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Chemical and Microbiological Quality of Mozzarella Cheese Consumed in Minia Governorate

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ABSTRACT

This study aimed to evaluate the chemical, some physical properties and microbiological quality of Mozzarella cheese consumed in Minia governorate. Six samples of Mozzarella cheese were collected from different local markets in Minia governorate. Cheese samples were coded B1, B2, B3, B4, B5 and B6. All cheese samples were subjected to chemical, meltability, oiling separation and microbiological assessment. Results revealed that pH were 6.55 ,6.25 ,6.26 ,6.28 and 6.48 in brand 1 ,2 ,3 ,4,5, and 6 respectively, titratable acidity, fat and ash ranged between (0.22-0.415%), (12.8-24.2) and (2.7-3.85) respectively. The highest value of dry matter was 50.05% in brand1. Protein content ranged from 11.25 % in brand6 to 18.1 % in brand1, soluble nitrogen ranged from 0.64 to 1.85. The highest value of calcium content was achieved by brand1(563mg /100g) but the lowest value was in brand 4 (146.5mg/100g). Also, data show the meltability in brand2 exhibited the higher value (67.5) while brand3 exhibited the low value (17.5). The result showed that oil separation of brand4 had the highest value, while brand5 was the opposite. The average value for salt content ranged from 1.85 to 2.55 %. Data shows wide variation among brands in soluble tyrosine and soluble tryptophan content. Soluble tyrosine content ranged from 48.29 to 274.56 mg/100, while soluble tryptophan content ranged 17.17 to 74 .62 mg/100. Total bacterial content was from 2.81 to 3.67 CFU /g, yeasts and moulds were also detected in all cheese samples.

Keywords: *Mozzarella , meltability, microbiological , calcium , protein.*

INTRODUCTION

Mozzarella cheese, as an Italian variety comes under the group of cheese called pasta filata cheese (Vacca et al.,2025). It originated in Italy from buffalo milk, which had widespread around the world and became the

second cheese type in USA Mozzarella cheese has become one of the most popular cheese varieties in the world because of its primary use in pizza preparation and other similar foods (Borghese, (2005)).

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Mozzarella cheese is a semi-soft, unripened cheese made from whole or partly skimmed milk. Mozzarella cheese is a rich source of nutrients, proteins, vitamins, fat, and carbohydrates (Jeewanthi *et al.*, 2016). It is providing many health benefits and can protect against gout, which causes uric acid crystals to develop in the joints (Li, *et al.*, 2018). Traditional Mozzarella cheese is made from buffalo, cow, and ewe milk; it can also be made from bovine milk mixed with 15 - 30% camel milk (Abdalla *et al.*, 2022). Traditional cow's milk Mozzarella is called non-pasta filata cheese. It is high in moisture (55–62%) and high in fat (44% on dry matter).

Several factors affect the quality of Mozzarella cheese, such as heat treatments of milk (Tripaldi *et al.*, 2021), type of used starters (Ahmed *et al.*, 2011), storage temperature (Jiménez-Maroto *et al.*, 2025), type of milk by (IA, 2014), fat content (Ayesha *et al.*, 2010), pH and calcium content (McMahon *et al.*, 2005), stretching temperature (Gonçalves *et al.*, 2020) and frozen storage (Alinovi *et al.*, 2020).

According to Ah and Tagalpallewar (2017), Mozzarella cheese quality depends on the physical properties, especially the ability to melt, elasticity, color, and free oil production. Good Mozzarella cheese is

characterized by its lively sheen surface, rheological and textural properties including meltability, stretchability, firmness, springiness, gumminess, elasticity, and cohesiveness (Henneberry, 2019), and free oil formation and browning (Sutariya, *et al.*, 2022). In Egypt, the introduction of pizza making is fairly new; accordingly, the processing of Mozzarella cheese on an industrial scale is also new. Therefore, this study was designed with the objectives of having an all overview on the general characteristics of Mozzarella cheese produced from different locations in Egypt. So, it was found of interest to assess the chemical composition and microbial quality of Mozzarella cheese on retail scale in Minia City.

