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Review

Composition and nutritional value of raw milk

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Milk is a considerable resource of products whose composition varies. Four components are dominant in quantitative terms: water, fat, protein and lactose; while the minor components are minerals, enzymes, vitamins, and dissolved gases. It satisfies the demand of the consumer who seeks more and more innovative products with consistent quality. The dairy industry needs to utilize all the riches of this raw material, which is both simple in appearance and complex in composition. In general, cow milk is less rich in lactose, fat content and protein. On the other hand, the mineral content is similar.

Key words: Milk composition, element, nutrition, components.

INTRODUCTION

The free dictionary simply defines milk as a whitish liquid containing milk proteins, fats, lactose, and various vitamins and minerals, produced by the mammary glands of all adult female mammals after childbirth and serves as food for their young. It should be noted that milk culture is infused with the sanctity of the cow in ancient Egypt, Iran and India. In Europe, the monks, including the Benedictines in the middle ages were the main producers of cheese for example Bishop, Munster. Thus, before the scientific revolution and industrial development in Europe during the nineteenth century, were fabrications and techniques of fermented milk, butter and cheese already had a considerable importance in human life (Konte, 1999).

The breeding of dairy animals dates back to nearly 8000 years and so has opened up opportunities to improve eating habits, especially for infant feeding, as it is a raw material in the dairy industry. Milk must be specific to human consumption i.e. come from well nourished healthy lactating animals. This means that the milk of infected animals (resulting from inflammation of the udder), undergoing a veterinary treatment is excluded. Milk should have a temperature of +4°C during all operations and delivery to the consumer (Kohler, 2013). We all as consumers and producers should know that the quality of the milk can be compromised by contamination and ensure proper handlind, since it is a perishable material. Milk is the most complete food, rich in protein, carbohydrates, mineral, vitamin and calcium. In this review of literature, we recorded for the first time the composition of milk of different species, in terms of their principal components to know that milk supports human nutrition and is a product in the dairy and food industry. The aim of the present study is to list the compositions of milk of different species and discuss their nutritional values. Given that some milk (e.g. cow and sheep milk) are promoted as a suitable alternative to breast milk and infant formula.

Definition of milk

In France, human milk consumption was defined in 1909 by the International Congress of Food by the following formula: "milk is the product of the total, full and uninterrupted milking of a dairy female in good health, also nourished and not overworked. It must be collected properly and not contain colostrum (Adib and Bertrand, 2009; Leseur and melik, 1991). Milk is a whitish food generally produced by the mammary secretory cells of females in a process called lactation; it is one of the defining characteristics of mammals. The milk produced by the glands is contained in the udder. Milk secreted in the first days after parturition is called colostrum (Kebchaoui, 2012). The quality of milk is paramount; therefore, it must be properly stored and transported in optimal conditions (Roux et al., 1995). This vital product consists of four physical phases:

- A gas phase, which essentially comprises CO_2 at

Table 1. The composition of milk from different mammals in g /100 g milk (Konte,1999).

Species	Water	Proteins	Fat	Lactose	Ash
Cow	87.2	3.5	3.7	4.9	0.72
Sheep	82.7	5.5	6.4	4.7	0.92
Goat	86.5	3.6	4.0	5.1	0.82
Camel	87.7	3.5	3.4	4.7	0.71

Table 2. Composition of milk and goat's milk per 100 g of milk (Cayot, 1998)

Species	Proteins	Casein	Fat	Lactose	Ash
Cow	3.2	2.8	3.90	0.90 to 4.9	0.90
Goat	2.8	2.3	3.38	4.4 to 04.7	0.5 to 0.8

milking time.

- A fatty phase composed of cells, fat (2 to 5 μm of diameter) which contain lipids and fat-soluble elements, the fatty globules are surrounded by phospholipids and protein membrane.
- A colloid phase comprising casein micelles associated with phosphates and citrates of calcium and magnesium (Michel, 2005).
- An aqueous phase consisting of the soluble proteins (whey protein), lactose and minerals (electrolytes). There is an inverse relationship between the content of lactose and minerals, in order to keep the milk in relation with the isotonic blood plasma.

