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Effect of selenium and zinc fortification on the physiochemical and sensory properties of Iraqi soft cheese

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Abstract. *Al-Garory NH, Al-Musa RS, Al-Hashimi AG. 2025. Effect of selenium and zinc fortification on the physiochemical and sensory properties of Iraqi soft cheese. Asian J Agric 9: 52-59.* Food industries, including the dairy industry, have developed to improve the health condition as they are the foods that provide the body with important nutritional components such as minerals, whose levels decrease after industrialization processes. This study aimed to evaluate the impact of fortifying Iraqi soft cheese with zinc and selenium. The study focused on the physicochemical properties, rheological behavior and sensory characteristics of the cheese along with peroxide value as an indicator of oxidative stability. Zinc and selenium elements were added at a concentration of 200 mg/L to milk for cheese making. The result showed that an increase in peroxide value with increasing storage time and a decrease in fat oxidation for zinc and selenium were noted in treatments compared to the control treatments made from buffalo milk (T1) and cow's milk (T2). This may be due to the presence of selenium and zinc, which reduce fat oxidation, and lower pH values after storage. No effect of selenium and zinc fortification was observed on the acidity values of cheese, while the chemical composition values varied as selenium fortification did not affect the percentage of fat and protein. Microbial tests also showed an increase in bacteria number after 10 days of storage compared to the samples after manufacturing, as well as increase in total bacterial number after fortification. The hardness and consistency of cheese increased during storage and after addition of minerals compared to control samples. Cheese flexibility decreased after storage and fortification. The sensory indicators were almost similar in control and fortified samples.

Keywords: Buffalo milk, cow milk, functional foods, Iraqi soft cheese, microbial counts, peroxide value, rheological properties

INTRODUCTION

In recent years, new methods and practices have been developed to improve the nutritional value and therapeutic benefits of food as well as maintain quality and safety standards in accordance with globally accepted laws (Terry and Diamond 2018). This has led to increased interest in functional foods, including fortified foods, especially with increased consumer awareness to maintain health and get rid of diseases as they do not cause side effects like synthetic drugs (Reuben et al. 2023). Functional food science arose from the link between food science and medical science, as researchers studied food components and their health effects by studying changes in health behavior and the balance of health indicators in the body (Lubna and Ahmad 2023). Such studies led to determining the health effects and safe doses of functional foods, which is basically a global marketing term for food if it is proven to have a beneficial effect on body functions in health and disease (Fawi and Salman 2023). The dairy industry is one of the most functional industries in the world due to the use of probiotics in its manufacture (Uzunsoy 2024). One of these foods is cheese, which is made from coagulating milk caseins and separating it from the whey using microbial starters that modify the appearance, texture, odor, nutrient composition, improve quality and extend shelf life (Reuben et al. 2023). Essential trace elements play an important role as cofactors for some enzymes involved in cellular metabolism and growth and most of them are involved in protein, carbohydrate, lipid, and energy metabolism (Fawi and Salman 2023). They are essential for human growth and development, muscle and nerve function, normal cellular functioning, and the synthesis of certain hormones and connective tissues (Reuben et al. 2023). The role of trace elements in bioprocessing may provide the key to understanding the etiology of certain diseases such as cancer (Çelebi et al. 2023). In the last decade, studies have focused intensively on determining the levels of trace elements in cancer patients to understand the nature of the relationships between cancer and trace elements (Naumova et al. 2020). The expected role of trace elements will enable us to understand the causes of cancer, provide a rapid diagnostic method and establish effective treatment methods (Al-Fartusie and Mohssan 2017). Recently, the use of cheeses fortified with minerals has increased due to their important benefits, Milk contains small amounts of zinc and selenium, estimated at less than 1 mg per cup and among these minerals is selenium, which has a role in the balance of the human body and the work of the immune system, as well as being an antioxidant and a cofactor for many enzymes (Batool et al. 2018). It also affects the redox balance and metabolism for hormones, including thyroid hormone and protecting the body from infections (Uzunsoy 2024). Its deficiency can lead to cardiovascular diseases, neuromuscular diseases, cancer, infertility, diabetes, depression, immune diseases, and increased intake causes poisoning, liver disease, deterioration of blood composition, bone tissue deformation, neurological disorders, and type 2 diabetes (Terry and Diamond 2018). Zinc and selenium are an essential element in food and are the second most abundant elements after iron (Çelebi et al. 2023). It is used as an antioxidant and anti-inflammatory, as well as essential for liver function and metabolism, and its lack of dietary intake or increased elimination through excretion or abnormal metabolism causes liver disease (Lubna and Ahmad 2023). Zinc is essential for the catalytic activity of about 100 enzymes and has a role in immune function, protein synthesis, wound healing, DNA synthesis and cell division (Maret and Sandstead 2015). Human lack a specific storage system for zinc, so its intake is necessary to maintain its viability, its deficiency leads to growth retardation, loss of appetite and impotence in men (Mostafa 2022). The aim of this study was to evaluate the effect of fortifying Iraqi soft cheese with zinc and selenium of these products, or the bacterial strains used, and to optimize the daily Se and Zn requirements of the consumer. The result of this study may be beneficial to people, especially those with zinc and selenium deficiency, or vegetarians who do not consume meat, as well as its nutritional value and its therapeutic and health benefits.