MATERIALS AND METHODS

Cheese Samples:

Six Mozzarella cheese samples manufactured at the industrial level were obtained from local grocery shops in Minia City; the following Mozzarella cheese brands were coded B1, B2, B3, B4, B5 and B6. All cheese brands were sold in vacuum sealed packs weighing about 300g of cheese and all cheese samples were taken randomly on six separate occasions. Label instructions for each brand of cheese presented in Table 1.

Table (1): Label instructions for six Mozzarella cheese brands.

| Cheese Brand | Ingredients |
|---------------------|--|
| Brand 1 (B1) | Pasteurized cow milk + milk protein powder + palm oil + table salt + vinegar + citric acid + acidity regulator + thickener + starter culture + microbial rennet + cream flavor (Fat/Dry matter not less than 40%, protein 19%, trans fat 0.2%) |
| Brand 2 (B2) | Pasteurized cow milk + palm oil + non-hydrogenated skim milk powder + salt + acetic acid + modified starch + calcium chloride + microbial rennet + potassium sorbate 1000 ppm (F/DM from 50–60%, trans fatty acids 2% and protein 15%) |
| Brand 3 (B3) | Pasteurized cow milk + microbial rennet + plant oils (Fat solids not less than 40%) |
| Brand 4 (B4) | Pasteurized cow milk + starters + microbial rennet + skim milk powder 1% + salt + thickness matter |
| Brand 5 (B5) | Cow + buffalo milk + pasteurized skim milk + rennet + palm oil + emulsifiers salts + milk protein + stabilizers + food salt + calcium chloride + potassium sorbate (1000 ppm). Trans fatty acids 2g/100g. Protein not less than 15%. |
| Brand 6 (B6) | Pasteurized cow milk + palm oil + skim milk powder + salt + microbial rennet, (Fat/DM not less than 40%). |

Chemical Analysis: Titratable acidity (TA) was determined using 1/9 N and 0.5% phenolphthalein solution as indicator. pH values were measured by using pH meter (model 3550, digital pH meter, Beckman, USA). Moisture, total solids, fat and ash content were determined by the methods described in **A.O.A.C (2012)**

Determination of protein: Total protein was determined by the Macro-Kjeldahl method according to **A.O.A.C (2012)**. Total nitrogen content was multiplied by factor 6.38 to determined total protein.

Determination of Soluble Nitrogen: Soluble nitrogen in the Mozzarella cheese samples was determined according to **AOAC, (2012)**.

Determination of Tryptophan and Tyrosine Content: Soluble tryptophan and tyrosine content were determined according to the method described by **Vakaleris and Price (1959)**.

Calcium Content: Calcium content of cheese samples was determined by the following complexometric method described by **Pearce (1979)**.

Salt Determination: Salt content in cheese samples was determined according to **Simov (1980)**.

Rheological Properties Determination:

1. **Meltability:** Meltability of Mozzarella cheese was measured using the method outlined by **Olson and Price (1958)**. A Pyrex glass tube (20 mm diameter and 200 mm long) was used to hold the cheese during the melting test.
2. **Oil Separation Index (IOS):** Oil separation index (OSI) of Mozzarella cheese was determined as described by **Thomas (1973)**.

Microbiological analysis:

The total viable counts were recorded by **Marth, (1978)**. Total yeasts and moulds counts were carried out according to **NMKL (1999)**.

RESULTS AND DISCUSSION

The compositional and functional properties of local Mozzarella cheese samples.

