Physicochemical Properties and Comparisons of Goat and Cow Milk. Review

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Abstract - Many infants and young children are fed nutritional milks. Although products are commonly based on cow milk and goat milk provides an alternative. We directly compared digestion of cow and goat milk proteins, lactose, varying pH, enzyme concentrations and incubation times to simulate infant and young child gastric conditions. Digestion of higher molecular weight whey proteins increased with decreased pH and higher enzyme concentrations of young child gastric digestion conditions compared to infant conditions. lactoglobulin was poorly digested under all gastric digestion conditions.

Keywords - digestion, pH, nutritional value, Physico-chemical properties, enzyme

I. INTRODUCTION

Milk is one of the most common food sources in the human diet and is also a product that is directly available for consumption. Its role is to nourish and provide immunological protection. Milk has distinct physical, chemical and biological characteristics, which justifies its high quality for consumption. These characteristics present a favorable environment for the multiplication of various bacteria. It is well known that freshly obtained milk contains some bacteria and somatic cells, which represent the biological constituent of the milk. According to the biological constituents easily change depending on production conditions, the health status of the cattle, hygiene practices during milking, keeping and transportation of milk. The quality of milk as well as its safety in the consumption depends on its chemical composition, microbiological, physical and organoleptic properties. A satisfactory quality of milk means it is high in nutritional value and that it is free of any forms of bodies and of foreign constituents which can cause diseases [1].

Milk provides a complete source of proteins, lipids and carbohydrates to support the growth of the neonate until they are able to digest foods from other sources. Breast feeding of infants is highly recommended for at least the first six months of life. Amongst mammals, humans are unique using milk from other species to feed their infants and young children. Thus, due to a myriad of reasons, many are fed milk formula manufactured from cow milk [2].

The physical and chemical composition of the milk is directly influenced by the diets given to animals, the forage: concentrate ratio directly interferes with the volume of milk produced as well as the concentrations of the components, especially the fat content. The use of concentrate in diets aims to raise the energy and protein concentration of the diet, increasing the total digestible nutrient content of the diet, promoting a greater input of nutrients for milk production, increasing the volume produced as well as increasing the amount of total solids [3].

II. PHYSICO-CHEMICAL PROPERTIES OF MILK

Physico-chemical analysis is important tool to monitor the quality of milk and other dairy products [4]. Moisture content, total solid (TS), total protein, ash contents, pH, specific gravity, and total titrable are physico-chemical properties of milk. [1]. Analytical method such as Ultrasonic Milk Analyzer is used to determine refractive index, freezing point and electrical conductivity of goat and cow milk [5].

2.1 Determination of pH

Milk has acidic properties inside of mammals due to the presence dissolved carbon dioxide. But the milk has alkaline properties outside of the mammals because of losing carbon dioxide to the air. The pH of milk is never determined immediately after milking processing due to the removes of dissolved gasses. The pH is determined after processing the milk to assure that lactic acid is being produced at the desired rate by added microorganisms during the preparation of cheeses and fermented milk. The casein in milk forms into a curd or a gel at a pH of 4.6.

The pH decreases with increasing temperature. This implies temperature-induced changes in milk’s complex buffering system rather than an increase in milk’s acidity. At a given temperature, differences in pH and buffering capacity between individual lots of fresh milk reflect compositional variation. The pH of colostrums can be as low as 6.0 and that of mastitic and endof-lactation milks as high as 7.5. High pH can be due to increases in [Na^+] and [Cl^-] (and possibly in the concentrations of other ions), a reduction in the lactose content, and a reduction in the concentration of soluble inorganic P – changes that alter buffering capacity in this pH range [6].

2.2 Titratable acidity

Titratable acidity is the amount of alkali required to bring the pH to neutrality. This property of milk is used to determine bacterial growth during fermentations, such as cheese and yogurt making as well as compliance with cleanliness standards. Naturally, there is no lactic acid in fresh bovine milk, however, lactic acid can be produced by bacterial contamination, but this is not common. The titratable acidity is due to the casein and phosphates.