Composition of milk

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 (Table 1). 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 (Table 2) is less rich in lactose, fat and proteins, but have similar mineral content.

Milk contains several groups of nutrients. Organic substances are present in about equal quantity and are divided into elements builders, proteins, and energy components, carbohydrates and lipids. It also comprises functional elements, such as traces of vitamins, enzymes and dissolved gases, and contains dissolved salts, especially in the form of phosphates, nitrates and chlorides of calcium, magnesium, potassium and sodium. It also contains dissolved gases (5% by volume), mainly carbondioxide (CO_2), nitrogen (N) and oxygen (O_2) (Gautheron and Lepouze, 2012).

Water

For all animals, water is the nutrient required in the highest quantity, and milk contains a lot of water (88.6%). This amount of water is controlled by the amount of lactose synthesized by the secretory cells of the mammary gland.

Carbohydrate

Lactose is the main carbohydrate of milk. It is formed by the union of one molecule of D-galactose (engaged by its semi-acetyl function) and one molecule of D-glucose (committed by its hydroxyl 4 position). It has a β-galactoside 1,4 bond (which is hydrolyzed by a β-galactosidase) and is a 4-D-glucopyranosyl-β-D-galactopyranose. Although lactose is a sugar, it does not have a sweet flavor. Its concentration varies slightly in milk (4.5 to 5.2 g / 100 g) contrary to the concentration of fat, that of lactose cannot be easily modified by feeding and true step of a dairy race to another. It is used as substrate during the fermentation of milk by lactic acid bacteria, differing in the fermented products such as yoghurt and cheese. It plays a role in fermented milk production. The amount of lactic acid produced by lactic acid bacteria in a fermented milk product depends not only on the bacterium itself (the bacterial strain more less active) and operating parameters, but also on the available amount of lactose bacteria. The buffer milk power also plays an important role as we shall see later (Fillion, 2006).

Proteins

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 (Konte, 1999). The denomination crude protein (CP) includes protein (TP) and non-protein nitrogen (including urea). The protein content is an important feature of the milk. The TP determines the

Table 3. Average composition and distribution of milk proteins (FAO, 1998)

Milk protein	Mean absolute (g / L)	Averages (g / L)
Crude protein	34	100
Protein	32	94
Insoluble proteins or whole casein	36	82
soluble protein	6	18
α-lactoglobulin	2.7	45
B-lactalbumin	1.5	25
Serum albumin	0.3	5
immune globulins	0.7	12
protein peptones	0.8	13
Non-protein nitrogen substances	2	6

Table 4. Physicochemical characterization of caseins (Brulé et al, 1997).

Parameter	Casein α_{s1}	Casein α_{s2}	Casein β	Casein K
Residue of AA (1)	199	207	209	169
Molecular weight (da)	23600	25200	24000	19000
Cysteine residues (1)	–	2	–	2
Group phosphorylating	8 – 9	10- 13	5	1 – 2
Carbohydrates	–	-	–	+
Sensitivity chymosin	+	-	+	++
Calcium sensitivity	++	+++	+	–

Number per mole (l)

market value of milk, the higher the TP value is compared to a reference, the more money the producer will get. In fact, the more TP, the higher the yield of cheese making. Milk proteins represent 95% of crude protein, but the remaining 5% is: free amino acids, small peptides and non-protein nitrogen. Protein comprise either only amino acid (β-lactoglobulin, α-lactalbumin) or amino acid and phosphoric acid (α and β casein) with a carbohydrate portion (sometimes even k casein). The base of the precipitation at pH 4.6 (20°C) or under the action of the rennet separates two components: caseins (α, β, γ and k) and the soluble protein or whey protein (Table 3).

Casein

The four major caseins that exist naturally in milk are αs1 caseins; αs2, *B* and *k*. Caseins are distinguished by their low solubility at pH 4.6 and are differentiated on the basis of the distribution of exchange and sensitivity to precipitation by calcium. Their physicochemical characteristics are presented in Table 4 (Brulé et al*.,* 1997).