Data show variation in chemical composition between brands, pH ranged from 6.2-6.3 average 6.25 in brand2, while ranged from 6.5 6.6 averaged 6.55in brand1. It was shown that pH for brand2 similar to brand 3 titratable acidity (%) of the brand 3 was the lowest value compared to other brands, while brand1 recorded the highest value 0.4-0.43%. The variations in fat content were quite large being as low as 18.0 % in brand1 while brand3 recorded the highest value 24.0%. According to the data obtained by **Hamouda ,(2020)**, found that the increase of fat content is due to the increase in total solids for white picked cheese Data represented in (Table2); revealed that the fat% in all examined samples was found in in brand3,4 agreed with the Egyptian standards for fat% while brand1,2,5,6 lower than the Egyptian standards for fat (20-46%). results in Table (2) brand1 recorded the highest value in ash content and ranged from 3-4.00% while brand3 recorded the lowest value ranged from 2.6-2.8% .Also it was shown that the sample of brand4 is similar to brand5 the range value was 3.7-3.9% , Remarkable difference in dry matter content was also appeared among the six brands .The average value for dry matter ranged from 24-53% . the Egyptian standards total solid 40.- 56.8% .

Table (2) Chemical composition of local Mozzarella cheese consumed in Minia governorate.

| Brand: NO | pH | Titrateable acidity% | Fat% | Ash % | Dry matter% |
|-----------|---|---|--|---------------------------------------|--|
| B1 | 6.55 ^a ±0.05 (6.5-6.6) | 0.415 ^a ± 0.01 (0.4-43) | 18.0 ^c ±0.45 (17.618.5) | 3.85 ^a ±0.15 (3.7-4) | 50.05 ^b ±1.25 (48.8-51.3) |
| B2 | 6.25 ^d ±0.05 (6.2-6.3) | 0.39 ^a ±0.01 (0.38-0.4) | 18.3 ^c ± 0.9 (17.4-19.2) | 3.55 ^b ± 0.15 (3.4-3.7) | 44.95 ^c ± 0.15 (45.1-44.8) |
| B3 | 6.26 ^d ±0.025 (6.24-6.29) | 0.22 ^d ±0.02 (0.2-0.24) | 24.2 ^a ±1 .8 (22.4-26) | 2.7 ^c ±0.1 (2.6- 2.8) | 53 ^a ± 1 (52-54) |
| B4 | 6.28 ^d ±0.035 (6. 5-6.28) | 0.32 ^c ±0.02 (0.3-0.34) | 22.67 ^b ±0.33 (22.34-23) | 3.8 ^a ±0.1 (3.7-3.9) | 49.5 ^b ± 0.5 (49-50) |
| B5 | 6.38 ^c ±0.015 (6.37-6.4) | 0.35 ^b ±0.01 (0.34-0.36) | 19.3 ^c ±0.1 (19.2-19.4) | 3.8 ^a ±0.1 (3.7-3.9) | 52.4 ^a ±0.45 (52-52.8) |
| B6 | 6.48 ^b ±0.02 (6.46-6.48) | 0.39 ^a ±0.015 (0.38-0.41) | 12.8 ^d ± 0.2 (12.6-13) | 2.9 ^c ±0.1 (2.8-3) | 36 ^d ± 1.25 (35-37.5) |

Values are expressed as means (N=3) ± standard division. Different superscripts between brands in the same column means significant differences at P < 0.05. Data in parentheses are minimum and maximum values of six samples.

Table (3): protein , SN, SN/TN, Calcium and salt content in Mozzarella cheese samples.