MATERIALS AND METHODS

Experimental design

The present study was conducted in the Department of Food Science, Faculty of Agriculture, University of Basrah, Iraq. The cow's milk was obtained from the Agricultural Research Station, and Iraqi buffalo milk from a breeder in the Garma area in Basra. The fungal microbial rennet *Rhizomucor pusillus* used was produced by the Japanese company Meito Sangyo Co, Ltd, within the validity period and according to the manufacturer's recommendations. The selenium and zinc were purchased from the British company BDH.

Cheese manufacturing

Soft cheese was made according to the method of Fasale et al. (2017) after pasteurizing the milk at 65°C for 15 minutes and cooling to 45°C. Zinc and selenium elements were added at a concentration of 200 µg/L. The rennet was used according to the manufacturer's instructions. Samples made from buffalo milk (T1) and cow's milk (T2) were considered as control treatments, while buffalo milk cheese treatments with added zinc and selenium were T3 and T4, and cow's milk cheese treatments were (T5) and (T6). Three replicates were made for each concentration which were left for 30 minutes at 45°C. The curd was cut into cubes, filtered and stored at 4°C. The peroxide value, physicochemical, microbial, rheological, and sensory properties of soft cheese were calculated over three storage periods of 0, 3, 7 and 10 days.

Cheese analysis

Peroxide value estimation

The peroxide value was estimated based on (AOAC 2008). 0.5 g of Buffalo and cow cheese oil were dissolved in 10 mL of chloroform, after that 15 mL of acetic acid, and saturated 1 mL of potassium iodide were added. Each of these solutions was gently stirred and incubated in the dark for 10 minutes. After incubation, 20 mL of distilled water and 0.3 mL of (1%) starch was added to the solution and mixed. The solutions were then titrated with thiosulphate 0.01 N till the color was transparent.

Physiochemical tests

pH was estimated using a Sartorius pH meter (Germany) and acidity by titration with 0.1 N NaOH. The percentage of protein was evaluated by Kjeldahl's method to estimate total nitrogen and multiplied by the protein factor 6.38. The percentage of fat was determined by Kerber's method, while moisture and ash were estimated by burning method (AOAC 2008).

Microbial test

Plate count agar technique was used to determine the total viable microbial count in the samples (Ali et al. 2020). Serial dilutions of the samples were prepared up to 10^5 and 10^6. From each dilution, 1 mL aliquots were plated on Plate count agar medium and incubated in an incubator at 32±1°C for 48 hours. Petri dishes were placed upside-down to prevent condensation from dripping onto the agar surface. After incubation, plates were placed on a colony counter to enumerate the bacterial colonies. Total bacterial counts in soft cheese were estimated using nutrient agar medium (Oxoid) and *Escherichia coli* using MaConkey agar medium (Holland) according to the manufacturer's recommendations.

Rheological tests

Tissue properties, such as elasticity, cohesion, and stiffness were estimated using a Testometric Texture Analyzer M350-10CT (AOAC 2008).