Casein k

Among the most studied casein is casein k (k-CN), probably because of its importance in the stability of the micelle and its role in dairy processing. The k-CN is also the only casein having carbohydrate residues in its constitution (Fox and Mulvihill, 1992). Caseins (α, β and κ) in the presence of calcium phosphate, form stable casein micelles (colloidal phase), which are balanced with the soluble phase of milk (St. Gelais et al*.,* 1992). It is possible to adjust the balance in terms of temperature, pH and the addition of salts. So long as the lactic acid bacteria converts lactose into lactic acid, it lowers the pH of the milk thereby decalcifying the casein micelles. There is another way to destabilize casein micelles and it is by using an enzyme such as chymosine.

Whey protein

Other milk proteins are present in the whey serum and whey proteins are defined as soluble proteins in the whey after precipitation of caseins at pH 4.6 and at 20°C. (De Wit, 1981). Serum proteins include a first protein fraction (80%) consisted of β-lactoglobulin (β-LG), β-lactalbumin (-LA Da), bovine serum albumin (BSA) and immunoglobulin. A second non-protein fraction (20%) is composed of proteose, peptone and nitrogen compounds (Filio, 2006).

Fat

In milk, fat is the main source of energy. Goat and cow milk are low in polyunsaturated fatty acids that are necessary for human metabolism (Grand-Pierre et al*.*, 1988). Fat is present in milk in the form of an emulsion of fat cells; the concentration of the fat content of milk can be found in small cells suspended in water which varies considerably by race and composition of feed. The unsaturated fatty

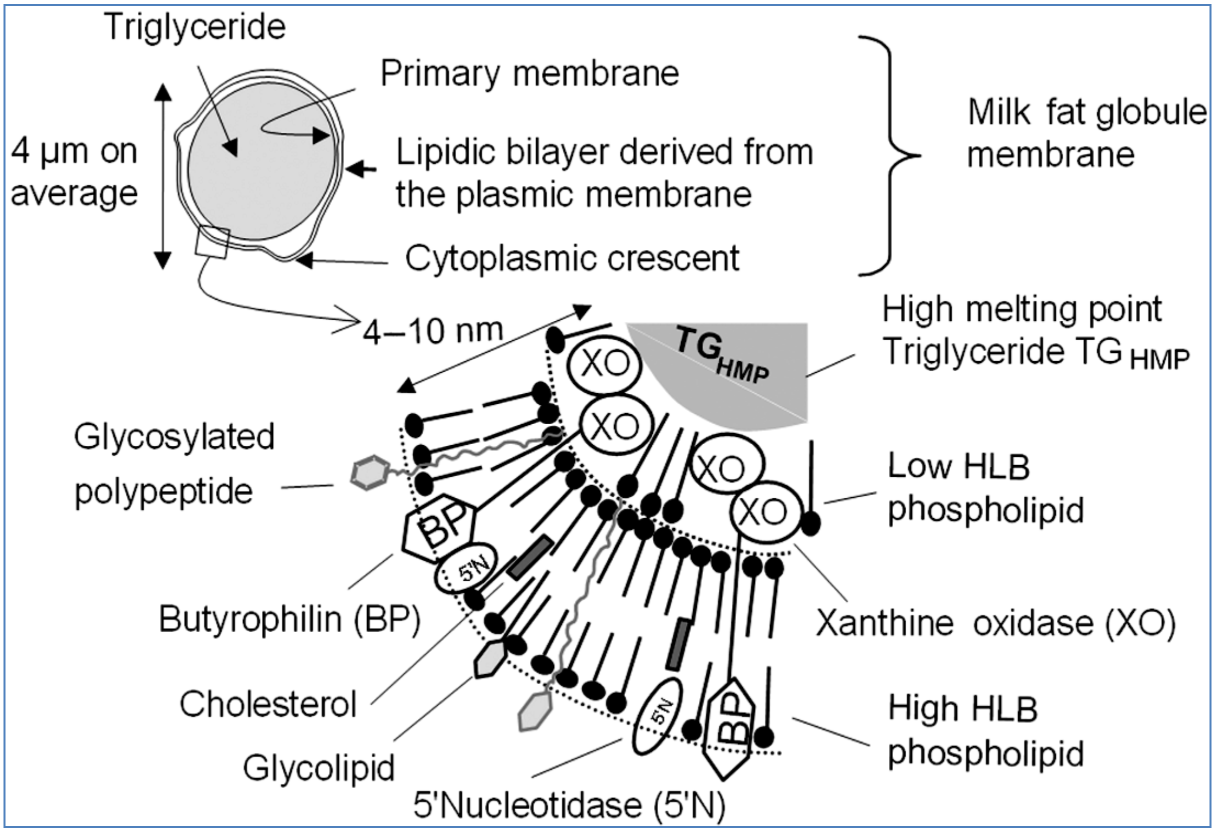

Figure 1: Typical structure of the native milk fat globule. Schemes are not to scale (Michalski et al, 2005).

