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The effect of some thermal treatments on the chemical and physical properties of bovine colostrum

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Abstract

In this study evaluated the physical characteristics, chemical composition, vitamins, and minerals in samples of bovine colostrum. It also examined the impact of pasteurization at 63 °C for 30 minutes (S1) and 72 °C for 15 seconds (S2) on the concentrations of vitamins and minerals and the chemical characteristics of moisture, protein, fat, lactose, and ash, as well as physical characteristics like pH, density and viscosity.

Pasteurization at 72 °C/15 seconds worked best. S1 and S2 treatments had 12.35% and 12.21% protein, respectively, compared to 12.50% for an unpasteurized sample. S1 and S2 had 5.80% and 5.90% fat, respectively, whereas S had 5.68%. S1 and S2 had 3.40% and 3.48% lactose, respectively, whereas S had 3.10%. While S had 2.13% ash, S1 and S2 had 2.43% and 2.51%, respectively. The samples S1 and S2 had 74.90% and 74.80% moisture, respectively, compared to S (an unpasteurized sample) it's 75.48%. The physical characteristics of colostrum were impacted by the pasteurization processes of S1 and S2, as evidenced by the pH values of 6.9, 6.12, and 5.94 for S1, S2, and S1, respectively. S1 and S2 had densities of 1.115 g/cm³, 1.170, and 1.082, respectively. S, S1, and S2 have respective viscosities of 15.70 CP, 25.45 CP, and 29.46 CP. While colostrum samples on the first day of life had significant levels of vitamins and minerals, pasteurization procedures S1 and S2 reduced the concentration of water-soluble vitamins B2 and B12 as well as fat-soluble vitamins A, D, E, and K when compared to unpasteurized. While magnesium, zinc, iron, and salt remained unchanged, the calcium and phosphorus concentrations were considerably reduced by pasteurization treatments S1 and S2 as compared to unpasteurized.

Keywords: Pasteurization, vitamins, chemical and physical properties, bovine colostrum, minerals

Introduction

The world has just recently become aware of functional foods, and bovine colostrum has emerged as the most widely consumed food type with a long history of health benefits dating back hundreds of years. Colostrum from cows can be referred to as immunological milk or a nutritious viscous fluid produced shortly after birth by the mammary glands. Approximately 0.5 percent of the total yearly production of cows is made up of bovine colostrum (Brian *et al.*, 2016) [8]. The high concentration of antibodies in colostrum (Immunoglobulin) has a significant effect on the preparation of the immune system, and this requires the absorption of immunoglobulins (Igs) within 24-36 hours of birth because the production of colostrum exceeds the requirements of the calf and because newborn calves do not have an active adaptive immune system. When breast milk is not accessible or cannot be obtained for an infant, colostrum from cows is used as a substitute (Merve *et al.*, 2022) [29]. Apart from immunoglobulins, colostrum is abundant in lactoferrin, lactoperoxidase, and lysozyme, all of which have antiviral and antibacterial properties. Additionally, colostrum contains a sizable amount of immunoglobulins. Antimicrobial, fungal, and viral characteristics of colostrum eliminate illnesses such as *Cryptosporidium*, Rotavirus, and *Escherichia coli* (Tsioulpas *et al.* 2007; Stelwagen *et al.* 2009) [41, 40]. A few factors influencing the composition and physical characteristics of colostrum are breed, age, season, prenatal diet, dry time for cows, and postpartum period. Except for lactose, which is less prevalent in colostrum, lipids, proteins, peptides, non-protein nitrogen, ash, vitamins, minerals, hormones, growth factors, cytokines, and nucleotides are all more concentrated in colostrum than in mature milk. (Tsioulpas *et al.*, 2007) [41].