Titratable Acidity of Milk The alkaline range of the titration curve is important because of the widespread use of titratable acidity to characterize milk. The titratable acidity is the buffering capacity of milk between its own pH (6.6) and pH 8.3 (the phenolphthalein end point). The measurement of titratable acidity (usually expressed, somewhat arbitrarily, as percentage lactic acid) is useful for determining the freshness of milk and for controlling the manufacture of fermented dairy products. The titratable acidity of fresh milk seldom falls outside the range 0.14–0.16%**.** [6]

2.3 Specific gravity

The specific gravity of milk is slightly higher than the water due to the presence of fat. Thus as the composition of milk is changed the specific gravity of the milk also changed. By removal of fat, the specific gravity of milk can be increase because of the weight of fat is much lower than the water. So, as the fat content decrease the specific gravity of milk is increase and reduces the milk nutritive contents; finally makes it low standard milk quality. The adulteration rate of water was almost common besides that some chemicals and powders might be commonly added to increase the specific gravity of milk. The widely used adulterant was water due to its cheapness and easy availability.

The specific gravity of the milk is measured using a Lactometer and the temperature deviation of milk is taken into consideration and correction applied, the lactometer is called Correct Lactometer Reading (CLR). The Auto CLR is an instrument incorporating electronics to observe the lactometer reading .It is a patented instrument of its manufacturer Solid State Technologies‘. In this case the manual process is preserved, only electronics is added ‘to it make observation error free and apply the temperature correction automatically [7].

2.4 Total Solids in Milk

Total solids are measured to ensure the quality of milk and milk products. The total solids in milk can be determined from the specific gravity and fat content from lactometer reading and it can be calculate the total solids in milk. Besides carrying out the total solids percentage from the indirect method of taking lactometer reading, a direct method of gravimetric analysis can also be used. This method involves accurately weighing a few grams of the material and subjecting it to heat until all moisture has been driven off on a water bath. The dry residue is weighed, its percentage calculated as total dry solids.

2.5 Solids Non-Fat (SNF)

Solid non-fat is an important criterion of milk selection for further processing. Milk solids non-fat would include the nitrogenous substances, milk sugar and mineral matter. Whole fluid milk contains a minimum 8.25 percent SNF. The determination of solid non-fat is done by taking lactometer reading at 40°C. Solids-not-fat (SNF) content was determined by the following formula [8].

SNF content (%) = TS (%) – Fat (%)

2.6 Fat content

Fats are one of the most important components of all mammals’ milks because they affect the cost, nutritional value, and the physical and sensory characteristics of dairy products positively. Milk fat has the most complex fatty acid composition of the edible fats. Over 400 individual fatty acids have been identified in milk fat. However, approximately 15 to 20 fatty acids make up 90% of the milk fat. The major fatty acids in milk fat are straight chain fatty acids that are saturated and have 4 to 18 carbons, monounsaturated fatty acids and polyunsaturated fatty acids. Some of the fatty acids are found in very small amounts but contribute to the unique and desirable flavor of milk fat and butter [9].

2.7 Proteins in Milk

Milk comprises of casein, lactoalbumins and lactoglobulins. About 82 percent of the protein in milk is casein and the remaining proteins are whey proteins, which are lactoalbumin and lactoglobulin. Casein binds with calcium in milk and forms the calcium-casein ate complex, which is present in the colloidal form. Acid, rennet, alcohol and heat can precipitate this complex.

The proteins in milk are of great quality, that is to say, they contain all the essential amino acids, and elements that our bodies cannot produce. It is important to remember that proteins are the building blocks of all living tissue. Milk proteins have roughly the same composition as the egg protein, except for the amounts of methionine and cystine, significantly lower. Indeed, the sulfur amino acids are the limiting factors in milk. Casein and, even more, the complex milk protein contains good proportion of all amino acids essential for growth and maintenance [10]. The denomination crude protein (CP) includes protein (TP) and non-protein nitrogen (including urea). The protein content is an important feature of the milk [11].

2.8 Ash content

Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents, which provides a measure of the total amount of minerals within a food. Analytical techniques for providing information about the total mineral content are based on the fact that the minerals can be distinguished from all the other components within a food in some measurable way. The most widely used methods are based on the fact that minerals are not destroyed by heating, and that they have a low volatility compared to other food components. The main analytical techniques used to determine the ash content of foods are based on this principle: dry ashing, wet ashing and low temperature plasma dry ashing.

