/DM%	Salt%	Salt/TS%	Ash%	SE
Control	Fresh	5.6^{Aa}	44.56^{Bb}	17.40^{Bb}	39.5^{Bb}	15.55^{Bb}	34.9^{Bb}	2.80^{Bb}	6.28^{Bb}	5.55^{Bb}	0.21
	60 days	5.2^{Bb}	50.17^{Aa}	21.15^{Aa}	42.2^{Aa}	19.88^{Aa}	39.6^{Aa}	3.99^{Aa}	7.95^{Aa}	6.25^{Aa}	0.14
T1	Fresh	5.1^{Aa}	45.22^{Bb}	18.82^{Bb}	41.6^{Bb}	16.30^{Bb}	36,0^{Bb}	2.90^{Bb}	6.41^{Bb}	4.89^{Bb}	0.16
	60 days	4.9^{Bb}	50.85^{Aa}	19.22^{Aa}	43.7^{Aa}	19.00^{Aa}	39.8^{Aa}	3.92^{Aa}	7.71^{Aa}	5.90^{Aa}	0.05
T2	Fresh	5.2^{Aa}	45.54^{Bb}	20.00^{Bb}	43.0^{Aa}	16.65^{Bb}	36.2^{Bb}	3.20^{Bb}	6.89^{Bb}	4.89^{Bb}	0.13
	60 days	5.1^{Ba}	51.55^{Aa}	22.32^{Aa}	43.3^{Aa}	21.43^{Aa}	41.6^{Aa}	4.00^{Aa}	7.76^{Aa}	6.15^{Aa}	0.11
T3	Fresh	5.00^{Aa}	47.44^{Bb}	20.84^{Bb}	43.4^{Aa}	17.20^{Bb}	36.3^{Bb}	3.60^{Bb}	7.59^{Bb}	4.50^{Bb}	0.07
	60 days	4.9^{Ba}	53.55^{Aa}	22.58^{Aa}	44.0^{Aa}	21.98^{Aa}	42.5^{Aa}	4.60^{Aa}	8.59^{Aa}	6.80^{Aa}	0.08

***See legend to Table (3) for details.**

Data in **Table (5)** showed that the texture profile parameters of Mozzarella cheese when fresh and after 60 days of storage period. All these parameters were found significantly ($p < 0.05$) higher in the control cheese than in the tomato paste cheese treatments except cohesiveness and springiness either when fresh or after 60 days of storage. Cheese of T3 had the highest hardness value among the tomato paste Mozzarella cheeses (T_1-T_2 and T_3). Hardness values of all treatments were increased significantly ($p < 0.5$) after 60 days of storage. These values (N), for fresh and after 60 days, were (36/54.1), (11.6/24.3), (17.4/26.6), and (26.6/34.6) for control, T1, T2, and T3 treatments, respectively. These results are in accordance with those reported for Mozzarella cheese by **Bhaskaracharya and Shah (1990),** who found that the hardness of Mozzarella cheese decreased with an increase in moisture content. Values of **Adhesiveness** for fresh and 60 days old cheese were (0.961/2.2002), (0.289/1.256), (0.206/1.041), and (0.239/1.179g) for the former treatments, respectively. Data in Table (5) moreover revealed that fresh tomato paste cheese springiness values were decreased when compared with the control treatment and increased gradually in all treatments till the end of storage period. Cohesiveness is the strength of internal bonds making up the body of the product **Szczesniak et al., (1963) and Bourne (1978).** There is a difference in the cohesiveness values among cheese of all treatments owing to the differences in their chemical composition and pH values, **Sunder and Upadhyay (1990).** Control recorded the highest significantly ($p < 0.05$) cohesiveness value (0.73%). The chemical changes in the structure of the cheese matrix during storage, playing important role in decreasing the cohesiveness values in all treatments. **Table (5),** also, indicated that gumminess values of all treatments were ranged between (12.7-32.2 N) and the lowest significantly ($p < 0.05$) value was observed in fresh control cheese, while the highest one was for T_3. During the storage period, gumminess values were increased in all treatments and chewiness values followed the same trend of gumminess results, being significantly ($p < 0.05$) low in fresh control cheese.

