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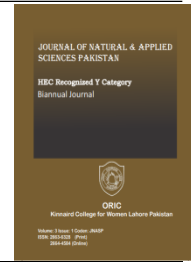

PHYSICOCHEMICAL CHARACTERIZATION OF BOVINE COLOSTRUM

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Abstract

This study aimed to perform a comprehensive physicochemical characterization of bovine colostrum and compare its properties to those of milk. Proximate analysis revealed that colostrum had lower moisture content (79.66%) and significantly higher levels of crude protein (16.24%) compared to milk. The crude fat content was lower in colostrum (4.00%) than in milk (4.72%), while the ash content was higher in colostrum (0.87%) than in milk (0.54%). Colostrum exhibited lower nitrogen-free extract (NFE) levels (0.77%) compared to milk (2.14%). Mineral analysis showed that colostrum had significantly higher levels of sodium and lower levels of potassium and calcium compared to milk. Colostrum also had a lower pH (6.40) and higher acidity (0.25) compared to milk (pH 6.62, acidity 0.16). The specific gravity of colostrum was higher (mean lactometer reading 49, mean specific gravity 1.049 g/ml) than that of milk (mean lactometer reading 30, mean specific gravity 1.033 g/ml), indicating denser consistency. Additionally, colostrum exhibited a darker color (lower L* value) and a more intense yellow-red hue (higher a* and b* values) compared to milk. These findings provide a comprehensive understanding of the physicochemical properties of bovine colostrum, highlighting its distinct composition and characteristics compared to milk

1. Introduction

Bovine Colostrum (BC), also called Gold Liquid, is the initial milk that is produced in the first 24 hours after giving birth to a calf. This liquid is referred to as Bovine Colostrum only up to first three days after delivery. This light yellowish, thick milky liquid contains all essential proteins, peptides, growth factors (GF), immunoglobulins (Ig), vitamins and minerals that are necessary for boosting immunity and protecting the newborn calf from viruses and bacteria (McGrath, 2016). The amount of colostrum produced by a healthy cow is much more than the new born calf actually requires. Approximately, a cow produces around 5 to 10 liters of colostrum out of which only 27% is consumed by the newborn calf and the remaining 73% is wasted (Castro & Pereira, 2017). Bovine colostrum is accepted as a food alternative that promotes health and is considered therapeutic in a wide variety of cultures and geographical areas. It has been used for thousands of years as an Ayurveda medicine to treat various illnesses. In India, the use of Bovine Colostrum to irrigate the eye after ocular surgery is mentioned in Ayurveda, an ancient Indian medicine. David Tyrell conducted clinical studies in 1980 that showed a significant portion of the antibodies and immunoglobulin's (Ig) in colostrum were not absorbed by the body but instead remained in the intestinal tract, where the immune factors play a crucial role in maintaining a healthy intestinal microflora. Many countries are using dried colostrum dietary supplements to treat gastrointestinal (GI) problems including diarrhea (Silva *et al*., 2019). BC has low lactose concentration than normal milk; hence, it can be consumed by lactose intolerant patients (Rocha, 2016). There are numerous reported health benefits of bovine colostrum. BC should be retrieved as soon as possible after delivery in order to maintain its quality. The most widely consumed form of fresh colostrum in the past was liquid. Additionally, pasteurized colostrum is marketed as a beverage on the markets. Bovine Colostrum is an excellent nutraceutical for immunological health, growth, and development. Bioactive compounds present in cow colostrum are more potent than those found in human colostrum. Humans have historically consumed colostrum from cows, and numerous studies have looked into its possible benefits for human nutrition and health (Dzik *et al.*, 2017). Furthermore, there is increasing evidence suggesting that Bovine Colostrum may serve as a beneficial supplement for athletes, as it can aid in improving exercise performance and recovery. Moreover, it has been found to be an effective treatment for various diseases in both adults and children. (Kotsis *et al*., 2018).

1.1 Composition of Bovine Colostrum

There is a significant difference in the chemical composition between colostrum and milk. Most of the nutrients and biologically active molecules are more concentrated in colostrum than in milk. BC contains many bioactive compounds including leukocytes, lactoferrin, lymphokines, cytokines, colostrinin, growth factors, immunoglobulins and hormones. These bioactive compounds promote heath in various ways by promoting regeneration of cells, binding and transport of iron, and interferon production. Other nutritional compounds present in BC are vitamins, minerals, amino acids, enzyme and oligosaccharides. As milk production volume increases over lactation, the mineral content of the milk also decreases in a comparable manner. Colostrum is a substitute for mature milk that is heavy in protein and relatively low in carbohydrates. Colostrum can undergo similar processing techniques as mature milk to decrease its fat content and modify its calorie density to meet specific nutritional requirements.