Numerous studies show how effective colostrum is in treating and preventing diseases related to bone growth, respiratory conditions, gastrointestinal infections like leaky gut syndrome, diarrhea, etc., as well as its role in enhancing athlete performance and health. As a result, interest in consuming colostrum for human consumption and creating supplements based on it began to grow (Rhaabe *et al.*, 2021) [33]. The primary technique used by the dairy industry to preserve milk and increase its shelf life is heat treatment. Even though colostrum is very important, the dairy sector does not use it extensively because of issues with heat treatment and storage, like low coagulation temperature. Colostrum coagulates as a result of heat treatment. To varying degrees, pasteurization can have less of an impact than other heat treatments because it denatures biologically active substances like lactoferrin, lactoperoxidase, and lysozyme and modifies their concentration as well as their chemical composition and viscosity. Nonetheless, there is enough of them in cow colostrum to have positive effects. (Gomes *et al.*, 2021) [17]. The purpose of this study was to identify the chemical and physical characteristics of colostrum and investigate how pasteurization procedures affect them, given the significance of colostrum.

Material and Methods

Collection of Samples

Samples of colostrum were taken from a local cow owned by a farmer in the Babil governorate that was healthy. After the cow was manually milked, samples were taken two hours after calving in a sterile environment. The colostrum samples were well mixed to homogenize them and then separated into three groups in one-liter sealed sterile containers, which were approved with the symbols S, S1, and S2. S1 was pasteurized at 63 °C for 30 minutes, S2 was pasteurized at 72 °C for 15 seconds, and Group S was maintained as the control group (unpasteurized). A water bath with temperature controls was used to pasteurize the samples. Following the completion of the pasteurization process, the samples were promptly chilled to 5 °C while undergoing continuous heat treatment.

Physical Assessments

The following estimates were obtained from the physical examinations of colostrum samples:

By comparing the flow rate of a known volume of colostrum to the flow rate of the same volume of water at 20 °C, the viscosity of the samples was ascertained using a viscometer (Röder *et al.*, 2023) [34]. Additionally, a Lactometer was used to measure the specific density of the colostrum in accordance with the method outlined in Sharma (2006). A pH meter was used to measure the samples' pH in compliance with the protocol outlined in (Hool *et al.*, 2004) [19].

Chemical Analysis

The Kjeldahl method, as described in (Van Dijk and Houba., 2000) [43], was used to ascertain the protein content of the colostrum samples. and the technique described in (AOAC, 2005) [4] was used to determine the water content.. We used the procedure described in (AOAC, 1995) [5] to ascertain the lipid content of the Soxhlet fat extractor. used the method described in (AOAC, 2005) [4] to estimate the percentage of ash. and used the difference to calculate the lactose%.

Vitamins in colostrum samples were examined using the high precision liquid chromatography (HPLC) technique (Romeu *et al.*, 2002) [3], whereas the wet burning method was used to assess minerals in colostrum samples (Flávio *et al.*, 2024) [14].

Analysis of Statistic

A factorial experiment design was used to examine the data, and Duncan's ultinomial test was used to assess significant mean differences at a 0.05 probability level. A statistical tool was used to do the comparisons (SAS, 2010) [38].

Results and Discussion

Table (1) displays the findings of the estimation of protein levels in colostrum samples. These findings demonstrated that colostrum had higher protein levels than mature milk, with a proportion of 12.50%, nearly four times higher than that of mature milk. The reason for the large increase in casein and immunoglobulin levels observed in colostrum is because their respective quantities have increased dramatically (Saldana *et al.*, 2019) [37]. The temperature and duration of the pasteurization process may have an impact on the protein content, as the percentage of protein decreases with increasing pasteurization temperature due to concurrent moisture loss and increased protein denaturation (Ibrahim *et al.*, 2020) [21]. (Godden *et al.*, 2006) [16], which reported that denaturation of whey proteins occurs at temperatures higher than 60 °C, resulting in a drop in protein concentration. Because heat treatment causes the whey proteins to become thermally unstable, increasing the pasteurization temperature and duration increases the degree of denaturation.

