

Review

# Protein and fat composition of mare's milk: some nutritional remarks with reference to human and cow's milk

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## Abstract

Milk composition of mammalian species varies widely with reference to genetic, physiological and nutritional factors and environmental conditions. In this survey, the composition of mare's milk is reviewed and compared to human and cow's milk, considering principal protein fractions and fatty acid content. Protein content in mare's milk is higher than in human milk and lower than in cow's milk; casein concentration in mare's milk is intermediate between the other two milks. Fat content is lower in mare's milk compared to human and cow's milk. Distribution of di- and tri-glycerides in mare's and women's milk is similar. The proportion of polyunsaturated fatty acids in mare's and human milk is remarkably higher than in cow's milk. Mare's milk shows some structural and functional peculiarities that make it more suitable for human nourishment than cow's milk.

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## 1. Introduction

Mare's milk, besides being the most important nutritional resource for foals during the first months of life, is also one of the most important basic foodstuffs for the human populations in those areas of central Asia, where a lactic-alcoholic beverage called Koumiss is traditionally produced through fermentation (Storch, 1985; Orskov, 1995; Montanari, Zambonelli, Grazia, Kamesheva, & Shigaeva, 1996; Montanari, Zambonelli, & Fiori, 1997). This ancient beverage which Scythian tribes used to drink some 25 centuries ago, is widely consumed throughout Eastern Europe and Asiatic regions (Koroleva, 1988) and is now produced on an industrial scale (Tamime, Muir, & Wszolek, 1999). In Western Europe, where the most important product of equine breeding is the foal, studies on mare's milk have been concerned mainly with the growth and health of the newborn horse. In the last several years, interest has been increasing in the use of mare's milk for human nutrition particularly in France and in Germany (Drogoul, Prevost, & Maubois, 1992). Recently, milk is being studied in Italy as well as a possible substitute for cow's milk or as formulas for allergic children (Businco et al., 2000; Curadi, Giampietro, Lucenti, & Orlandi, 2001) and to find a new exploitation for local equine breeds (Pinto, Faccia, Di Summa, & Mastrangelo, 2001).

The aim of this review is to compare the composition of mare's milk to human and cow's milk and to discuss several parameters that could be of interest in terms of human nutrition.

## 2. Gross composition

Milk represents the essential source of nourishment of mammals during the neonatal period, the preferential aliment. Gross composition of milk varies considerably from species to species, as mammary secretion is physiologically and structurally correlated to the nutritional requirements of the newborns of each species.

The gross composition of mare's, human and cow's milk (Table 1) shows remarkable quantitative differences in terms of the nutritional value. Mare's milk has noticeably less fat content when compared to human and cow's milk. The lactose content of mare's milk is similar to that of human milk and higher than that of cow's milk. On the other hand mare's and human milk are poorer in protein and mineral salt content when compared to cow's milk. The energy supply of mare's milk is clearly lower than that of human milk, which in turn is comparable to that of cow's milk (Neseni, Flade, Heidler, & Steger, 1958; Neuhaus, 1959; Jenness & Sloan, 1970; Alais, 1974; Doreau & Boulot, 1989; Mariani, Martuzzi, & Catalano, 1993; Solaroli, Pagliarini, & Peri, 1993; Salimei, 1999) (Table 1).

Mare's and human milk are quite similar in terms of sugar supply, including galactose, a constituent of the myelinic sheath of the central nervous system cells. The structural complexity of the minor carbohydrate fractions (e.g. growth-promoting factor of *Bifidobacterium bifidum*) (Alais, 1974; Kunz, Rodriguez-Palmero, Koletzko, & Jensen, 1999) of human milk makes a functional comparison with cow's and mare's milk difficult, and this aspect has not been sufficiently studied in mare's milk (Urashima, Saito, & Kimura, 1991) from this point of view. Sialic acid is a component that affects intestinal flora development and, most probably, the level of glycosylation of gangliosides of the brain and central nervous system (Ziegler, 1960; Nakano, Sugawara, & Kawakami, 2001). The values found in human milk (~100 mg) are significantly higher than that found in cow's (~20 mg) and mare's (~5 mg/100 mL<sup>-1</sup>) milk (Morrissey, 1973; Kulisa, 1986; Heine, Wutzke, & Radke, 1993).