Sensory tests

Sensory evaluation of soft cheese parameters was performed by 10 specialized evaluators from the Department of Food Science, College of Agriculture, Basra University. The test, included flavor, texture, and appearance qualities (El-Desoki and Hamed 2022).

Data analysis

The data was statistically analyzed using CRD, ANOVA and LSD tests to calculate significant differences between the mean coefficients at a probability level of 0.05 using Genstat software 12.1 (Schmuller 2017).

RESULTS AND DISCUSSION

Peroxide value

The peroxide value is an indicator of fat oxidation and product spoilage. The peroxide values for both control cheese (T1 and T2) and fortified cheese (T3, T4, T5 and T6) are presented in Figure 1. The results of statistical analysis showed that there were significant differences ($P<0.05$) in the peroxide value of the buffalo milk cheese samples T3 and T4 compared to the cow's milk cheese samples. This may be due to higher fat percentage in buffalo milk compared to cow milk, the peroxide value of buffalo milk cheese increased compared to cow milk cheese. The results also showed that there were significant differences ($P<0.05$) in the peroxide value with increasing storage periods. The peroxide value increased as the storage periods progressed, at storage time 0 it was 0.32, 0.25, 0.32, 0.30, 0.25 and 0.22 $MeqO_2$/kg respectively, which increased to 0.88, 0.66, 0.58, 0.54, 0.51 and 0.52 $MeqO_2$/kg at the storage period of 10 days. The antioxidant activity of cheese is due to the degradation of proteins by proteolytic enzymes and the production of bioactive peptides with the ability to inhibit lipid peroxidation due to their content of the amino acids histidine, methionine, cystine and tryptophan which possess antioxidant activity by capturing free radicals, inhibiting peroxides and binding to metal ions (Uzunsoy 2024). A decrease in lipid oxidation was observed for zinc and selenium treatments (T3, T4, T5 and T6) compared to control treatments T1 and T2. The presence of selenium and zinc reduces lipid oxidation, free radical formation, and metallic taste production (Batool et al. 2018).

pH and acidity

Figures 2.A and 2.B exhibit the pH values and percentage of acidity of control cheese treatments (T1 and T2) and buffalo and cow milk cheese fortified with zinc and selenium (T3, T4, T5 and T6) during storage periods of 0, 3, 7 and 10 days. The results showed that significant differences were observed at a probability level of $P<0.05$ for pH but there was no difference for acidity values in all treatments. The pH values of (T1) and (T2) immediately after manufacturing were 6.23 and 6.25, and for (T3, T4, T5 and T6) were 6.21, 6.22, 6.4 and 6.25, respectively. The post-storage values decreased in all treatments, reaching 5.61, 5.64, 5.61, 5.63, 5.63 and 5.64% after the 10th day of storage at 4°C (in refrigerator). This can be attributed to the continued activity of starter bacteria during storage to produce lactic acid, reducing pH and raising acidity.

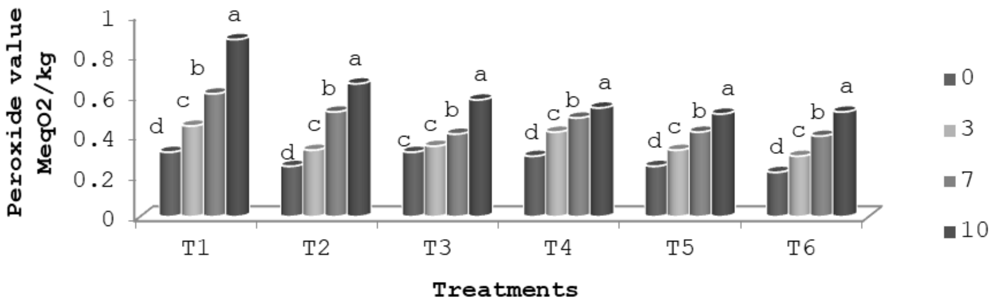

Figure 1. Peroxide value ($MeqO_2$/kg) of soft cheeses made from buffalo and cow milk fortified with zinc and selenium during different storage periods. *Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability ($P<0.05$)