The results displayed in Table No. (1) demonstrate that the fat content of colostrum was high, at 5.68%, and these results were similar to those which were found by (Lokke *et al.*, 2016) [25]. The results showed that the percentage of fats increased significantly with the pasteurized S1 and S2 treatments at a level of (p 0.05) in comparison to the unpasteurized S. The fact that the S1 and S2 treatments' percentage increase reached 5.80% served as evidence of this. and 5.90%, in that order. Furthermore, the findings showed that there was no discernible rise in the proportion of lipids following the unpasteurized S treatment. Furthermore, the results showed that the amount of lactose in colostrum samples was 3.10%, which was less than that in milk. The proportion of lactose increased significantly with pasteurization treatments S1 and S2, reaching 3.40% and 3.48%, respectively, according to the data. These findings corroborated the findings of (Quinn *et al.*, 2020) [32], who claimed that because of the absence of moisture, the lactose content of the pasteurized samples at various temperatures was higher than the lactose content of the unpasteurized samples. As can be observed from the results in Table (1), the amount of ash in colostrum was significantly higher than on the days that followed, coming in at 2.13%. These outcomes went beyond what was mentioned in (Godden *et al.*, 2019) [15]. The results of the statistical analysis indicate that the treatments S1 and S2 differ, significantly from S, reaching 2.43% and 2.51%, respectively, after pasteurization. These differences imply that the percentage of ash increased following the process. due to the fact that an increase in temperature causes the ash content to rise (Ul Haq *et al.*, 2013) [42].

Also the moisture content of colostrum samples on the first day of life is displayed in Table (1) together with the impact of pasteurization procedures S1 (63 °C for 30 minutes) and S2 (72 °C for 15 seconds) on the moisture content.

According to the findings, colostrum's moisture content was low. The moisture percentage dropped significantly at a probability level ($p \leq 0.05$) in pasteurization treatments S1 and S2 compared with S, as the moisture percentage in treatments S1 and S2 was 74.90% and 74.80%, respectively. These results are in line with what was mentioned by (Puppel *et al.* 2019) [31], who stated that the moisture content of colostrum on the first day ranges between 66.4 and 79.1%. These findings support the claims made by (Aldubhany *et al.* 2014) [1] that pasteurization temperatures reduce the moisture content during heat treatment by causing some water to evaporate. Colostrum's high total solids content could be the cause of its declining moisture content.

Table 1: Effect of pasteurization on the chemical properties of bovine colostrum (%).

Treatments	S	S1	S2
Protein	12.50	12.35	12.21
Fat	5.68	5.80	5.90
Lactose	3.10	3.40	3.48
Ash	2.13	2.43	2.51
Moisture	75.48	74.90	74.80

S: unpasteurized colostrum S1: pasteurized colostrum at 63 °C for 30 minutes S2: pasteurized colostrum at 72 °C for 15 sec.

Colostrum sample pH values and the impact of S1 and S2 treatments on pH values are displayed in Table (2). The findings indicate that the colostrum's pH was low, at 5.94. The findings were consistent with those of (Álvarez 2023) [3], which showed that pasteurization procedures S1 and S2 resulted in a noticeably greater level of pH values when compared to S. Given that the S1 and S2 treatments increased to 6.9 and 6.12, respectively, the high concentration of red blood cells in colostrum may be the cause of the drop in colostrum's pH when compared to regular milk, as colostrum's pH is correlated with blood pH (Mehra *et al.*, 2020) [28]. The elevated pH levels after pasteurization may be caused by the deformation of the whey protein micelles, which alters their properties and decreases their bond with the casein micelle surface (Donahue *et al.*, 2012) [13]. The results displayed in Table (2) indicate that the average density of colostrum on the first day was 1.082 g/cm³, which is fairly high. These results were obtained using a different methodology from that described in (McGrath *et al.*, 2016) [27]. A statistically significant difference in density was seen between S and S1 and S2, with S1 producing densities of 1.115 g/cm³ and S2 producing densities of 1.170 g/cm³, respectively. The evaporation of some moisture levels during heat treatment may be the cause of the post-pasteurization rise in density. This would increase the total solids content of the treated samples and consequently their density.

The viscosity values in colostrum samples and the impact of treatments S1 and S2 are also shown in Table (2). The mean value of 15.70 CP increases as the temperature rises. There are statistically significant discrepancies in these statistics. According to the viscosity rose by 25.45 and 29.46 CP between treatments S1 and S2 in comparison to S. (Green *et al.*, 2003) [18]. The increase in viscosity of pasteurized

colostrum may be caused by coagulation brought on by interactions between beta-lactoglobulin and kappa casein, which result in particles with large molecular weights and increase the bonding forces between the particles (Chavan *et al.*, 2011) [11]. An other explanation for the increase could be that the heating process damages the membranes of the fat granules, causing the globules to fuse and sinter and changing their physical properties.