Whole protein and salt content are comparable between mare's and human milk, while cow's milk is clearly richer in salts, and thus less suitable as a replacement for human milk. From these several considerations on the gross composition, mare's milk would appear to be, on the whole, a more suitable nourishment for infants than cow's milk (Stoyanova, Abramova, & Ladodo, 1988; Marconi & Panfili, 1998).

Table 1  
Gross composition of mare's milk in comparison to human and cow's milk

	Mare		Human		Cow	
Fat (g kg <sup>-1</sup> )	12.1	(5–20)	36.4	(35–40)	36.1	(35–39)
Crude protein (g kg <sup>-1</sup> )	21.4	(15–28)	14.2	(9–17)	32.5	(31–38)
Lactose (g kg <sup>-1</sup> )	63.7	(58–70)	67.0	(63–70)	48.8	(44–49)
Ash (g kg <sup>-1</sup> )	4.2	(3–5)	2.2	(2–3)	7.6	(7–8)
Gross energy (kcal kg <sup>-1</sup> )	480	(390–550)	677	(650–700)	674	(650–712)

Mean value, and between brackets, *minimum–maximum* values reported in literature.

References common to mare, human and cow: Jenness and Sloan (1970), Alais (1974), Solaroli et al. (1993) and Salimei (1999).

References only for mare: Storch (1985) and Mariani et al. (1993).

Qualitative differences between the milks of these species are undoubtedly much more striking, when single structural components are considered, with particular regard to protein fractions and lipid composition.

### 3. Protein fractions

#### 3.1. Main components

The whole protein system of mare's milk is quite similar to that of human milk. Both whey protein *in toto* and NPN concentrations are comparable. Cow's milk, on the other hand, has a higher casein content, and is thus defined as a *caséineux* milk (definition of French Authors) (Alais, 1974; Boland, Hill, & Creamer, 1992; Mariani et al., 1993; Pagliarini, Solaroli, & Peri, 1993; Doreau, 1994; Csapó-Kiss, Stefler, Martin, Makray, & Csapó, 1995; Martuzzi, Tirelli, Summer, Catalano, & Mariani, 2000) (Table 2).

The whey protein fraction, indeed, represents approximately 40% in mare's milk, slightly more than

50% in human milk and less than 20% in cow's milk. Cow's milk protein features, like other ruminant milks (e.g. goat and sheep), are quite different, as characterised by an acid-enzymatic, mixed coagulation.

From this point of view mare's milk is more similar to human milk, which could be defined typically as *albumineux*. The richness in whey protein content of mare's milk makes it more favourable to human nutrition than cow's milk, because of the relatively higher supply of essential amino acids (Hambraeus, 1994).

#### 3.2. Whey proteins

The whey protein pattern clearly shows the physiological specificity of different mammary secretions; as seen by both the concentration and distribution of the single proteins and whey enzymes (Minieri & Intrieri, 1970; Lönnerdal, 1985; Boland et al., 1992; Pagliarini et al., 1993; Solaroli et al., 1993; Martuzzi et al., 2000) (Table 3).

Human milk is devoid of  $\beta$ -lactoglobulin, while this protein is present in significant amounts in both cow's

Table 2  
Main nitrogen fractions of mare's milk in comparison to human and cow's milk

	Mare		Human		Cow	
Crude protein (g kg <sup>-1</sup> )	21.4	(15–28)	14.2	(9–17)	32.5	(31–38)
True whey protein (g kg <sup>-1</sup> )	8.3	(7.4–9.1)	7.6	(6.8–8.3)	5.7	(5.5–7.0)
Casein (g kg <sup>-1</sup> )	10.7	(9.4–12.0)	3.7	(3.2–4.2)	25.1	(24.6–28.0)
NPN × 6.38 (g kg <sup>-1</sup> )	2.4	(1.7–3.5)	2.9	(2.6–3.2)	1.7	(1.0–1.9)
True whey protein (%)	38.79		53.52		17.54	
Casein (%)	50.00		26.06		77.23	
NPN × 6.38 (%)	11.21		20.42		5.23	

Mean value and, between brackets, *minimum–maximum* values reported in literature.