Table 5. Lipid composition of cow milk and localization in the physico-chemical fractions (g / 100 g fat) (FAO, 1998).

Lipid compositions	Proportions	Location
Triglycerides	96 - 98	fat globule
Di-glycerides	0.3-1.60	fat globule
Mono-glycerides	0.0-0.10	fat globule
Phospholipides	0.2-1.00	Fat globule membrane and whey
Cerebrosides	0.0-0.08	Fat globule membrane
Steroides	0.2-0.40	fat globule
Free fatty acid	0.1-0.40	Fat globule membrane and whey
Cholesterol esters	Traces	Fat globule membrane
Vitamin	0.1-0.20	fat globule

acids are lipid molecules containing at least one double bond, according to the structure of this or of these double bonds. It is possible to distinguish the cis fatty acids and trans fatty acids (Figure 1). Most unsaturated fats in our diet are in the cis form, and a lower proportion are in the trans form (Stender and Dyerbery, 2003). The fat content of goat milk is slightly greater than that of cow milk, in both cases; triglycerides represent more than 95% of total lipids. Phospholipids comprise 30 to 40 mg/100 ml of cow milk which contains 8 to 10 mg of lipid, cholesterol is from 10 to 20 mg per 100 ml, most of which is in the free form (Table 5).

During the homogenization of milk, the fat globule increases in number and considerably decreases in diameter (less than 1 micron). Therefore, the contact area increases about 20 times. This change prevents fat from rising (in the long-life milk) and promotes digestion. The lipid composition of milk includes two major groups: simple lipids (triglycerides) and complex lipids (phospholipids). The milk fat has a nutritional role by energy intake, 9 kcal/g as dietary lipids (Florence, 2010). It also has a role in the construction of the body; we tend to charge animal fat of all disadvantages, but experts point out that health risks exist only if consumption is excessive. Finally, milk fat provides essential vitamins to the body: vitamins A and D above; Vitamin A is essential to the

Table 6. Modifications lipid in domestic or industrial treatment (Mireille, 2006).

Treatment	Major chemical changes	Main based products	Toxicity (rat)
Storage, Refrigeration	Oxidation	Peroxidase cyclic monomers hydrocarbon compounds	+ ++ +++
Heating immune to air + 200°C	Decomposition lipolysis	Cyclic ester polymers	++++ -
Air Heating	Oxydation Decomposition lipolysis	Oxidised triglycerides, esters, + other	+++

epithelia, hence its role in reproduction, vision, while Vitamin D is essential in the binding of calcium and bone growth. Fat milk therefore has a place in the diet, but it must be reasonable: high energy value, as all lipids; presence of saturated fatty acids and cholesterol, harmful in high doses. Milk fat therefore has a place in the diet, but it must be reasonable as all lipids contain saturated fatty acids and cholesterol, harmful in high doses. The fat has a very important sensory role during tasting; it gives a creamy texture appreciated, smooth, and velvety, fondant, etc. On the other hand, many flavors are associated with fat; it intervenes in intensity, balance, after taste of these aromas. The reduction or elimination of lipids from dairy products will therefore require technological improvements, to keep the finished products familiar organoleptic qualities. Fat plays an important role in determining the flavor and texture of the finished product. It conditions the use of additives and ingredients to compensate for its absence. It also determines the spreadability of butters and spreads; it depends on the fatty acid composition, and is heavily dependent on animal nutrition and season. Butter is richer in unsaturated fatty acids when the animals eat green fodder; hence, butter is less soft (harder) during winter, because animals feed primarily on grass or hay. Note that the fat globules are separable by microfiltration and fractional crystallization, making it possible to obtain products with a specific character. Fat globules have a different composition depending on their size of AG. It should be remembered that only physical processes are allowed for the transformation of milk fat. Lipids are also subject to changes related to temperature changes during storage, for example. Table 6 lists the main chemical changes that must be taken into account in the choice of process technology and the use of additives such as antioxidants (Mireille, 2006).