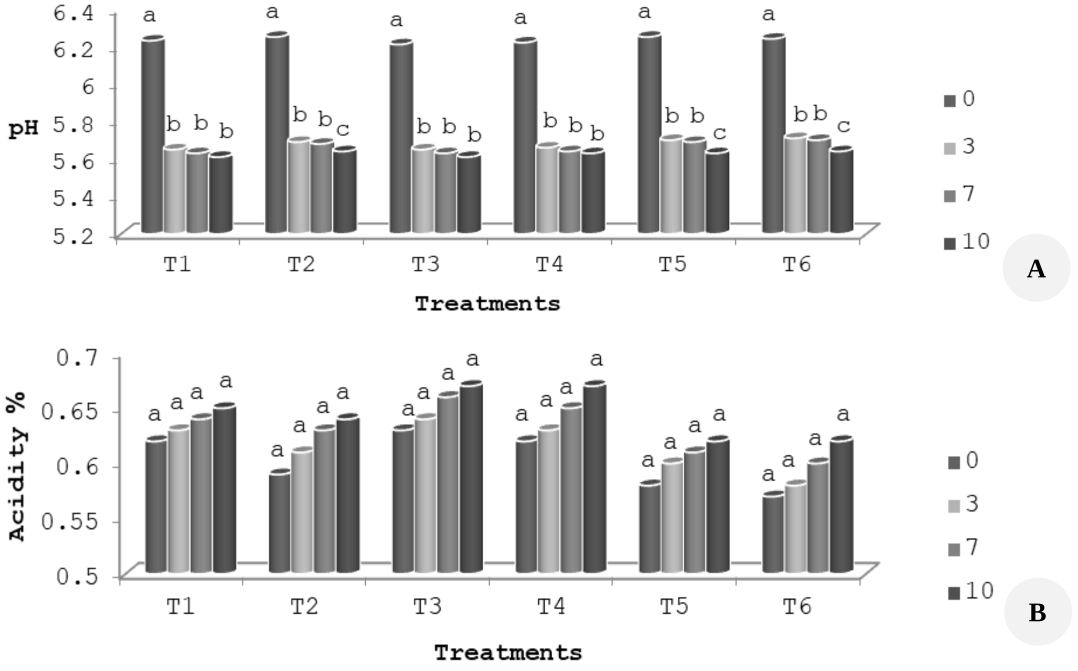

Figure 2. A. pH and B. Acidity of soft cheeses made from buffalo and cow milk fortified with zinc and selenium during different storage periods. *Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability ($P<0.05$)

Table 1. Chemical composition of soft cheese made from buffalo and cow's milk fortified with zinc and selenium during different storage periods

Treatments	Storage periods/days	Ash %	Moisture %	Fat %	Protein %
T1	0	3.68^{a}	59.70^{a}	15.68^{a}	20.98^{a}
	3	3.81^{a}	59.52^{a}	15.69^{a}	21.12^{a}
	7	3.83^{a}	59.32^{a}	15.75^{a}	21.16^{a}
	10	3.83^{a}	59.09^{a}	15.80^{a}	21.20^{a}
T2	0	3.61^{a}	62.40^{a}	14.40^{a}	19.61^{a}
	3	3.74^{a}	62.30^{a}	14.44^{a}	19.67^{a}
	7	3.75^{a}	62.22^{a}	14.48^{a}	19.73^{a}
	10	3.77^{a}	62.12^{a}	14.56^{a}	20.77^{a}
T3	0	3.78^{a}	59.57^{a}	15.68^{a}	20.97^{a}
	3	3.80^{a}	59.46^{a}	15.69^{a}	21.15^{a}
	7	3.83^{a}	59.22^{a}	15.73^{a}	21.17^{a}
	10	3.85^{a}	59.05^{a}	15.81^{a}	21.21^{a}
T4	0	3.75^{a}	59.57^{a}	15.65^{a}	20.95^{a}
	3	3.78^{a}	59.45^{a}	15.67^{a}	21.13^{a}
	7	3.80^{a}	59.20^{a}	15.70^{a}	21.19^{a}
	10	3.84^{a}	59.10^{a}	15.83^{a}	21.22^{a}
T5	0	3.70^{a}	62.30^{a}	14.40^{a}	19.60^{a}
	3	3.73^{a}	62.28^{a}	14.43^{a}	19.66^{a}
	7	3.75^{a}	62.18^{a}	14.45^{a}	19.72^{a}
	10	3.78^{a}	61.07^{a}	14.53^{a}	20.75^{a}
T6	0	3.69^{a}	62.30^{a}	14.35^{a}	19.60^{a}
	3	3.70^{a}	62.26^{a}	14.40^{a}	19.67^{a}
	7	3.74^{a}	62.14^{a}	14.43^{a}	19.75^{a}
	10	3.79^{a}	61.02^{a}	14.54^{a}	20.76^{a}