References common to mare, human and cow: Doreau (1994).

References common to human and cow: Alais (1974) and Boland et al. (1992).

References only for mare: Mariani et al. (1993), Pagliarini et al. (1993), Csapó-Kiss et al. (1995) and Martuzzi et al. (2000).

Table 3  
Whey proteins distribution<sup>a</sup> of mare's milk in comparison to human and cow's milk

	Mare		Human		Cow	
True whey protein (g kg <sup>-1</sup> )	8.3		7.6		5.7	
$\beta$ -lactoglobulin (%)	30.75	(25.3–36.3)	Absent		20.10	(18.4–20.1)
$\alpha$ -lactalbumin (%)	28.55	(27.5–29.7)	42.37	(30.3–45.4)	53.59	(52.9–53.6)
Immunoglobulins (%)	19.77	(18.7–20.9)	18.15	(15.1–19.7)	11.73	(10.1–11.7)
Serum albumin (%)	4.45	(4.4–4.5)	7.56	(4.5–9.1)	6.20	(5.5–76.7)
Lactoferrin (%)	9.89		30.26		8.38	
Lysozyme (%)	6.59		1.66		Trace	

Mean value, and between brackets, *minimum–maximum* values reported in literature.

References common to human and cow: Boland et al. (1992) and Solaroli et al. (1993).

References only for mare: Pagliarini et al. (1993) and Martuzzi et al. (2000).

Reference only for human: Lönnerdal (1985).

<sup>a</sup>Proteose-peptone fraction was not reported in the considered references.

and mare's milk. This protein is responsible for the onset of allergic forms to milk proteins that affect a significant percentage of infants nourished with maternal milk replacements (cow milk formulas) (Businco & Bellanti, 1993; Sélo et al., 1999). This problem seems to occur less often when mare's milk is used (Konig, 1993; Businco et al., 2000).

Antimicrobial defence in mare's milk seems to be due mainly to the presence of lysozyme (as in human milk) and, to a lesser degree, to lactoferrin, which is preponderant in human milk (Solaroli et al., 1993; de Oliveira, de Araujo, Bao, & Giugliano, 2001). These antimicrobial factors are scarce in cow's milk, where immunoglobulins represent the principal defense against microbes and are particularly abundant in colostrum (Boland et al., 1992; Solaroli et al., 1993).

### 3.3. Caseins and micelles size

Current data has defined only an approximation of the percentage distribution of mare's milk caseins (Visser, Jenness, & Mullin, 1982; Ochirkhuyag, Chobert, Dalgalarondo, & Haertlé, 2000). Mare's milk casein is composed mainly of equal amounts of  $\beta$ -casein and  $\alpha_s$ -casein (Abd El-Salam, Farag, El-Dein, Mahfouz, & El-Etriby, 1992; Ochirkhuyag et al., 2000) (Table 4), which have been recently characterised (Egito et al., 2002). The proportions of the main  $\alpha_s$ -casein fractions, i.e.  $\alpha_{s1}$ - and  $\alpha_{s2}$ -casein, is still under study (Malacarne, Summer, Formaggioni, & Mariani, 2000; Egito et al., 2002). Recently, mare  $\kappa$ -casein has also been identified and characterised (Egito et al., 2002; Iametti, Tedeschi, Oungre, & Bonomi, 2001). It shows several biochemical properties similar to that of bovine and human  $\kappa$ -casein, such as the presence of carbohydrate moieties and susceptibility to hydrolysis by chymosin (group II) (Egito et al., 2001). The proportion of  $\kappa$ -casein in mare's milk appears to be lower compared to that of cow's and human milks (Egito et al., 2001).