1.2 Micronutrients

Bovine colostrum is rich in water and fat-soluble vitamins that are essential for human health (Stockler & Chamorro, 2021). As compared to mature cow milk, BC has more fat-soluble vitamins. Some vitamins and minerals abundantly found in BC are vitamin A, vitamin B, vitamin C, selenium, zinc, magnesium (Pereira, 2014). These vitamins and minerals are good for growth, functioning and maintenance. High calcium levels helps in reducing the risk of bone problems and osteoporosis. According to researchers, processing techniques have no impact on the micronutrient levels of Bovine Colostrum (Eddleman, 2014). Among different types of fat soluble vitamins, vitamin A is the most abundant and is present in the form of retinol, retinal, pro-vitamin A and retinoic acid. Vitamin E is present in the form of tocopherols and tocotrienols (McGrath *et al*., 2016) whereas vitamin K is present in the form of phyllo Quinone, and menaquinones (Morrissey & Hill, 2009). According to studies, vitamin D levels in bovine colostrum are significantly higher than those in regular cow milk and are essential for the absorption of calcium and phosphorus (Bagwe *et al*., 2015).

1.3 Macronutrients

1.3.1 Oligosaccharides

Bovine colostrum is rich in complex and selective oligosaccharides and glycans that differ from those found in mature cow milk. These oligosaccharides are present in quantities of 0.7-1.2 mg/mL, with a majority being acidic and not found in mature cow milk (Umar *et al*., 2023). In Bovine Colostrum, 6′ sialyllactose, 3′ sialyllactose, 6′ siayllactosamine and disialyllactose are the main oligosaccharides (DSL). There are currently forty different oligosaccharide compositions identified in bovine colostrum (Jena *et al*., 2022). Studies have demonstrated that oligosaccharides derived from bovine colostrum possess anti-infective properties against a virulent type of C. jejuni, indicating that cow colostrum might be a potential source of glycans with anti-infective activity (Masterson *et al*., 2022).

1.3.2 Fats

Bovine Colostrum is rich in fats including myristic palmitic, and palmitoleic acids which are low in mature milk (O'Callaghan et.al, 2020). According to researchers, BC has low fat content as compared to milk, hence it can be a good low fat dietary option for people who are on a diet or who want to lose weight, but more studies are required to verify this (Simon *et al*., 2022). Some evidences suggest, fatty acids found in BC regulate lipogenesis in the liver (German, Argov-Argaman, & Boyd, 2019). Fat content can be reduced by using dairy technologies to produce low fat or fat free BC and its products (German *et al*., 2009). The lipid profile of Bovine Colostrum shows lower quantities of saturated fatty acids and higher concentrations of monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA)which allow BC to be an excellent functional food for human health (Mašek *et al*., 2014). The calving season has an impact on the fat percentage of bovine colostrum at 24 and 48 hours after birth. Calves born in the spring and summer have a lower percentage of colostrum fat than animals born in the fall and winter. Seasonal fluctuations in the metabolism, the amount of feed consumed, and the amount of water consumed could all play a role (Erdem & Okuyucu, 2020).

1.3.3 Bioactive Protein

Major protein compounds in Bovine Colostrum are lactoferrins (LF), growth factors (GH) and immunoglobulin's (Ig). BC contains triple amount of protein as compared to normal cow milk, using BC in the production of dairy products can result in high protein products. The high protein content of BC may have the potential to mitigate the risk of protein energy malnutrition (PEM) globally. There are two types of proteins in cow milk i.e., whey and casein. Whey proteins are soluble proteins whereas casein is insoluble proteins. These milk proteins contain all essential amino acids (AA) that is why they are also called "high quality proteins" and are also the by-products in cheese making. The amino acid composition and high digestibility of milk proteins, particularly whey proteins, make them widely recognized as a "complete protein" source (Arslan et.al, 2021). Both these milk proteins are important for body functions and are digested and absorbed easily (Lambrini *et.al*, 2021). For a healthy adult, more than 0.8 g/kg of protein per day is advised (Richter et.al, 2019). It is particularly difficult for elderly populations to consume enough protein to prevent the loss of skeletal muscle that comes with ageing. This problem is made worse by the aging-related decline in proteolytic activity. Colostrum can be a complete source of protein for all age groups. An extensive amount of tryptophan which is an essential amino acid may be isolated from cow colostrum. According to a study, tryptophan is good for sleep and mood and is essential for newborns' growth and development (Ruddick *et al*., 2006).