The ash components of milk or milk replacer are essential for the growth and health of the animal. Suggesting they are harmful to the animal is either immature or shows a marketing strategy that is self-serving. The only impact that higher ash levels have on the nutrition of the animal is the resulting impact described above on the amount of energy available from lactose. Ash content of the milk replacer should only be considered in detail when energy is known to be the limiting nutrient in the diet. Milk replacer has four major components: Protein, Fat, Lactose and Ash. Protein and Fat are traditionally set by the formula such as creating a 20:20 or 24:20 milk replacer, respectively. Ash is fixed for the formula depending on the ash content of the various ingredients. Lactose is variable and makes up the difference of the total weight from the weights of protein, fat and ash. [12, 13]

2.9 Conductivity

Electrical conductivity (EC), is a measure of a material's ability to carry an electrical current. It ranges in value from 10^{-18} to $10^{7}Sm^{-1}$ (Siemen per meter), depending on the material. The EC of normal whole milk is about 0.460 Sm^{-1}. EC of milk is determined mainly by the charged species present, particularly the salts. There is very little contribution from lactose; casein, also, makes a much smaller contribution than do the milk salts. The main effect of milk proteins in general is to hinder the migration of ions and thus depress EC. However, the release of calcium ions from the casein micelles as a result of a decrease in pH, caused by either deliberate acidification or bacterial growth, results in an increase in EC. A drop in milk pH to about 5 causes all of the colloidal calcium phosphate to dissolve, and the equilibria of milk buffer systems to change, resulting in saturation of the EC to a constant maximum value. This phenomenon is the basis of the automatic monitoring of the growth of lactic acid bacteria by conductimetric methods.

The EC of fresh milk and cream decreases with increasing fat content because the fat globules (themselves non-conducting) occupy volume that would otherwise be filled with the conducting aqueous phase of the product, thus impeding the mobility of the conducting ions and increasing the distance that migrating ions have to travel. For a fat content in the range 0.15–51% (w/w), the EC of milks. [6]

III. Comparison of Goat and Cow Milk

Table 1. The Basic Composition of Goat and Cow Milks [10, 11, 14]

Constituents	**Goat**	**Cow**
Food energy (kcal)	69	61
Fat (g/100 g)	4.5	3.7
Total protein (g/100 g)	3.6	3.4
lactose (g/100 g)	4.3	4.7
Minerals (g/100 g)	0.8	0.7
Ash content (/100 g)	0.83	0.71
Total solid (g/100 g)	12.62	13.3

The basic chemical composition of goat milk in regard to the total solid, fat, total protein, casein, whey proteins, and lactose, mineral, and vitamin contents is similar to that of cow milk. The gross composition of goat and cow milk varies with breed, age, environmental conditions, lactation period, the health status of udder, feeding and the milking period. [14]

Goat milk contained (g/100 g): 3.6 proteins, 4.5 fats, 0.83 ashes, 87.38 water, 12.62 total solids and 0.8 minerals of which 4.7 are lactose (96.26 %). The main component of goat milk as protein, total solids, and lactose differs from cow milk. It has significantly lower content while fat content is somewhat similar.

Cow milk contained (g/100 g): 3.4 protein; 3.7 fat; 0.71 ash; 86.70 water; 13.30 total solids; 0.7 minerals, of which 4.70 are lactose (94.46 %). Cow milk is significantly different from goat. Cow milk has highly significant protein content than and goat milk. Cow milk has significantly similar to the goat milks. It also has significantly lower ash content than the goat milk. [15]

The lactose of goat milk is more digestible than that of cow milk because the lactose of goat milk is smaller and have a greater surface area. The proteins in goat milk are digested more readily and their constituent amino acids absorbed more efficiently than those of cow milk. [16, 17]

The nutritional value of milk is particularly high due to the balance of the nutrients that compose it. The composition varies among animal species and breeds within the same species, and also from one dairy to the other, depending on the period of lactation and diet. For instance, goat milk is 88% water and 11.4% solids; it contains 3.2% fat and 8.13% of fat solids. It is also comprised of calcium (0.11%), phosphate (0.08%) and magnesium (0.21%). In general, goat milk compared to cow milk is less rich in fat and proteins, but it has almost similar mineral content. [14]

IV. Conclusion

Physico-chemical analysis is important tool to monitor the quality of milk and other dairy products. Moisture content, total solid (TS), total protein, fat content, conductivity, ash contents, pH, specific gravity, and total titrable are Physico-chemical properties of milk. The basic chemical composition of goat milk in regard to the total solid, fat, total protein, casein, whey proteins, and lactose, mineral, and vitamin contents is similar to that of cow milk. In general, the nutritive value of goat milk and cow milk is not significantly different but the size of fat globule is smaller for goat milk which increases the digestibility and nutritive importance of goat milk.

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