Simple lipids

Simple lipids are composed mainly of triglycerides (98% fat), in small quantities, and of sterides and cerebrosides. Glycerides (neutral lipids) consist of triglycerides (98%), diglycerides (A1.5 0.2%) and monoglycerides (traces). Gravimetrically, glyceride fatty acids account for almost 90% of the fat. If over 400 compounds have been identified in bovine milk, only 15 of them are present in substantial amounts (> 1% of total lipids). The origin of milk fatty acids is two-fold: fatty acids with carbon chain lengths from 4 to 12 carbon atoms are synthesized by the mammary gland from blood precursors, fatty acids with carbon chain lengths 18 (and more) carbon atoms are directly collected in the blood plasma (they are derived from the diet, the fat reserves or synthesis in tissues other than the mammary gland) and fatty acids and 16 to 14 carbon atoms is derived from de novo synthesis by the udder or a levy in the bloodstream (Table 7) (Florence, 2010).

The complex lipids

These lipids are complex with phosphorus and/or nitrogen. The most important are the phospholipid, which account for only 1% of fat (0.3 to 0.5 g/l), but acts as a constituent of fat globules and emulsion stabilizer.

Their hydrophilic and lipophilic characteristics allow them to form bridges between fatty and aqueous phases. So, we found both in the cream (about 60%) and butter in skim milk (40%) or buttermilk (Table 8). There are three main phospholipids: lecithin, Cephalin and Sphingomyelin. Approximately 85% of fatty acids constituting phospholipids are long chain fatty acids. Other complex lipids present in minor amounts are gangliosides, glycolipids and glycosphingolipids (Florence, 2010).

The composition of milk fat varies greatly according to race and feeding. It is presented in the form of small milk cells suspended in water, in goat milk, fat consists of triglycerides and fatty acids, and are globular in shape with a variable diameter (Figure 1). The milk fat globules are developed in the cells of the mammary secretory epithelium. Indeed, the endoplasmic reticulum, where proteins are synthesized, and triglycerides; these triglycerides are then accumulated in the form of small droplets in the cytoplasm. These lipid droplets are of 1 to 5 μm in diameter (Danthine et al., 2000).

Minerals

They play an important role in the structural organization

Table 7. Distribution of the major fatty acids in the fat of cow's milk (%) (FAO, 1998).

Fatty acids	Nomenclature	Averages
Saturated		
Butyric	C4 :0	3.6
Caproic	C6 :0	2.3
Caprylic	C8 :0	1.3
Capric	C10 :0	2.7
Lauric	C12 :0	3.3
Myristic	C14 :0	10.7
Pentadecanoic	C15 :0	1.2
Palmitic	C16 :0	27.6
Stearic	C18 :0	10.1
Arachidic	C20 :0	0.2
Monounsaturated		
Myristoleic	C14 :1	1.4
Palmitoleic	C16 :1	2.6
Oleic	C18 :1	26.0
Polyunsaturated		
unconjugated:		
linolenic	C18 :2	2.5
linolenic	C18 :2	1.4
Arachidonic	C20 :4	0.3
conjugates:		
Diene	C18 :2	0.8

Table 8. Levels of phospholipids in cow's milk and dairy products (g / kg) (FAO, 1998).

Dairy	Phospholipids
Whole milk	0.30-0.50
Skimmed milk	0.14-0.23
Whey	1.03-1.91
Cream	1.00-5.00
Butter	1.00-2.50
Cheese	1.00-2.00

Table 9. Different mineral content in cow's milk (Amiot et al., 2002).

Minerals	Na	Mg	P	Cl	K	Ca	Fe	Cu	Zu	I
Content (ppm)	445	105	896	958	1500	1180	0.5	0.1	3.8	0.28

of casein micelles, the main minerals present in milk are given in Table (9). The major salt constituents, potassium, sodium, calcium, magnesium etc., are distinguished if the content is greater than 0.1 g per liter of those containing trace amounts (Amiot et al., 2002).