Bovine casein composition (Creamer, 1991; Boland et al., 1992) is well known: it is relatively richer in  $\alpha_{s1}$ -casein, a fraction believed to be responsible for the onset of allergic forms in children (Mercier, 1986; Whitelaw et al., 1990). Both mare's and cow's casein outlines differ from that of human milk (Creamer, 1991; Boland et al., 1992; Cuilliere, Tregoa, Bene, Faure, & Montagne, 1999), being characterised by a clear prevalence of  $\beta$ -casein. However mare's casein could be considered relatively rich in  $\beta$ -casein as well, and thereby able to supply children with abundant amounts of casomorphins (Clare & Swaisgood, 2000).

Mare's milk micelles are the largest as compared to both human and cow's milk micelles (Buchheim, Lund, & Scholtissek, 1989). Micellar structure varies considerably from species to species. In cow's and mare's milk it has a spongy structure, while in human milk it is reticular, fairly regular and very loose, due to numerous canals and caverns (Jasińska & Jaworska, 1991). This affects susceptibility to pepsin hydrolysis, which, however, depends mainly on the high  $\beta$ -casein micellar content.

The different protein composition *in toto* (casein content and whey protein/casein ratio) and the different micellar structure (caseins distribution and micelles size) determine marked differences in the rheological properties of the curds obtained from each of the milks under consideration, and consequently influence the digestive utilisation of milk nutrients. Mare's and human milk forms a finer, softer precipitate, which is physiologically more suitable for infant nutrition because it is more easily digestible than the firm coagulum of cow's milk (Kalliala, Seleste, & Hallman, 1951; Solaroli et al., 1993).

## 4. Lipid composition

The fat content of mare's milk is very low when compared to that of human and cow's milk (Table 1).

Table 4  
Caseins distribution of mare's milk in comparison to human and cow's milk

	Mare		Human		Cow	
Casein (g kg <sup>-1</sup> )	10.7		3.7		25.1	
$\alpha_s$ -casein (%)	46.65	(40.2–59.0)	11.75	(11.1–12.5)	48.46 <sup>a</sup>	(48.3–48.5)
$\beta$ -casein (%)	45.64	(40.1–51.4)	64.75	(62.5–66.7)	35.77	(35.8–37.9)
$\kappa$ -casein (%)	(7.71) <sup>b</sup>		23.50	(22.2–25.0)	12.69 <sup>c</sup>	(12.7–13.8)
Micelles size (nm)	255		64		182	

Mean value and, between brackets, *minimum–maximum* values reported in literature.

References common to mare, human and cow: Buchheim et al. (1989).

References common to human and cow: Creamer (1991) and Boland et al. (1992).

References only for mare: Abd El-Salam et al. (1992) and Ochirkhuyag et al. (2000), Malacarne et al. (2000).

Reference only for human: Cuilliere et al. (1999).

<sup>a</sup> 38.46  $\alpha_{s1}$ -casein and 10.00  $\alpha_{s2}$ -casein.

<sup>b</sup>  $\kappa$ -casein and other fractions not characterised.

<sup>c</sup> 100% was reached with  $\gamma$ -casein fraction (3.08%).

Lipids in milk are dispersed as emulsified globules; in mare's milk, fat is organised in globules of about 2–3  $\mu\text{m}$  of size (Kharitonova, 1978; Welsch, Buchheim, Schumacher, Schinko, & Patton, 1988). Fat globules are coated with three layers: an internal protein layer, an intermediate layer consisting of a phospholipid membrane and the external layer consisting of high-molecular-weight glycoproteins. On the surface of these glycoproteins there is a branched oligosaccharide structure, which is similar to that of the fat globules in human milk and which is not found in cow's milk (Solaroli et al., 1993).