Note: *Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability (P<0.05)

Similar results were found by El-Desoki and Hamed (2022) who observed a decrease in pH of selenium-fortified cheese after 60 days, which amounted to 4.43 compared to the values on the first day of manufacture of 6.71. This can be explained by continuous activity of starter bacteria during the storage process without the effect of selenium and zinc on bacterial activity. No effect of selenium and zinc fortification was observed on the acidity values calculated on the basis of lactic acidity of the cheese, as the percentage of acidity immediately after processing for (T1) and (T2) (0.59 and 0.62%). For fortified cheese (T3, T4, T5 and T6), pH was 0.57, 0.58, 0.62 and 0.63%, respectively. The results also show that pH for all treatments increased with storage, so the values after 10 days were 0.65, 0.64, 0.67, 0.67, 0.62 and 0.62%, respectively. These results are consistent with El-Desoki and Hamed (2022) who found that acidity at the end of storage period after 60 days increased to 1.38% compared to 0.21% immediately after manufacturing.

Chemical composition

Table 1 shows the percentages of protein, fat, moisture and ash content of (T1, T2, T3, T4, T5 and T6) during a storage of 0, 3, 7 and 10 days. The results of statistical analysis indicate that there were no significant differences in the values of protein, fat, moisture and ash at a probability level of P<0.05. Protein content increased with increasing storage time in all treatments (T1, T2, T3, T4, T5 and T6) 21.20, 20.77, 21.21, 21.22, 20.75 and 20.76 after 10 days of storage. The increase in protein content as the storage period increases is due to the decrease in moisture content and the increase in solids content, including protein (Batool et al. 2018). The percentage of fat increased with storage periods, and varied between the control and the zinc and selenium-fortified treatments. Zinc fortification had no significant effect on it. The fat percentage at day 0 was 15.85, 14.40, 15.68, 15.68, 14.40 and 14.35% for (T1, T2, T3, T4, T5 and T6), which increased after 10 days to 15.85, 14.56, 15.81, 15.83, 14.53 and 14.54%. According to Batool et al. (2018), selenium fortification did not influence the fat and protein content of cheese. The reduction in fat percentage observed during cheese production was primarily due to the fermentation process. Furthermore, decrease in fat percentage during storage was attributed to the progressive degradation of fat components over time. A decrease in the percentage of moisture was observed for all samples as the storage time progressed. The moisture in day 0 decreased from 59.70, 62.40, 59.57, 59,57, 62.30, 62.30% to 59.09, 62.12, 59.05, 59.10, 61.07 and 62.02% after 10 days. The ash content increased during storage for all treatments and the values after 10 days were 3,83, 3.77, 3.85, 3.84, 3.78, and 3.75%. The values also increased after zinc and selenium fortification where the ash content in T1 and T2 reached 3.68 and 3.61%. The values of treatments (T3, T4, T5 and T6) also increased after fortification to 3.78, 3.75, 3.70 and