Vitamins

Levels of vitamin A, D and E are variable; depending on the season as there is a slight increase during the pasture season (spring-summer). They are fat-soluble, so it is found in fat and can be lost during skimming. Other vitamins are water soluble and are found in the serum. In the case of ascorbic acid (C), it is present in small quantities in fresh milk and is destroyed by contact with air and also during pasteurization (Schrdos, 1982). For cow milk, the milk processing techniques can significantly change the amount of vitamin C (Florence, 2010).

Enzymes

Enzymes are specific globular proteins produced by living cells. Each enzyme has its isoelectric point and is susceptible to various denaturing agents such as pH change,

Table 10. General composition of the casein micelle (Brulé et al, 1997).

Caseins	(g/100 g)	(g/100)	Salt components
α_{s1}	33	2.9	Calcium
α_{s2}	11	0.2	Magnesium
Β	33	4.3	Inorganic phosphate
Κ	11	0.5	Citrate
Γ	04	/	/
Total caséines	92	0.8	Total saline component

temperature, ionic strength, organic solvent (Carole and Vignola, 2002).

Casein micelle

The casein micelle contains different salt components and caseins, whey and embedded lipase and plasmin enzymes (Table 10). The exact proportions of the components are variable depending on the influence on milk composition. There are four main ways to induce aggregation namely the use of proteolytic enzymes, acid conditions, heat treatment and gelation caused by aging (Amit et al., 2002).

The total casein fraction is precipitated by lowering the pH of the milk to about 4.7. It includes several types of molecules (50% . αs -casein, β - 15% casein, and γ - 03% casein). These compounds, PM 25, 000 closes, in the monomer state, can be separated by electrophoresis and ultracentrifugation. At pH 7 and 37°C, alpha and β caseins are precipitated in the presence of Ca^{2+} ion during coagulation. Other proteins remain in solution along with the lactose and salts, forming the whey, caseins combine to form micelles. When curdling milk (action of lactic acid bacteria) there is a decrease in casein Κ with the formation of the para-casein. In the presence of Ca^{2+}, the micellar assemblies coagulate and polymerize to form a gel or curd that expels the whey by syneresis,. This process is used in traditional cheese making, the rate and extent of coagulation and syneresis increases with the casein content, calcium content and the acidity of the milk. The physicochemical properties of the casein micelles play an important role in many technological treatments other than the manufacture of cheese (El Hakmaoui, 2008).

Conclusion

Milk for human consumption must be properly collected from a healthy well fed female, be colostrum free and not overworked. Milk production is not regular, the main causes of variations are related to race and species, but also depends on individual factors related to the health, nutrition, and age of the animal. Quantitatively, cow milk is the raw material most widely produced and processed worldwide. However, the milk of other mammals - goats, sheep, buffalo, and camel - is of significant importance in the economy of semi - arid regions, and especially those of the Mediterranean basin.

REFERENCES

Adib A, Bertrand S (2009). Risk Analysis transfer pesticides to milk. Institute of Livestock. National Interprofessional Centre : 9.

Amitot J, Foumier F, Lebeuf Y, Paquin P, Simpson R (2002). Composition, propriétés physicochimiques. Valeur nutritive, qualité technologiques, et techniques d'analyse du lait. Dans : science et technologie du lait : transformation du lait, Presses internat ionales polytechnique, montréal : pp. 1– 73.

Brulé G, Lenoir J, Reneuf F (1997). Les micelles de Caséine et la coagulation du lait. Dans le fromage : de la science à d'assurance qualité. ECRA et gillis J-C (Ed), lavoisier TES. DOC, Paris : 89.

Carole L, Vingola (2002). Science et technologie du lait. Edit. Fondation de technologie laitière du Québec Inc., Canada : 599.

Cayot PH, (1998). Structures et techno-fonctions des protéines du lait. Ari lait. Recherches, ISBN. (15): 2 - 7430-02298-8

Danthine S, Blecker CH, Paquot M, Innocent N, Deroanre C (2000). Evolution des connaissances sur la membrane du globule gras du lait : synthèse bibliographique, Revue, Unité de Technologie des Industries Agro-alimentaires. 5030. Gembloux. Belgique.Via Marangoni 97. 33100. Udine. Italie. Lait 80 : 209 – 222.