In human milk, fat globules have an average diameter of about 4  $\mu\text{m}$ . The external membrane is coated with an array of glycoprotein filaments, similar to that of mare's milk, that may enhance digestion by binding lipases (Jensen, Ferris, & Lammi-Keefe, 1992; Koletzko & Rodriguez-Palmero, 1999). In cow's milk the globules have an average diameter of 3–5  $\mu\text{m}$  (Welsch et al., 1988), and are coated by a thin protective film, with external layers constituted of proteins and phospholipids (Jensen, Ferris, Lammi-Keefe, & Henderson, 1990).

#### 4.1. Triglycerides

Mare's milk lipids are less rich in triglycerides (about 80% of total) than human and cow's milk (about 98% in both milks) (Pastukhova & Gerbeda, 1982; Doreau & Boulot, 1989; Jensen et al., 1992) (Table 5). The number of carbon atoms in di- and tri-glycerides is a characteristic that varies from species to species (Parodi, 1982). In mare's and human milk fat the distribution follows a typical unimodal pattern (*maximum* at 50–52 carbon atoms), whereas in cow's milk it follows a bimodal pattern (first *maximum* ranging from 34 to 40 carbon atoms and the second from 42 to 54) (Pagliarini et al., 1993).

From a nutritional point of view, the triglyceride structure is a principal factor influencing the action of lipolytic enzymes and, therefore, fat absorption. In human milk, palmitic acid ( $\text{C}_{16:0}$ ) is preferably located in

the *sn*-2 position which is considered favourable by some authors for the assimilation of this fatty acid in children (Lien, Yuhas, Boyle, & Tomarelli, 1993; Winter, Hoving, & Muskiet, 1993). However, this has not yet been definitively confirmed (Jensen et al., 1992). In mare's milk  $\text{C}_{16:0}$  is also preferentially associated with the *sn*-2 position (Parodi, 1982). On the other hand  $\text{C}_{16:0}$  in cow's milk is equally located in 1 and 2 positions.

#### 4.2. Phospholipids

Phospholipids, complex compounds constituted mainly by polyunsaturated fatty acids, are present in all living cells as components of the lipoprotein layers of the cell membrane, in particular of neural cells (Alais, 1974). Mare's milk is richest in phospholipids when compared to human and cow's milk (Pastukhova & Gerbeda, 1982) (Table 5). The phospholipid composition of mare's milk (Kharitonova, 1978) is different from both human and cow's milk (Jensen et al., 1990). Compared to human milk, phospholipids of mare's milk are relatively richer in phosphatidylethanolamine (31% vs 20%) and in phosphatidylserine (16% vs 8%), and less rich in phosphatidylcholine (19% vs 28%) and phosphatidylinositol (trace vs 5%); sphingomyelin proportion is similar (34% mare vs 39% human).

#### 4.3. Sterols

Mare's milk seems to have a higher proportion of the unsaponifiable fraction (Pastukhova & Gerbeda, 1982) in comparison to cow's and human milk (Table 5). The unsaponifiable content is lower in human milk, whereas the value of mare's milk would be similar to that of cow's milk. The sterol fraction in mare's, human and cow's milk is constituted partially by cholesterol (about 0.3–0.4% of the lipid content in all milks) (Travia, 1986; Jensen et al., 1990; Pagliarini et al., 1993).

#### 4.4. Fatty acids

Compared to human and cow's milk (Alais, 1974; Travia, 1986; Solaroli et al., 1993), mare's milk fat (Antila, Kylä-Siurola, Uusi-Rauva & Antila, 1971; Kulisa, 1977; Doreau, Boulot, Bauchart, Barlet & Martin-Rosset, 1992; Doreau, Boulot, & Chilliard, 1993; Intrieri & Minieri, 1970; Csapó, Stefler, Martin, Makray, & Csapó-Kiss., 1995; Salimei, Bontempo, & Dell'Orto, 1996; Mariani, Martuzzi, Summer, & Catalano, 1998; Martuzzi, Summer, Catalano, Barbacini, & Mariani, 1998) is especially poorer in stearic and oleic acids, and richer in palmitoleic, linoleic and linolenic acids (Table 6). Like human milk, and different from cow's milk, mare's milk has a lower proportion of saturated fatty acids with a low and high number of carbon atoms ( $\text{C}_{4:0}$ ;  $\text{C}_{6:0}$ ;  $\text{C}_{16:0}$ ;  $\text{C}_{18:0}$ ).