1.3.4 Immunoglobulins (Ig)

Bovine colostrum contains a sizable amount of complex proteins called immunoglobulin's (Igs), also known as antibodies. Immunoglobulins are glycoprotein molecules that are responsible for detecting and protecting the human body against foreign particles like viruses and bacteria. Bovine colostrum is a rich source of various immunoglobulins such as Immunoglobulin A (IgA), Immunoglobulin G (IgG), and Immunoglobulin M (IgM). Among these, IgG is the most predominant, constituting 85-90% of the total immunoglobulin content in bovine colostrum (Bagwe *et al.*, 2015). Colostrum collected 2 hours after parturition has highest concentration of IgG and has much better quality than colostrum collected later (Moore *et al*., 2005). Immunoglobulins play a vital role in protecting the new born calf against viruses and bacteria, improves digestion and absorption and increase weight of the new born. Survival of the new born calf greatly depends on transfer of IgG via placenta (Beam *et al*., 2009). For several decades, the use of Bovine Colostrum as a source of antibody preparations to promote the health of both humans and bovines has been a major subject of research (Korhonen & Pihlanto, 2007). BC is regarded as a good source of immunoglobulin G (IgG) for the creation of pharmaceutical and food derivatives for human consumption, as it benefits human health through immune system enhancement (Gaspar-Pintiliescu *et al*., 2020). The majority of BC based products in the market are supplement powders or pills containing around 20-25% IgG.

1.3.5 Lactoferrins

Lactoferrin also called lacto transferrin, is a protein that in abundantly found in Bovine Colostrum and is responsible for iron absorption (Buttar *et al.,* 2017). LF has bacteriostatic effect, it stops bacteria from growing. Doctors have been using BC as a treatment option for children who have recurrent UTI and diarrhea (Poonia, 2022). Due to high amount of lactoferrin in BC, it has anti-cancerous properties. Bovine Colostrum contains four times more Lactoferrin as compared to normal milk. Research suggests that lactoferrin from bovine colostrum may enhance the proliferation of cells necessary for bone development, such as osteoblasts, and the secretion of several growth factors from osteoblasts (Sudarev *et al*., 2022).

1.3.6 Lacto peroxidase

Bovine colostrum is known to have a considerable amount of lacto peroxidase, which is an antibacterial enzyme. This basic glycoprotein has the ability to oxidize thiocyanate and generate intermediate compounds that exhibit antimicrobial properties (Fox & Kelly 2006). Bovine colostrum has higher lacto peroxidase catalase activity than mature milk. Bovine colostrum contains 11–45 mg/L of lacto peroxidase, while mature bovine milk contains 13–30 mg/L. It starts out with a low concentration in bovine colostrum, but within 3 to 5 days of parturition, it reaches its highest level (Farkye & Bansal 2011). Lacto peroxidase system has the ability to inactivate deadly viruses including the poliovirus, vaccinia virus, and HIV

1.3.7 Growth Factors

Naturally occurring substances referred to as Growth factors (GF) have a molecular mass ranging from 6000 to 8000 Daltons. The growth factor components of colostrum differ substantially between species. Bovine Colostrum is loaded with growth factors that are necessary for calves' growth and development. In colostrum, more than twenty distinct peptide growth factors have been identified. The growth factors generated from cheese whey or bovine colostrum have been recommended for use in a number of health-related applications, but only a few have been put on the market thus far. IGF-1 and IGF-2 are high in bovine colostrum than in human milk and are responsible for cell differentiation and proliferation. These two growth factors have a similar structure to pro insulin hence can act like insulin in the body. Both these growth factors can withstand exposure to heat and acid and maintain biological integrity (Petersen & Shulman, 2018). Vascular endothelial growth factor (VEGF) displays numerous effects that could be pathogenic significance, such as promoting proliferating cells and the development of new blood vessels and exercise that increases vascular permeability. Bovine Colostrum VEGF content can help in improving the local vascular supply in diseases like peptic ulcers.