Table (5): Texture profile analysis (TPA) of Mozzarella cheese as affected by pH of milk and tomato paste (Average of 3 replicates) *

Parameters	Ripening period (days)	Treatments			
		Control	T1	T2	T3
Hardiness (N)	Fresh	36.0^{Ab}	11.6^{Db}	17.4^{Cb}	26.6^{Bb}
	60	54.1^{Aa}	24.3^{Ca}	26.6^{Ca}	34.6^{Ba}
Adhesiveness (g)	Fresh	0.961^{Aa}	0.289^{Bb}	0.206^{Bb}	0.239^{Bb}
	60	2.002^{Aa}	1.256^{Ba}	1.041^{Ca}	1.179^{Ba}
Springiness (mm)	Fresh	3.37^{Aa}	3.08^{Aa}	2.91^{Ba}	2.79^{Ba}
	60	2.03^{Bb}	2.98^{Aab}	2.86^{Aab}	2.73^{Ba}
Cohesiveness (Ratio)	Fresh	0.73^{Aa}	0.70^{Aa}	0.66^{Ba}	0.65^{Ba}
	60	0.66^{Aa}	0.65^{Ab}	0.61^{Bb}	0.62^{Ba}
Gumminess (N)	Fresh	12.7^{Db}	18.2^{Cb}	28.8^{Bb}	32.2^{Ab}
	60	16.9^{Da}	31.6^{Ca}	36.9^{Ba}	40.1^{Aa}
Chewiness (J)	Fresh	40.81^{Db}	56.08^{Cb}	70.84^{Bb}	77.22^{Ab}
	60	51.19^{Ca}	93.88^{Ba}	107.31^{Aa}	111.12^{Aa}
SE		0.021	0.022	0.014	0.013

***See legend to Table (3) for details.**

The scoring points for various cheese treatments through the 60 days period of storage are shown in **Table (6).** Control cheese treatment gained significantly ($p < 0.05$) had the highest score in appearance and significantly ($p < 0.05$) the lowest scores in body and texture, and flavor than the other treatments. Organoleptic scores of all cheese treatments increased as ripening period progressed except appearance. Total scoring points for fresh and 60 days old cheese were (73/81), (74,83), (76/83) and (78/85) out of 100 for control, T_1, T_2 and T_3, respectively.

Table (6): Organoleptic properties of the resultant Mozzarella cheese as affected by pH of milk and tomato paste (Average of 10 panelists).

Properties	Ripening period (days)	Treatments			
		Control	T1	T2	T3
Appearance (30)	Fresh	25^{Aa}	23^{Ba}	21^{Ca}	19^{Da}
	30	23^{Ab}	22^{Aab}	21^{Aba}	18^{Bab}
	60	23^{Ab}	22^{Ab}	20^{Bab}	17^{Cb}
Body &Texture (30)	Fresh	20^{Cb}	22^{Bb}	23^{Ab}	25^{Ab}
	30	23^{Bab}	24^{ABab}	24^{ABab}	27^{Aab}
	60	24^{Ca}	25^{Ba}	25^{Ba}	28^{Aa}
Flavor (40)	Fresh	28^{Cc}	29^{Cc}	32^{Bc}	34^{Ac}
	30	32^{Bb}	33^{Bb}	35^{Ab}	36^{Ab}
	60	34^{Da}	36^{Ca}	38^{Ba}	40^{Aa}
Total (100)	Fresh	73^{Dc}	74^{Cc}	76^{Bc}	78^{Ac}
	30	78^{Bb}	79^{Bb}	80^{Ab}	81^{Ab}
	60	81^{Ca}	83^{Ba}	83^{Ba}	85^{Aa}
SE		0.017	0.026	0.025	0.016

***See legend to Table (3) for details.**

Conclusions

It is concluded that using tomato paste (as a natural acidulant) to pre-acidification cow's milk increased the yield, TS, and improved the textural profile of the resultant Mozzarella cheese, which consequently increased its economic value.

Conflicts Of Interest/ Competing Interest

All authors declare that they have no conflicts of interest.

Data Availability Statement:

All data sets collected and analyzed during the current study are available from the corresponding author on reasonable request.

List of Abbreviations

SMS	Stable Micro System
TPA	Texture profile analysis
TS	Total solids

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