Table 5  
Lipids composition of mare's milk in comparison to human and cow's milk (mean value)

	Mare	Human	Cow
Fat ( $\text{g kg}^{-1}$ )	12.1	36.4	36.1
Triglycerides (%)	81.1 <sup>a</sup>	98.0	97.0
Phospholipids (%)	5.0	1.3	1.5
Unsaponifiable (%)	4.5 <sup>b</sup>	0.7	1.5
Free fatty acids (%)	9.4	Trace	Trace

Reference only for mare: Pastukhova and Gerbeda (1982).

Reference only for human: Jensen et al. (1990).

Reference only for cow: Alais (1974).

<sup>a</sup> Mono- and di-glycerides 1.8%.

<sup>b</sup> Non identified fractions 0.3%.

Table 6

Percentages of fatty acids relatives to total fatty acids of mare's milk in comparison to human and cow's milk

		Mare		Human		Cow	
C <sub>4</sub>	Butyric (%)	0.2		0.1		1.4	(1.4–3.3)
C <sub>6</sub>	Caproic (%)	0.4		0.2		2.1	(1.6–2.2)
C <sub>8</sub>	Caprylic (%)	3.3	(1.0–5.9)	0.3	(0.1–0.3)	1.7	(1.3–1.8)
C <sub>10</sub>	Capric (%)	8.6	(3.7–15.1)	2.0	(1.1–2.1)	3.5	(3.0–3.6)
C <sub>12</sub>	Lauric (%)	9.3	(3.5–14.7)	6.8	(3.1–7.2)	3.9	(3.1–4.0)
C <sub>14</sub>	Myristic (%)	8.5	(4.6–10.2)	10.4	(5.1–10.9)	12.6	(13.0–14.2)
C <sub>16</sub>	Palmitic (%)	23.8	(19.7–27.9)	28.1	(20.2–29.6)	29.5	(30.2–42.7)
C <sub>16:1</sub>	Palmitoleic (%)	6.1	(3.9–9.7)	3.5	(3.7–5.7)	1.7	
C <sub>18</sub>	Stearic (%)	1.7	(1.1–3.1)	6.9	(6.0–8.6)	13.3	(5.7–13.7)
C <sub>18:1</sub>	Oleic (%)	19.1	(12.1–28.3)	33.6	(33.3–46.4)	26.3	(16.7–27.1)
C <sub>18:2</sub>	Linoleic (%)	9.6	(5.1–15.5)	6.4	(6.0–13.0)	2.9	(1.6–3.0)
C <sub>18:3</sub>	Linolenic (%)	9.4	(2.8–15.7)	1.7	(1.0–3.4)	1.1	(0.5–1.8)

Mean value and, between brackets, *minimum–maximum* values reported in literature.

References common to human and cow: Alais (1974), Travia (1986), Jensen et al. (1990), Solaroli et al. (1993).

References only for mare: Antila et al. (1971), Kulisa (1977), Doreau et al. (1992, 1993), Intrieri and Minieri (1970), Csapó et al. (1995), Salimei et al. (1996), Mariani et al. (1998), Martuzzi et al. (1998).

Table 7

PUFA of mare's milk in comparison to human and cow's milk

	Mare	Woman	Cow
Saturated fatty acids (%)	55.8	54.8	68.0
-C <sub>4</sub> , C <sub>6</sub> , C <sub>8</sub> (%)	3.9	0.6	5.4
-C <sub>10</sub> , C <sub>12</sub> , C <sub>14</sub> , C <sub>16</sub> , C <sub>18</sub> (%)	51.9	54.2	62.6
Unsaturated fatty acids (%)	44.2	45.2	32.0
C <sub>16:1</sub> , C <sub>18:1</sub> (%)	25.2	37.1	28.0
C <sub>18:2</sub> , C <sub>18:3</sub> (%)	19.0	8.1	4.0

References: see Table 6.