1.4 Storage and Processing of Bovine Colostrum

To avoid unnecessary pathogenic contamination, colostrum should be handled in a sanitary manner. Cold storage is the sole viable method of keeping colostrum safe for future use. Colostrum can be easily frozen in plastic containers in amounts sufficient for feeding of individual calves. Metal containers corrode as a result of acid additions or acid production during fermentation. Stirring colostrum immediately before feeding results in a more uniform diet for calves. The suitable temperature and duration recommended for bovine colostrum storage is 30-35 º F for 6 months, thawing of colostrum can be done using hot water or microwave oven to prevent damage to immunoglobulins. Unfermented colostrum can be mixed with fermented colostrum without significantly changing the composition. Food processing seeks to maximize the decomposition of harmful and spoilage bacteria with a longer shelf life while preserving the nutritional content and biologically active compounds of food. Several processing techniques have been reported in the literature to lower the microbial burden in Bovine Colostrum (Foster et.al, 2016) (Chatterton et.al, 2020). The BC mixture undergoes thermal processing, producing a gel-like structure. When Bovine Colostrum is heated, the high proteins denature and rearrange to form a gel like mixture. These denatured proteins have a high cysteine content, which forms disulfide bonds with other proteins to create a gel network (Hege *et.al,* 2021). Drying techniques (freeze or spray drying) and gentle pasteurization of Bovine Colostrum may serve as a barrier technology that reduces the microorganism load with little impact on the bioactive components mainly immunoglobulin's and antioxidant activities (Salar *et.al,* 2021). According to research, thermal treatment completely denatured immunoglobulin 1 but has less impact on immunoglobulin 2 concentration. Additionally, when Bovine Colostrum undergoes thermal treatment for 30 min or 1 hour it immensely reduces the microbial load with no effect on viscosity (Elizondo, Jayarao & Heinrichs, 2010). Bovine colostrum nutritional and bioactive components are frequently significant, and processing conditions have a big impact on them. These processing methods improve the functional qualities (good shelf life and less microbial load) of Bovine Colostrum based products. Additionally, these processing techniques are regularly used in the production of a variety of Bovine Colostrum based products, including purified major and minor proteins, colostrum powder, and IgG-concentrate powder. These products are then extensively used in the production of a variety, beauty cosmetics, pharmaceuticals products and food and feed additives. The aim of the study is to perform physiochemical analysis on Bovine Colostrum and compare it with cow milk.

2. Materials and Methods

2.1 Sample Collection

Fresh bovine colostrum's was sourced from a local dairy farm located in Lahore, Pakistan. Cow milk was purchased from dairy shop located in Gulberg, Lahore.

2.2 Location of study

Physicochemical tests including proximate analysis, mineral analysis, color analysis and texture analysis were performed at Pakistan Council of Scientific and Industrial Research (PCSIR) and University of Veterinary and Animal Sciences (UVAS) Lahore.

2.3 Sample Preparation

The collected Bovine Colostrum sample was homogenized. If necessary, any visible impurities or solid particles were removed through filtration or centrifugation.

2.4 Physiochemical Characterization of Bovine Colostrum

2.4.1 Proximate Analysis

Proximate analysis of bovine colostrum's and milk was performed by using AOAC methods (2016) to evaluate content of Crude Ash by incineration in a muffle furnace at 550 °C, Crude Carbohydrates by difference method, Crude Fat by Gerber Method, Crude Protein by Kjeldahl Method and Moisture content by oven drying method at 105 ºC. All the tests were performed in Food Science Laboratory of University of Veterinary and Animal Sciences (UVAS), Lahore.

2.4.2 Mineral Analysis

Mineral analysis of milk and bovine colostrums was performed by Atomic Absorption Spectrometry (AAS). The minerals determined were calcium, potassium and sodium. The method involved the preparation of a sample solution by diluting the milk with deionized water and then ashing the sample in a muffle furnace at a high temperature to completely burn off all organic matter. The ash was then dissolved in an acid solution and the minerals of interest were determined using atomic absorption spectroscopy.

2.4.3 pH

The pH of the raw samples was determined using digital potentiometer (AOAC, 2019). SARTORIUS-PB-10 BASIC BENCH TOP pH METER was used to check the pH and temperature of raw sample. In two separate beakers 100 ml of milk and colostrum was taken. The temperature and pH electrode of the pH meter was dipped into the sample one by one and readings were noted from the automatic screen display. The test was performed three times for both the samples for better accuracy of result.

2.4.4 Acidity

According to AOAC 974.13 (2016) titrimetric method was used for measurement of acidity of milk and bovine colostrum. A milk sample was taken and standardized with a sodium hydroxide (NaOH) solution of known concentration. Phenolphthalein was added to the milk sample as an indicator, and the sample was titrated with the NaOH solution until the endpoint was reached. The endpoint was indicated by a color change from pink to colorless. The amount of NaOH used in the titration was recorded, and the acidity of the milk was calculated based on this value.

2.4.5 Specific Gravity

Lactometer was used to check the density of sample. Milk and colostrum was added in two separate measuring cylinders. Temperature of both the samples was noted to be 20 ºC each. Lactometer was dipped in both the samples and readings were noted. The test was performed three times for both the samples for better accuracy.

2.4.6 Color

Color analysis of the sample was done by colorimetric system (CIELAB). CIE LAB is a color space that describes colors based on three parameters: L*, a*, and b*. L* represents lightness, a* represents the red-green axis, and b* represents the yellow-blue axis (Mayta-Hancco *et al.*, 2019). To perform color analysis of milk using CIE LAB, the milk sample was first placed in a container and allowed to come to room temperature. A colorimeter or spectrophotometer equipped with a CIE LAB color space option was then used to measure the color of the milk.