3.69%, respectively. The reason for the high percentage of total solids, including proteins and fats, is due to evaporation and low moisture content in storage and consolidation, which increases the percentage of solids (Al-Shaikh and Doosh 2018). About 32% of the zinc in cow's milk is bound to casein and about 63% is bound to colloidal calcium phosphate, so casein has a greater ability to bind to zinc. It is about 32% of the zinc in cow's milk is bound to casein and about 63% is bound to colloidal calcium phosphate, so casein has a higher ability to bind zinc, while lactoferrin has a low ability to bind to zinc. This minimizes zinc loss in whey, enhances its retention in the cheese, and consequently increases the ash content in the final product (Ianni et al. 2020; Sorice et al. 2024)

Microbial test

Total bacterial count

The logarithm of total bacterial counts and coliform counts (cfu/gm) for treatments (T1, T2, T3, T4, T5 and T6) during storage for 0, 3, 7 and 10 days are presented in Figures 3.A and 3.B. Statistical analysis revealed that there were no significant differences at a probability level of P<0.05 between all treatments. Higher total number of bacteria was observed with increasing zinc and selenium fortification, and higher number was observed upon storage periods. The number in cheese treatments made from cow's milk was higher than that of buffalo milk treatments, as total number (T1, T2, T3, T4, T5 and T6 at 0 time were 4.5, 4.9, 4.8, 4.9, 5.3 and 5.4 cfu/gm, respectively. These number increased after 10 days to 5.0, 5.4, 5.5, 5.6, 6.2 and 6.4. Low number of coliform bacteria in (T1) and (T2) increased after storage and fortification, where after 10 days reached 2.0, 2.5, 2.3, 2.4, 2.6, and 2.9 cfu/gm in comparison to 1.2, 1.5, 1.4, 1.5, 1.7 and 1.9 cfu/gm at 0 day. Inadequate manufacturing or pasteurization processes add additional bacterial populations to the naturally occurring lactic acid bacteria in dairy products. Selenium fortification does not reduce these populations, which are caused by contamination after cheese manufacturing and increase during storage, while a decrease in coliform bacteria populations can be observed due to the presence of lactic acid bacteria that work to eliminate spoilage pathogens (Naumova et al. 2020). Aquilanti et al. (2012) found that zinc fortification of cheese reduces the growth of different types of bacteria, and mentioned that 25 ppm is capable of inhibiting *Lactobacillus arabinosus*, and positive ions Mn, Ca, Mg and Sr counteract the inhibition of zinc by removing cations from proteins when they bind to zinc. The toxicity of zinc to bacteria was observed to decrease with decreasing pH due to the interaction of Gram-positive bacterial cell components such as lactic acid bacteria with zinc. El-Desoki and Hamed (2022) mentioned that fortification of cheese with selenium increases the number of *Lactobacilli* and *Streptococcus* bacteria, as the total number of bacteria immediately after manufacture in control samples and samples fortified with different percentages of selenium 0.5, 0.8 and 1.0 ppm (Na_2SeO_3) reached 5.5, 6.2, 6.5 and 7.1 cfu/gm, which increased to 8.2, 8.6, 9.0 and 9.3 cfu/gm, respectively after 60 days storage at a refrigerator.