| Brand: NO | Protein % | SN% | SN/TN | Calcium mg/100g | Salt % |
|-----------|--|--|---|---------------------------------------|---|
| B1 | 18.1 ^a ±0.7 (17.4-18.8) | 1.0275 ^c ±0.027 (1-1.055) | 0.362 ^c ± 0.004 (0.358-0.366) | 563 ^a ± 8 (555-571) | 2.175 ^{bc} ± 0.125 (2.05-2.3) |
| B2 | 13.75 ^c ± 0.15 (13.6-13.9) | 1.75 ^b ±0.05 (1.7-1.8) | 0.81 ^b ± 0.032 (0.78-0.84) | 523.5 ^b ± 3.5 (520-527) | 2.55 ^a ±0.05 (2.5-2.6) |
| B3 | 14.025 ^c ± 0.475 (13.5-14.5) | 0.84 ^d ±0.045 (0.79-0.88) | 0.379 ^c ±0.033 (0.347-0.414) | 225 ^c ± 8 (217-233) | 2.3 ^b ± 0.1 (2.2-2.4) |
| B4 | 16.2 ^b ±0.6 (15.6-16.8) | 0.64 ^c ± 0.025 (0.61-0.66) | 0.25 ^d ± 0.019 (0.23-0.269) | 146.5 ^f ±5.5 (141-152) | 2.25 ^b ±0.05 (2.2-2.3) |
| B5 | 17.05 ^b ±0.25 (16.8-17.3) | 1.055 ^c ±0.055 (1-1.11) | 0.39 ^c ± 0.026 (0.36-0.42) | 390 ^d ±1 (389-391) | 2.1 ^c ±0.1 (2-2.2) |
| B6 | 11.25 ^d ±0.55 (10.7-11.8) | 1.85 ^a ±0.05 (1.8-1.9) | 1.05 ^a ±0.079 (0.97-1.13) | 492.5 ^c ± 4.5 (488-497) | 1.85 ^d ±0.05 (1.8-1.9) |

TN: Total nitrogen

S. N: Soluble nitrogen

Values are expressed as means (N=3) ± standard division. Different superscripts between brands in the same column means significant differences at P < 0.05. Data in parentheses are minimum and maximum values of six samples.

Data in table (3) shows big variation among brands in total protein content. protein content ranged from 11.25 % in brand6 to 18.1 % in brand1 these results were lower than those reported by **Islam (2006)**, who found that the Mozzarella cheese of cow milk contained 21.9% protein.

Data also showed that the soluble nitrogen content ranged from 0.64 to 1.75 for all tested cheese samples. The difference in soluble nitrogen in the content data compared to the other data could be due to the different

factors such as the type of milk, age of cheese, coagulant agent, % of salt and moisture. Low concentration of soluble nitrogen was due to restricted proteolysis, the restriction of proteolysis due to the high concentration of salt in cheese (Table3). Results in the same table show the obtained data for calcium content. It was shown that brand1 recorded the high level of calcium 563 mg/100g while brand4 recorded the low level of calcium (146.5 mg/100g). Salt content ranged from 1.85 to 2.55% in brand6 and brand4 respectively.

Table (4): Analysis of the content of soluble tyrosine and tryptophan in Mozzarella cheese samples.

| Brand No | Soluble Tyrosine mg/100gm | Soluble Tryptophan mg/100gm |
|-----------|---|---|
| B1 | 274.56 ^a ± 6.2 268.3-280.7 | 74.62 ^a ± 6.46 (68.08-81.49) |
| B2 | 155.19 ^d ± 1.7 153.4-156.9 | 35.45 ^c ± 0.285 (35.16-35.73) |
| B3 | 202.83 ^c ± 1.54 201.2-204.3 | 45.36 ^b ± 1.18 (44.57-48.89) |
| B4 | 48.69 ^e ± 1.85 46.8-50.5 | 21.84 ^d ± 0.72 (21.12-22.56) |
| B5 | 251.4 ^b ± 3.62 247.7-255 | 35.00 ^c ± 2.41 (32.59-37.42) |
| B6 | 48.29 ^e ± 1.24 47.05-49.5 | 17.17 ^d ± 0.12 (17.05-17.30) |

Values are expressed as means (N=3) ± standard division. Different superscripts between brands in the same column means significant differences at P < 0.05. Data in parentheses are minimum and maximum values of six samples.

According to data obtained by **Urbach, (1997)**, who found that total volatile fatty acids, tyrosine, tryptophan, acetaldehyde, diacetyl and ethanol as flavor components in some dairy products. The obtained data in Table (4) shows a wide variation between all tested brands, in soluble tyrosine, it was shown that brand1 recorded the high level of soluble tyrosine (274.56 mg/100g) while brand6 recorded the low level (48.29 mg/100g). Brand5 recorded 251.4 mg/100g,

followed brand3 recorded 202.83 mg/100g, between the content of tyrosine and tryptophan it was shown that the content of tyrosine was higher than that the content of tryptophan in all tested samples.