On the whole, the percentage of unsaturated fatty acids in mare's and human milk is similar and higher than that in cow's milk. This is due mainly to a high content in polyunsaturated fatty acids (PUFA) with intermediate and high numbers of carbon atoms; this high unsaturation could represent a nutritional advantage (Solaroli et al., 1993). The percentage of mono-unsaturated fatty acids in mare's milk is lower than human milk, and similar to cow's milk (Table 7). Free fatty acids are found in mare's milk in marked amounts, while only traces are present in human and cow's milk (Pastukhova & Gerbeda, 1982) (Table 5).

#### 4.5. Polyunsaturated fatty acids

The fat composition of mare's milk is particular when compared with other species, due to the high content in linoleic and especially linolenic polyunsaturated fatty acids (Alais, 1974; Travia, 1986; Doreau & Boulot, 1989; Martuzzi et al., 1998) (Table 7). Linoleic acid (C<sub>18:2</sub>), of the omega-6 group, and alpha-linolenic acid (C<sub>18:3</sub>) of the omega-3 group, are considered essential fatty acids because animal organisms are unable to synthesise these

compounds (Mussa & Meineri, 1997; Svahn, Feldl, Rähä, Koletzko & Axelsson, 2002), which have important biological functions. Research with humans has indicated a role for linoleic acid as a precursor of prostaglandin E, in the prevention of gastric ulcers (Grant, Palmer, Kelly, Wilson, & Misiewicz, 1988).

PUFA are precursors of long-chain polyunsaturated fatty acids (LC-PUFA), indispensable structural components of all cellular membranes. Moreover, some LC-PUFA are precursors of eicosanoids, molecules with a potent biological activity which modulates various cellular and tissue processes (Koletzko & Rodriguez-Palmero, 1999). The properties attributed to mare's milk and Koumiss as curative substances for hepatitis, chronic ulcer and tuberculosis (Storch, 1985; Solaroli et al., 1993) may be due to the high concentration of such compounds.

#### 4.6. Conjugated linoleic acid group

Milk fat is an important source of potential anticarcinogens from the naturally occurring conjugated linoleic acid (CLA) group. Mare's milk is nearly CLA-free (mean value 0.09% of total fatty acids). CLA content in human milk has been reported to vary from 0.2 to 1.1%. In cow's milk values ranging from 0.2 to 2.4% have been reported (Jensen et al., 1992; Jahreis et al., 1999).

## 5. Conclusions

Compared to human and cow's milk, mare's milk has a lower energy value, due to a lower fat supply, while the sugar content is similar in both mare's and human milk. The whole protein and salt supply of mare's milk is

similar to that of human milk, whereas cow's milk, richer in salts, is less suitable as a replacement for mother's milk.

The whole protein system of mare's milk, regarding both whey protein *in toto* and NPN concentrations, is similar to human milk as well, whereas cow's milk differs from both for higher casein content. The richness and pattern of the whey protein of mare's milk make it more favourable than cow's milk for human nourishment. Mare's milk casein is composed of nearly equal parts of  $\beta$ -casein and  $\alpha_s$ -casein; human milk is characterised by a prevalence of  $\beta$ -casein; cow casein is relatively richer in  $\alpha_{s1}$ -casein, which is believed to be responsible for the onset of allergic forms in nursing infants. Through the concurrence of several structural factors, mare's and human milk form a finer, softer precipitate, more easily digestible than the firm coagulum of cow's milk.

The external layer of mare's and human milk fat globules and the distribution of di- and tri-glycerides in mare's and human milk are similar. The percentage of unsaturated fatty acids in mare's and human milk is higher than that in cow's milk; due mainly to a high content in polyunsaturated fatty acids with an intermediate and high number of carbon atoms (PUFA).

Despite the need for further studies on the properties and composition of mare's milk, it is possible to conclude from these few considerations that mare's milk is, on the whole, more suitable than cow's milk as nourishment for infants.

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