De Wit JN (1981). Structure and junction al behavior of whey proteins. Netherlands Milk and dairy journal. 35 : 47 – 54.

El Hakaoui A (2008). Les principaux systèmes biochimiques alimentaires lait et produits dérivés. Chapitre IV. Universite HassanII – Mohammadia, FSTM : pp. 67 – 69.

FAO (1998). Organisation des Nations Unies pour l'alimentation et l'agriculture, Le lait et les produits laitiers dans la nutrition humaine, Collection FAO: Alimentation et nutrition. P 28,

Fillion MM (2006). Amélioration de la stabilité thermique du lait par modulation du potentiel d'oxydoréduction. Thèse : pp.23 – 447.

Florence CL(2010). Qualité nutritionnelle du lait de vache et de ses acides gras, voies d'amélioration par l'alimentation. Ecole nationale vétérinaire d'ALFOR. thèse. Doctorat vétérinaire. P 51.

Fox PF, Mulvihill D (1992). Milk protein: molecular colloidal and functional proprieties. Journal of Duruy research. 49: 679 – 693.

Gautheron M, Lepouze A (2012). Le lait, un aliment indispensable.
Grand Pierre C, Ghisolfi J, Thomsent TH(1988). Etude biochimique du lait de chèvre. Edition CCAN. Nutr. DIET. 23 : 364 – 374.
Kebchaoui J (2012). Le lait composition et propriétés. Coopérations universitaire 2012 -2013 entre la faculté polydiscplinaire de Taroudant (MAROC) et l'enil de Besancon mamirolle région Franche compte (France). ENIL.Mamirolle (25620) : 1 - 4
Kohler G (2013). Note d'information relative à la vente directe de lait cru. Projet des Pyrénées. Atlantiques: pp.1 – 4.
Konte M (1999). Le lait et les produits laitiers. Développement de systèmes de productions intensives en Afrique de l'ouest. Université de Nouakchott (R.I.M) Faculté des Sciences et Technologies des aliments, B. P. 5026. ISRA/ URV – LNERV/FEVRIER : 2-25.
Leseur R, Melik N (1990). Lait et produits laitiers. Edition : Cedex. Paris : pp.2 – 7.
Lopez C, Madec MN, Jimenez-Flores R (2010). Presence of lipide rafts inthe bovine milk fat globule membrane revealed by the lateral segregation of phospholipide and heterog neous distribution of glycoproteins. Food chem. (120): 22 – 33.
Michalski MC, Briard V, Michel F, Tasson F and Poulain P (2005). Size Distribution of Fat Globules in Human Colostrum, Breast Milk and Infant Formula. J. Dairy Sci. 88:1927–1940.
Michel de S (2005). Les cahiers de l'élevage de chèvre. 2003.Edition Rustica /Fler. Paris dépôt légal aout 2003. 2ième édition . ISBN : 2 – 840
Mireille L (2006). Les produits laitiers allégés : murage ou panages : aspects technologiques et nutritionnels. Thèses de Doctorat vétérinaire. Diplôme d'état, Université Paul-Sabatier de Toulouse, Ecole nationale vétérinaire Toulouse, Tou. (31-34) : 3-4007.
Roux Y, Guinot-Thomas P, Colin-Schoelleno, Laurent F (1995). Protéolyse et qualité du lait. Colloque National (filière lait, système qualité et certification) INPL-université henry Poincaré : pp. 28 – 29.
Schrodes MJA (1982). Effect of oxygen on the keeping quality of milk, I. Oxidized flavor development and oxygen uptake in relation to oxygen availability, J. Dairy Res. (49): 407– 424.
Stender S, Dyerberg (2003). The influence of trans fatty acids: health aspect of the danish nutrition council. Quatrième edition. 34.
St-Gelais DS, Haché Gros- Lois (1992). Combined defects of temperature, acidification, and diafiltration on composition of skim milk Retentate and permeate. J. Dairy. Sci. 75(5):1167–1172 Crossref.