Table 2: Effect of pasteurization on the physical properties of bovine colostrum.

Treatments	S	S1	S2
PH	5.94	6.9	6.12
Density g/cm ³	1.082	1.115	1.170
Viscosity CP	15.70	25.45	29.46

S: unpasteurized colostrum S1: pasteurized colostrum at 63 °C for 30 minutes

S2: pasteurized colostrum at 72 °C for 15 sec.

Vitamins

The effects of S1 and S2 pasteurization on the vitamin content in first-day calving bovine colostrum samples are shown in Table (3). The results in Table (3) show that colostrum had a higher concentration of vitamin B2 than natural milk, which had a concentration of 4.60 µg/ml. Additionally, the pasteurization treatments S1 and S2 significantly reduced the concentration of vitamin B2 when compared to unpasteurized S, reaching 4.20 and 4.11 µg/ml, respectively. These findings corroborated the observation made by (Bezie, 2019) [7] that heat treatment had an impact on water-soluble vitamins.

Vitamin B12 concentration in raw, unpasteurized colostrum samples was 0.85 µg/ml, according to the same table. This concentration dropped following pasteurization treatments S1 and S2, which resulted in a significant difference in vitamin B12 concentrations compared to unpasteurized S, with concentrations of 0.51 and 0.44 µg/ml, respectively. These results were consistent with those of (Lucey, 2015) [26], who found that pasteurization affects vitamin B12 content and causes a drop in concentration following pasteurization. The findings indicated that the vitamin A concentration of colostrum was much higher than that of ordinary milk (5.15 g/g). and Compared to the unpasteurized S, the pasteurized S1 and S2 treatments had vitamin A contents that were 4.77 and 4.68 g/g lower, respectively. The study's findings demonstrate that they were in line with those conclusions, which relate (Jensen *et al.* 1999; Debier *et al.* 2005) [22, 12].

Additionally, Table (3)'s results demonstrate that colostrum has a high concentration of vitamin D, coming in at 2.29 µg/g. The findings also demonstrated that, in comparison to the unpasteurized S, the pasteurization treatments S1 and S2 significantly reduced the vitamin D concentration, which was 2.05 µg/g and 1.92 µg/g, respectively (Bulgari *et al.* 2013) [9]. Vitamin E concentration in raw colostrum samples was found to be 2.77 g/g, with pasteurization treatments S1 and S2 resulting in a significant decrease compared to unpasteurized S, with concentrations of 2.42 and 2.36 g./g, respectively., these findings agree with (Kehoe *et al.* 2007), that the pasteurization process has a slight effect on vitamin E concentration. The findings also demonstrated that the unpasteurized colostrum sample had a vitamin K concentration of 1.55 µg/g. Following pasteurization treatments S1 and S2, the concentration of vitamin K decreased to 1.19 and 1.16 µg/g, respectively, with a

significant difference level when compared to the unpasteurized S sample. (Morrissey and Hill 2009) [30].

Table 3: Effect of pasteurization on the concentration vitamins of bovine colostrum

Treatments		S	S1	S2
Vitamins	B2	4.60	4.20	4.11
	B12	0.85	0.51	0.44
	A	5.15	4.77	4.68
	D	2.29	2.05	1.92
	E	2.77	2.42	2.36
	K	1.55	1.19	1.16