2.5 Statistical Analysis

After collecting the data, it was evaluated using Statistical Package for the Social Sciences (SPSS) software, and graphs were made using Microsoft Excel. Complete variables were identified and the data was interpreted accordingly.

Table 1: Comparison between Physicochemical Analysis of Bovine Colostrum and Milk

	Milk	**Bovine Colostrum**
Proximate analysis (%)		
Protein	3.50 ± 0.57^{B}	16.24 ± 0.00^{A}
Fat	4.72 ± 0.01^{A}	4.00 ± 0.57^{B}
Moisture	89.10 ± 0.57^{A}	79.66 ± 0.00^{B}
Ash	0.54 ± 0.00^{B}	0.87 ± 0.00^{A}
NFE	2.14 ± 0.05^{A}	0.77 ± 0.10^{B}
Minerals Analysis (mg/100ml)		
Calcium	28.1 ± 0.04^{A}	23.1 ± 0.06^{B}
Sodium	18.03± 0.03^{B}	47.03 ± 0.04^{A}
Potassium	74.03 ± 0.03^{A}	58.13 ± 0.04^{B}
pH	6.62 ± 0.05	6.40 ± 0.02
Acidity (Lactic Acid /100ml)	0.16 ± 0.01	0.25 ± 0.02
Color		
L*	94.51±0.14^{A}	82.82±0.09^{B}
a*	-2.4±0.04^{B}	5.5±0.06^{A}
b*	9.15±0.04^{B}	24.90±0.05^{A}

Means carrying same letters vary non-significantly

NFE=Nitrogen Free Extract

L*= lightness a*= Redness/green b*= yellow/blue

3.Result

Table 3.1 illustrates a comparison of the composition of Cow Milk and Bovine Colostrum regarding various parameters.*3.1 Proximate Analysis.* The moisture content of milk was higher (89.10% ± 0.57) as compared to colostrum (79.66% ± 0.00). The crude protein content was observed to be much higher in colostrum (16.24% ± 0.00) than in milk (3.50% ± 0.57). The crude fat content in colostrum was (4.00 % ± 0.57) which was lower than milk (4.72% ± 0.01). In addition, the ash in colostrum was (0.87% ± 0.00) and in milk (0.54% ±0.00). Lastly, Colostrum had a lower NFE (nitrogen-free extract) percentage of (0.77% ± 0.10), in contrast to milk (2.14% ± 0.05).

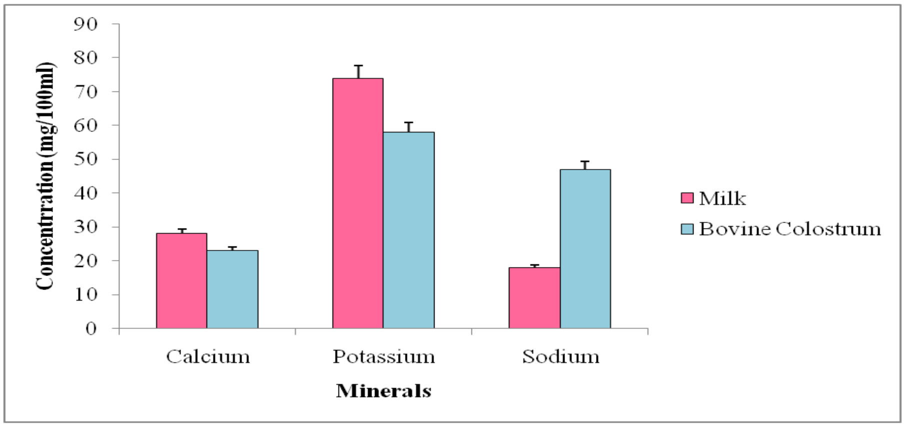

Figure 3.1: composition of Cow Milk and Bovine Colostrum regarding various parameters

3.2 Mineral Analysis

The mineral analysis results of both milk and Bovine Colostrum. The data analysis revealed that Bovine Colostrum had significantly higher levels of sodium and lower level of potassium and calcium, respectively. The mean calcium level in Bovine Colostrum was 23.1 ± 0.06 mg/100ml, which was significantly lower than the mean calcium level of milk 28.1 ± 0.04 mg/100ml. The mean sodium level of Bovine Colostrum was significantly higher 47.03 ± 0.04 mg/100ml as compared to the mean sodium level of milk18.03± 0.03 mg/100g. Similarly, the mean potassium level of Bovine Colostrum was 58.13 ± 0.04 mg/100ml, which was significantly lower than the mean potassium level of milk 74.03 ± 0.03mg/100ml