Meltability

The data in Table (5) show the meltability of Mozzarella cheese brand, it showed that B2 exhibited the higher value (67.5), followed by B4 (57.5), B5 (29.5), B6(25.5) and B1 (25) respectively, while B3

samples exhibited the low value. According to the results obtained by (Abd El -Hamid et al. ,2006), the changes in meltability value in brands could be a function of several factors. The increase of meltability in brand2 (67.5) other than treatments may be attributed to the proteolysis and breakdown of protein in the cheese matrix and/ or solubilization of calcium by the developed acidity (Kebary et al. ,2025).

Oil Separation Index: -

Oiling off is regarded as a defect of this type of cheese when melted on the top of a pie. According to (El zoghby (1994), and

Abbas (2003) they found that excessive free oil in Mozzarella cheese is a significant quality problem. The results obtained in Table (5) showed that oil separation of Mozzarella cheese brand4 had the highest value, followed by brand2, brand3, brand4, brand5. The oiling off increased by storage period advanced, but lower oiling off occurred after four weeks (Ghosh and Singh,1991) and (Kebary et al., 2025), explained the increase of oiling off could be due to the increase in meltability and the change in the polymorphic structure of milk fat during the storage of the type of this cheese.

Table (5): Analysis of Meltability and Oil separation index% in Mozzarella cheese samples.

| Cheese brands | B1 | B2 | B3 | B4 | B5 | B6 |
|---------------------------------|---------------------------------------|--|--|---------------------------------------|------------------------------------|------------------------------------|
| Meltability(mm) g cheese | 25 ^d ± 1 (24-26) | 67.5 ^a ± 2.5 (70-65) | 17.5 ^e ± 2.5 (15-20) | 57.5 ^b ± 2.5 (55-60) | 29.5 ^c ± 0.5 29-30 | 25.5 ^d ± 1.5 (24-27) |
| Oil separation index% | 59.4 ^c ± 0.6 (58.8- 60) | 75.4 ^b ± 4.9 (70.5-80.3) | 72.6 ^b ± 3.9 (68.7-76.5) | 85.1 ^a ± 3.1 (82- 88.2) | 56.5 ^c ± 1.5 (55-58) | 61 ^c ± 1 (60-62) |

Values are expressed as means (N=3) ± standard division. Different superscripts between brands in the same column means significant differences at P < 0.05. Data in parentheses are minimum and maximum values of six samples.

Yeasts and moulds in Mozzarella cheese samples

Microbial examination (Table 6) showed variation in microbial number among the tested Mozzarella brands. Total bacterial count ranged from 2.81 CFU/g to 3.67 CFU/g, it was shown that all cheese brands are statistically differed at (P>0.05) according to total bacterial count (Log/CFU). Also, the data obtained in (Table 6) showed that B5 was the highest of total count (3.67 CFU/g). All cheese samples contained number of

yeast and moulds and ranging from 2.3 to 3.1 CFU/g. It was shown from the current data that B4 increased significantly compared with all samples in the item of yeast and moulds . The high presence of moulds and yeasts may be attributed to the numerous sources of cheese contamination such as milk used, washing water, environment utensils and equipment and through personal taking part in manufacturing and handling the product (Raghda and Khalil ,2021).

Table (6): Total count of bacteria, yeasts and moulds in Mozzarella cheese samples.

| | B1 | B2 | B3 | B4 | B5 | B6 |
|--------------------------|---|--|---|--|---|---|
| Total count | 3.24 ^d ±0.012 (3.23-3.25) | 33.45 ^c ±0.015 (3.43-3.46) | 2.81 ^f ±0.033 (2.77-2.84) | 3.53 ^b ± 0.012 (3.51-3.54) | 3.67 ^a ±0.004 (3.67-3.68) | 2.97 ^e ± 0.022 (2.95-3) |
| Moulds and yeasts | 2.39 ^b ±0.088 (2.3-2.47) | 2.54 ^b ±0.062 (2.47-2.60) | 2.39 ^b ±0.088 (2.39-2.47) | 3.15 ^a ±0.031 (3.11-3.18) | 2.46 ^b ± 0.15 (2.3-2.6) | 2.54 ^b ±0.062 (2.47-2.60) |

Values are expressed as means (N=3) ± standard division. Different superscripts between brands in the same column means significant differences at P < 0.05. Data in parentheses are minimum and maximum values of six samples.