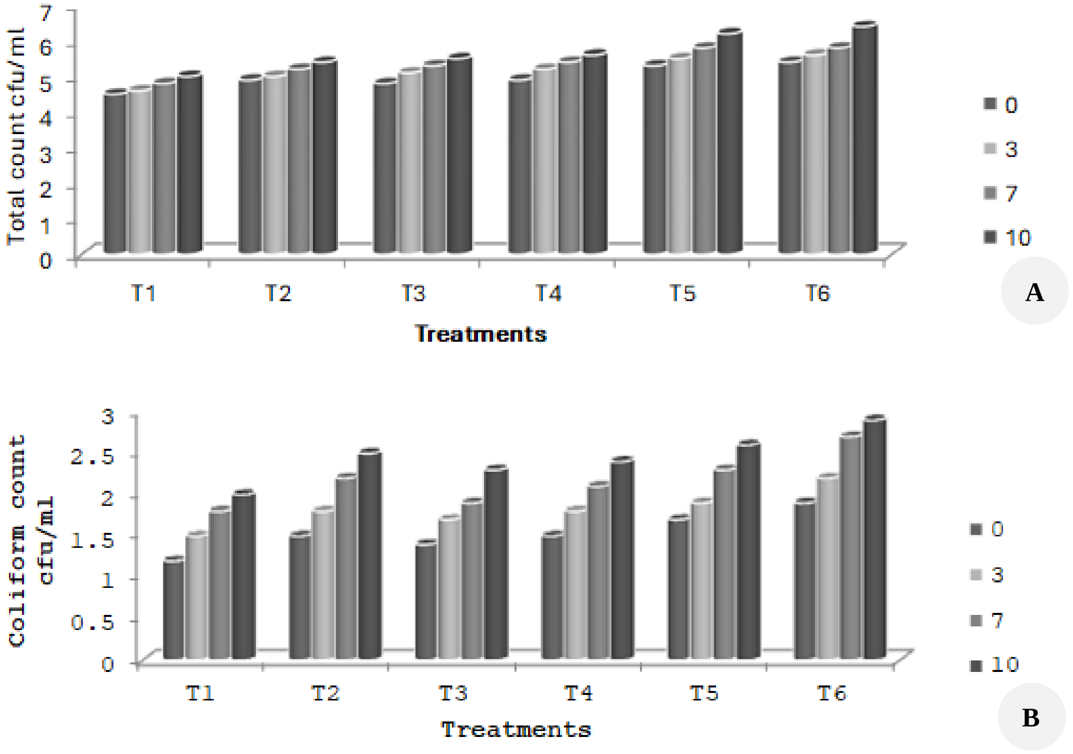

Figure 3. Microbial tests of soft cheeses made from buffalo and cow's milk fortified with zinc and selenium during different storage periods. A. Total count and B. Coliform counts

Rheological tests

The rheological test is an important test to determine the characteristics of food products and is one of the main factors, along with flavor and appearance, that determines the sensory acceptance of that food by the consumer (Dos Santos Rocha et al. 2022). Table 2 shows the rheological tests of soft cheese made from buffalo and cow's milk and fortified with zinc and selenium during different storage periods. Statistical analysis indicates that there were significant differences in the values of rigidity and flexibility and no differences in the values of cohesion at a probability level of $P<0.05$. Higher hardness and firmness were observed in the cheese during storage and mineralization compared to the control sample, while lower elasticity values were observed during storage and fortification. At 0 day hardness value of samples (T1, T2, T3, T4, T5 and T6) were 38.3, 35.2, 47.6, 38.0, 64.8 and 53.2 g, which increased after 10 days to 45.3, 40.9, 57.7, 68.6, 68.3 and 59.9 g. Cohesion values at the beginning of storage were 0.45, 0.43, 0.50, 0.59, 0.64 and 0.63%, increased to 0.65, 0.55, 0.63, 0.70, 0.75 and 0.71% after 10 days storage. The reason for the increase in hardness upon storage is due to the decrease in moisture upon evaporation, and the higher hardness in the mineralized samples compared to the control samples is due to the higher proportion of solids, and this is directly proportional to the cohesiveness of the samples (Liu et al. 2015). The results showed that after 10 days elasticity decreased to 2.0, 3.5, 1.2, 3.0, 3.2 and 3.0 mm. Loss of elasticity after storage is due to increase in proteolysis or reduction in moisture content, which reduces its elasticity (Picciotti et al. 2022; Azorín et al. 2024).

Sensory tests

Table 3 exhibits the sensory tests of soft cheese made from buffalo and cow's milk fortified with zinc and selenium during different storage periods. The results showed that there were significant differences in the values of sensory characteristics at a probability level of $P<0.05$. Lower quality indicators for flavor, appearance, and texture were observed for (T1) and (T2) compared to (T3, T4, T5 and T6) samples, where the flavor values were 47.9, 47.5, 47.5, 47.3, 47.2 and 47.4 immediately after manufacturing. Similarly, appearance values were 8.5, 8.4, 8.2, 8.4, 8.2 and 8.3. All values increased after storage at 4°C, and the control samples were slightly higher for all treatments. The sensory quality indicators of cheese play an important role for the consumer compared to its chemical composition, which decreases after storage and expiration, resulting in discoloration and flavor changes due to high acidity (Naumova et al. 2020). The texture is directly proportional to the amount of added minerals, which leads to an increase in hardness after fortification with metals such as zinc (Sorice et al. 2024).