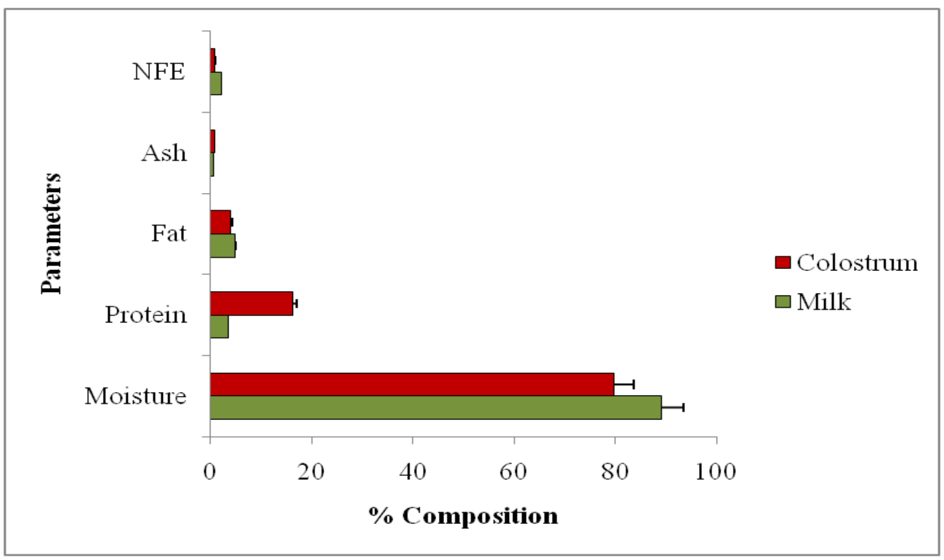

Figure 3.2: Mineral analysis results of both milk and Bovine Colostrum

3.3 pH and Acidity The pH of Bovine Colostrum (6.40 ± 0.02) was significantly lower than that of milk (6.62 ± 0.05) whereas, the acidity of milk (0.16 ± 0.01) was less than colostrum (0.25 ± 0.02) respectively.

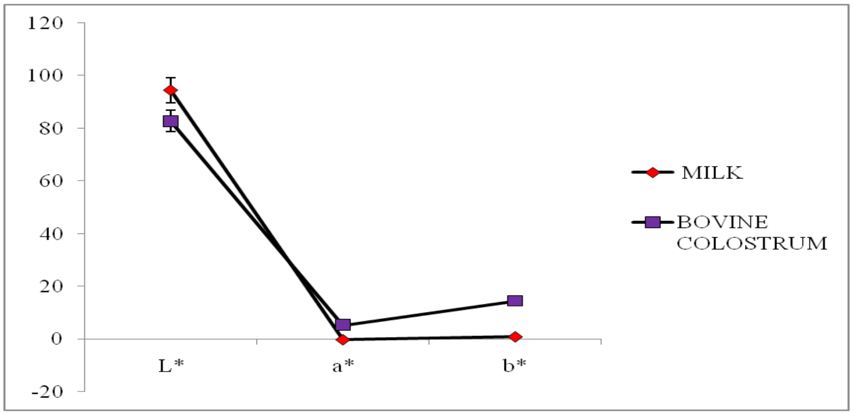

Figure 3.3: The pH of Bovine Colostrum was significantly lower than that of milk

3.4 Specific Gravity

The mean lactometer reading for milk was 30, with a mean specific gravity of 1.033 g/ml, while for bovine colostrum, the mean lactometer reading was 49, with a mean specific gravity of 1.049 g/ml. These findings suggest that bovine colostrum is denser than milk.

3.5 Color

Bovine Colostrum had lower L* values and higher a* and b* values compared to milk and b* values compared to milk. The mean L* value of Bovine Colostrum was (82.82±0.09), which was lower than the mean L* value of milk (94.51±0.14). The mean a* value of Bovine Colostrum was (5.5±0.06), which was higher than the mean a* value of milk (-2.4±0.04). The mean b* value of Bovine Colostrum was (24.90±0.05), which was higher than the mean b* value of milk (9.15±0.04). The results suggest that bovine colostrum has a darker color(lower L* value) and a more intense yellow-red color (higher a* and b* values) compared to milk.13% of milk is made up of other components.