S: unpasteurized colostrum S1: pasteurized colostrum at 63 °C for 30 minutes

S2: pasteurized colostrum at 72 °C for 15 sec

Minerals

The mineral content in samples of bovine colostrum on the first day after calving, as well as the impact of S1 and S2 pasteurization procedures, are displayed in Table (4). The data show that the Phosphorus levels in colostrum samples are higher than those in natural milk, as indicated in Table (4). The amount of phosphorus in raw, unpasteurized colostrum was 348.60 mg/100 ml. Additionally, the results demonstrated a statistically significant decrease brought about by pasteurization treatments s1 and s2. In contrast to what was reported by, the amounts found, at 337.52 and 329.36 mg/100 ml, are lower than expected. (Buttar *et al.*, 2017) [10], who claimed that the concentration of the phosphorus element in raw, unpasteurized colostrum, was 445.2mg/100 ml. These results supported those of (Arslan *et al.*, 2021) [6], which discovered that colostrum's phosphorous concentration ranged from 158.6 to 450.0 mg/100 ml on the first day following birth. Pasteurization causes the dissolved concentration to decrease and speeds up the solubility-induced shift to the colloidal form, which happens at higher temperatures. Calcium content of colostrum was substantial, reaching 396.69 mg/100 ml, which is three times the amount seen in normal milk. These findings concur with (Tsioulpas *et al.* 2007) [41]. The findings demonstrated that the pasteurization treatments S1 and S2 had a substantial impact on the calcium concentration, causing it to drop to 378.10 and 367.41 mg/100 ml, respectively. These findings corroborated what was stated by (Šestan *et al.*, 2016) [39] that all samples' calcium contents changed as a result of the pasteurization temperature because the conversion of calcium from the dissolved to the colloidal states caused the concentration of calcium to drop. The obtained results are also shown in the same table, the concentration of magnesium element in unpasteurized colostrum was 32.48 mg/100 ml. This concentration rose following pasteurization procedures S1 and S2, as opposed to S, where it was 32.83 and 33.12 mg/100 ml, respectively. The findings corroborated the findings of (Jeong *et al.* 2009 ; Ibrahim 2016) [23, 20], which reported that following heat treatment, the magnesium content grew gradually and that the pasteurization treatments S1 and S2 only slightly raised the concentration of magnesium while having no effect on the total concentration. Additionally, Table (4) shows that colostrum had a greater zinc content (2.63 mg/100 ml) than regular milk. The pasteurized samples S1 and S2 showed a little increase in zinc content, indicating that pasteurization affected the concentration of zinc. from comparing unpasteurized S with pasteurized S1 and S2 (2.73 and 2.75 mg/100 ml, respectively). These results supported the

conclusions of (Alkaladi and associates, 2014) [2], who stated that the pasteurization procedure, revealed the concentration of zinc increased significantly when milk was pasteurized at 63 °C for 30 minutes. As demonstrated by Table (4), colostrum had an iron concentration of 0.80 mg/100 ml, which was higher than that of natural milk. Additionally, the findings demonstrated that pasteurization procedures S1 and S2 had no discernible impact on the concentration of iron compared with unpasteurized S, where it reached 0.82 and 0.83 mg/100 ml, respectively.

These results also agreed with what was indicated by (Safaa *et al.*, 2013) [36], that pasteurization of milk at 63 °C/30 minutes led to an increase in the concentration of iron.

In line with (Weiser and Playford, 2021) [44], the colostrum's salt content on day one was between 70 and 110 mg/100 ml. Where it reached S 71.79 mg/100 ml in the unpasteurized sample (S), while in the other two samples, it was S1 and S2 73.19 mg/100 ml and 74.88mg/100 ml, respectively.

Table 4: Effect of pasteurization on The concentration Minerals of bovine colostrum

Treatments		S	S1	S2
Minerals mg/100 ml	P	348.60	337.52	329.36
	Ca	396.69	378.10	367.41
	Mg	32.48	32.83	33.12
	Zn	2.63	2.73	2.75
	Fe	0.80	0.82	0.83
	Na	71.79	73.19	74.88

S: unpasteurized colostrum S1: pasteurized colostrum at 63 °C for 30 minutes

S2: pasteurized colostrum at 72 °C for 15 sec.

Conclusions

The present investigation leads us to the conclusion that both slow and quick pasteurization processes resulted in a notable reduction in moisture and protein and a rise in fat, lactose, and ash. The pH, density, and viscosity all significantly increased as a result of the pasteurization processes. We also draw the conclusion that colostrum has a greater than average concentration of vitamins and minerals. Pasteurization procedures reduced the concentration of calcium and phosphorus and decreased the concentration of vitamins in natural milk, but had no effect on the other elements.

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