CONCLUSION

From the foregoing results, the present study clearly illustrated wide variation in chemical composition, meltability, oiling off and microbial population among brands of mozzarella cheese consumed in Minia governorate. This indicates the clear need to apply standard methods when manufacturing this type of cheese, along with applying control over factories to try to standardize the qualities of the resulting cheese in accordance with Egyptian standards.

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الجودة الكيميائية والميكروبيولوجية لجبن الموزاريلا المستهلكة في محافظة المنيا

هدى محمد حافظ عبد الهادي، مها محمود بخيت، سلمى محمد جلال، رغده مختار سيد، فوزي سيد ابراهيم

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تهدف هذه الدراسة الى تقييم الجودة الكيميائية والميكروبيولوجية والخصائص الوظيفية لجبن الموزاريلا المستهلكة في محافظة المنيا. تم جمع ست عينات من جبن الموزاريلا من مناطق مختلفة في محافظة المنيا، تم تقدير التحليل الكيميائي لهذه العينات، والقابلية للانصهار، وانفصال الزيت والتقييم الميكروبيولوجي. وكانت قيم التحليل الكيميائي ٦.٢٦، ٦.٢٥، ٦.٥٥، ٦.٢٨، ٦.٣٨، ٦.٤٨ لاس الهيدروجيني في العينة ١، ٢، ٣، ٤، ٥، ٦ على التوالي. وكانت قيم النسبة المئوية للحموضة (٠.٢٢، ٠.٤١، ٠.٤١، ٠.٤١، ٠.٤١، ٠.٤١)، نسبة الدهن (١٢.٣-٢٤.٤%) والرماد (٢.٧ - ٣.٨٥%). كانت أعلى قيمة في المادة الجافة ٥٠.٥% في العينة ١، بينما كانت أدنى قيمة ٣٦% في العينة ٦. أظهرت النتائج أيضاً أن القيمة الإجمالية للبروتين كانت ١٨.١، للعينة ١ وكانت اقل قيمة في العينة ٦ ١١.٢٥%. وكانت قيم النيتروجين الذائب تتراوح بين (٠.٦٤ - ١.٨٥%)، وكانت اعلي قيمة لمحتوى الكالسيوم في العينة ١ (٥٦٣ ملجم/١٠٠ جم) ولكن القيمة الأقل كانت العينة ٤ (١٤٦.٥ ملجم/١٠٠ جم)، اما نسبة الملح تراوحت لمتوسط قدره من ١.٨٥ إلى ٢.٥٥%. كما أظهرت النتائج تبايناً كبيراً بين العينات في محتوى التيروسين الذائب والترينوفان الذائب. تراوح محتوى التيروسين الذائب بين ٤٨.٢٩ إلى ٢٧٤.٥٦ ملجم/١٠٠ جم بينما تراوح محتوى التريتوفان الذائب من ١٧.١٧ إلى ٧٤.٦٢ ملجم/١٠٠ جم. ولقد أظهرت النتائج ان العينة ٢ اعلي قيمة في المطاطية بينما العينة ٣ كانت الأقل وبالنسبة لانفصال الزيت فلقد اوضحت النتائج ان العينة ٤ كانت الأعلى في قيم انفصال الزيت بينما العينة ٥ كانت الأقل، وأوضحت النتائج ان العدد البكتيري الكلي بين ٢.٨١ إلى ٣.٦٧ مستعمرة/جم ، وقد لوحظ وجود كلا من الفطريات والخمائر في كل العينات تحت الدراسة.