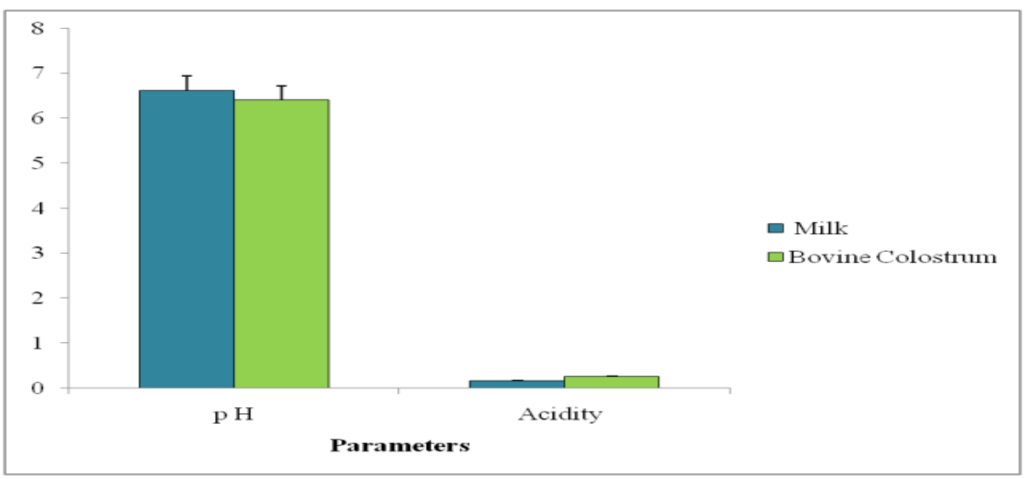

Figure 3.5: Bovine Colostrum had lower L* values and higher a* and b* values compared to milk

4. Discussions

4.1 Proximate Analysis

Water is the major component of milk, making up about 87% of its weight. The amount of water in milk can vary slightly depending on factors such as breed of cow, stage of lactation, and feed and water intake. The remaining 13% of milk is made up of other components such as proteins, fats, carbohydrates, minerals, and vitamins. The water in milk is not just plain water, but also contains dissolved gases such as oxygen, nitrogen, and carbon dioxide, as well as other soluble components such as lactose, minerals, and vitamins (Juvinal *et al*., 2023). However, in general, colostrum contains less water than mature milk, with a typical range of 60-80% water content. This is because colostrum is richer in nutrients, such as proteins and antibodies, which are essential for the newborn calf's growth and immune system development. As the calf grows and its nutritional needs change, the composition of the milk shifts towards a higher water content to meet the calf's changing requirements (Polidori *et al*., 2022). The protein content in milk and cow colostrum differs significantly. Milk from healthy cows typically contains around 3.2% protein, while the protein content in cow colostrum can range from 15 to 20% depending on the time of milking after parturition (Astuti *et al*., 2021). The high protein content in colostrum is essential for the growth and development of the newborn calf. Colostrum contains a wide variety of proteins, including immunoglobulins, growth factors, and enzymes, that are important for the calf's immune system, growth, and development. These proteins are also more easily digestible compared to those found in milk, making them more available to the calf. As the calf grows, the protein content in the milk gradually decreases, and the composition of milk becomes more similar to that of regular milk. However, the protein in milk still contains all the essential amino acids required by the human body. The protein in milk is important for maintaining and building muscle mass, repairing tissues, and supporting immune function (Puppel *et al*., 2019). Colostrum has lower fat content than milk due to the physiological changes that occur in the mammary gland during the transition from pregnancy to lactation. During late pregnancy, the mammary gland synthesizes colostrum, which is rich in proteins, antibodies, and other bioactive molecules needed to provide passive immunity to the newborn. The synthesis of colostrum is regulated by different hormones such as prolactin, insulin, cortisol, and progesterone. These hormones affect the composition of colostrum by regulating the expression of different genes involved in milk synthesis (Simon *et al*., 2022). Compared to mature milk, colostrum has a lower fat content due to the fact that the mammary gland synthesizes more casein and other proteins during the colostrum stage, which reduces the proportion of milk fat in the gland. Additionally, the synthesis of milk fat requires the presence of specific enzymes that are not fully activated until a few days after parturition, which further contributes to the lower fat content in colostrum (Wilms *et al*., 2022). Other factors that contribute to the lower fat content in colostrum include differences in the volume of milk produced and the frequency of milk removal. Colostrum is produced in lower quantities than mature milk and is usually removed less frequently from the mammary gland during the first few days after parturition, which can also affect its fat content (Simon *et al.,* 2022). The results obtained in this study are consistent with previous studies which have also reported higher moisture and protein while lower fat content in Bovine Colostrum (Simon *et al.*, 2022). In conclusion, this study suggests that Colostrum has a significantly different composition compared to milk, with higher protein, moisture, ash, and lower fat content.