Table 2. Rheological tests of soft cheeses made from buffalo and cow's milk fortified with zinc and selenium during different storage periods.

Treatments	Storage periods/days	Elasticity/mm	Cohesion %	Hardness/gm
T1	0	4.0^a	0.45^a	38.3^d
	3	3.7^b	0.49^a	40.1^c
	7	3.2^b	0.55^a	43.9^b
	10	2.0^c	0.65^a	45.3^a
T2	0	4.6^a	0.43^a	35.2^d
	3	4.3^a	0.45^a	37.5^c
	7	3.8^b	0.48^a	39.3^b
	10	3.5^b	0.55^a	40.9^a
T3	0	3.5^a	0.50^a	47.6^d
	3	3.1^a	0.54^a	49.0^c
	7	2.9^b	0.60^a	53.4^b
	10	1.2^c	0.63^a	57.7^a
T4	0	4.0^a	0.59^a	38.0^d
	3	3.9^b	0.60^a	41.4^c
	7	3.7^b	0.67^a	45.1^b
	10	3.0^b	0.70^a	68.6^a
T5	0	4.1^a	0.64^a	64.8^b
	3	3.9^b	0.69^a	66.5^a
	7	3.7^b	0.72^a	67.2^a
	10	3.2^b	0.75^a	68.3^a
T6	0	4.2^a	0.63^a	53.2^c
	3	3.9^b	0.66^a	55.0^b
	7	3.3^b	0.68^a	56.2^b
	10	3.0^b	0.71^a	59.9^a

Note: *Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability ($P<0.05$)

Table 3. Sensory tests of soft cheeses made from buffalo and cow's milk fortified with zinc and selenium during different storage periods

Treatments	Storage periods/days	Appearance (10)	Texture (40)	Flavor (50)	Total (100)
T1	0	8.5^a	35.2^a	47.9^a	91.6
	3	8.0^a	34.5^a	46.7^a	89.2
	7	7.6^b	32.8^b	44.5^b	84.9
	10	6.4^c	30.9^c	42.6^c	79.9
T2	0	8.4^a	34.8^a	47.5^a	90.7
	3	8.0^a	34.0^a	46.3^a	88.3
	7	7.3^b	32.1^b	44.2^b	83.6
	10	6.2^c	30.5^c	41.7^c	78.4
T3	0	8.2^a	36.7^a	47.5^a	90.4
	3	7.6^b	35.5^b	46.2^a	87.3
	7	7.0^b	33.8^c	43.6^b	82.4
	10	6.1^c	31.0^d	41.7^c	77.8
T4	0	8.4^a	36.5^a	47.3^a	90.2
	3	8.2^a	35.3^b	46.3^a	87.8
	7	7.5^b	33.9^c	43.5^b	81.9
	10	6.5^c	31.0^d	41.4^c	77.9
T5	0	8.2^a	35.7^a	47.2^a	90.1
	3	7.8^a	35.3^a	46.5^a	88.6
	7	7.0^b	32.0^b	44.0^b	83
	10	6.0^c	30.2^c	41.5^c	77.7
T6	0	8.3^a	35.5^a	47.4^a	90.2
	3	7.5^a	35.2^a	46.4^a	88.1
	7	7.3^a	32.0^b	44.2^b	83.5
	10	6.5^b	30.5^c	41.4^c	78.4

Note: *Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability ($P<0.05$)

In conclusion, the results of fortification of Iraqi soft cheese resulted in a decrease in the peroxide value after the addition of zinc and selenium compared to the control samples manufactured from buffalo and cow milk and a reduction in pH by a small ratio. The variation of chemical composition values and high bacterial growth were observed after the fortification of these metals. Rheological test results showed that hardness and cohesion values increased, leading to reduced elasticity of the cheese. There was no significant variation in sensory quality indicators for flavor, texture, and appearance. The result enables the fortification of dairy products with zinc and selenium elements to offset the shortage of these minerals in food, especially for vegetarians who do not consume meat but consume dairy products.

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