4.2 Mineral Analysis

Milk contains more calcium than cow colostrum because calcium levels increase in the mammary gland as lactation progresses. During pregnancy, the maternal body accumulates calcium in preparation for lactation. As milk production begins, calcium is transferred from the blood into the mammary gland for milk synthesis. In the early stages of lactation, such as during colostrum production, the transfer of calcium into the mammary gland is still being established, resulting in lower levels of calcium in cow colostrum compared to milk. As lactation progresses and milk production increases, the calcium concentration in milk also increases (Jeong *et al*., 2009). Another factor that contributes to the higher calcium content in milk is the dilution effect. The dilution effect during milk production does not lead to a decrease in the concentration of calcium in milk. In fact, calcium is a major component of milk and is present in a relatively stable concentration in the milk of healthy cows, typically ranging from 1000-1200 mg of calcium per liter of milk. As milk production increases, the volume of milk increases while the concentration of calcium remains relatively stable. This means that the total amount of calcium in the milk also increases, making it a good dietary source of calcium. However, the dilution effect can lead to a decrease in the concentration of other water-soluble components, such as lactose and some minerals, in the milk. Therefore, while the concentration of calcium in milk remains constant the total amount of these other components may decrease as the volume of milk produced increases (Jeong *et al*., 2009). (Abushelaibi *et al*., 2018). According to Kehoe *et al*. (2007), the concentration of potassium in colostrum varies between 983 to 5511 $mg.kg^{-1}$, with a mean value of 2845 $mg.kg^{-1}$, which is notably higher than what has been reported in previous studies. The reasons for the variability in potassium levels in colostrum are not fully understood, but could be attributed to the animal's nutritional status, genetic factors, and environmental conditions (Cashman, 2002). Cow colostrum is known to have higher levels of sodium compared to mature milk or regular cow's milk. This is because sodium plays an important role in the immune system of newborn calves, which is the primary purpose of colostrum. Sodium is essential for maintaining fluid balance in the body and for regulating blood pressure. It is also involved in nerve and muscle function. The high sodium and low calcium levels in cow colostrum can be an adaptation to the needs of newborn calves, which require a lot of sodium for maintaining fluid balance and regulating blood pressure, and, a lot of calcium for their rapidly growing bones and tissues (Abushelaibi *et al*., 2018). Overall, the results suggest, Bovine Colostrum could be used to enhance the mineral content of dairy products, which could be beneficial for individuals with mineral deficiencies. Additionally, the higher mineral content in Bovine Colostrum may be attributed to its potential as a functional food, with potential health benefits such as improving bone health and supporting the immune system.

4.3 PH and Acidity

Milk has a higher pH and lower acidity than cow colostrum due to the differences in their composition. Milk contains a higher proportion of casein proteins, which have a buffering effect that helps to maintain a higher pH. Additionally, lactose in milk is a relatively weak acid that contributes to a lower acidity level compared to the high levels of acidic components, such as immunoglobulins and minerals, found in cow colostrum. The pH of milk typically ranges from 6.5 to 6.7, while the pH of cow colostrum is lower, ranging from 5.5 to 6.5, due to the presence of higher levels of acidic components (Setyawardani *et al*., 2020). The acidity of milk is usually expressed as the treatable acidity, which is the amount of acid required to neutralize a given volume of milk. Cow colostrum has a higher acidity level than milk due to its higher content of lactic acid. Lactic acid is a byproduct of the fermentation of lactose, which is a sugar found in milk. During the early stages of lactation, cow colostrum contains a higher proportion of lactose compared to mature milk. The higher lactose content provides more substrate for the bacteria present in the colostrum to ferment and produce lactic acid, leading to a lower pH level (Barbosa *et al*., 2020). In summary, the differences in pH and acidity between milk and cow colostrum are due to their different compositions, with milk having a higher pH and lower acidity due to the presence of casein proteins and lactose, while cow colostrum has a lower pH and higher acidity due to the presence of acidic components such as immunoglobulins and minerals (Chatterton, 2020).

4.4 Specific Gravity

The differences in specific gravity between milk and bovine colostrum can be attributed to their composition, particularly the variation in the concentration of bioactive molecules such as lactoferrin and immunoglobulins in bovine colostrum (Poonia, 2022). Bovine colostrum is produced during the early stages of lactation and is rich in bioactive molecules that provide immunity and nutrition to newborn calves. These bioactive molecules can affect the density of bovine colostrum, making it denser than milk.

4.5 Color Analysis

The difference in color between milk and colostrum can be attributed to differences in their composition. Colostrum contains higher amounts of fat and protein compared to milk, which can affect the scattering and absorption of light, resulting in a darker color. Additionally, colostrum contains higher levels of carotenoids, which are responsible for the yellow-red color (Barbosa *et al*., 2020). The L* value of colostrum is significantly lower than that of milk, which means that colostrum is darker than milk. The higher a* and b* values of colostrum indicate a more intense yellow-red color compared to milk. This could be due to the presence of carotenoids, which are fat-soluble pigments that contribute to the color of milk and dairy products.

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