Human and Donkey Milk

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Contributor: Paolo Polidori

Whole milk is a good source of all the nutrients, and it also contains a sufficient number of vitamins to permit the regular growth of the neonate. Dairy cow milk can create allergy in infants less than 12 months old because of the high caseins and β-lactoglobulin content. In these circumstances, donkey milk can represent a good replacement for dairy cows' milk in children affected by Cow Milk Protein Allergy (CMPA) because of its close chemical composition with human milk, mainly due to its low protein and low mineral content.

Keywords: donkey milk ; human milk ; vitamins deficiency ; fortified foods ; Cows Milk Protein Allergy

1. Introduction

The production of animal source foods through the breeding of domesticated species represents a milestone in the development of human civilizations. Milk is the most important food for newborns in all mammalian species, supplying energy, proteins, fat, carbohydrates, and micronutrients, such as vitamins and minerals. Milk consumption started with animal domestication about 10,000 years ago, the advantages of which were mainly related to the positive effects on growth and bone health [1]. The term "milk" is normally associated with bovine milk because it represents 83% of global milk production in 2010 [2].

However, milk produced from other animal species is also consumed. Equid milk, obtained both from mare (*Equus caballus*) and donkey (*Equus asinus*), shows remarkably interesting therapeutic properties, especially in the treatment of Cow Milk Protein Allergy (CMPA) in infant nutrition [3]. Clinically, CMPA is an abnormal immunological reaction to cow milk proteins, normally caused by the interaction between one or more milk proteins and one or more immune mechanisms, provoking immediate IgE-mediated reactions. The clinical diagnosis CMPA can be achieved by skin or blood tests, and the incidence of CMPA in children ranges from 0.3 to 7.5% [3]. Non-IgE-mediated dairy reactions occur at variables time after milk exposure. These reactions are significantly more common compared to IgE-mediated immune reactions and are caused by a T-cell-mediated reaction to cow milk proteins, sometimes through a combination of both IgE- and non-IgE-mediated reactions. The allergenicity of cow milk in children's nutrition is basically due to the ratio between caseins and whey proteins. Variations in the ratio between caseins and whey proteins in donkey milk are considered the main factor responsible for reducing the allergenicity of bovine milk [3].

A significant part of the population in Russia, Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and Mongolia drink mare milk [4]. Milk produced by these two monogastric species shows similar protein, fat, lactose, ash, and water content (Table 1), with a chemical composition very close to that in human milk, considering the high lactose, low protein, and ash content [5].

Table 1. Chemical composition in human, cow, and equid milk (g/100 g).

Mammal	Water	Dry Matter	Fat	Proteins	Lactose	Ash	Energy Value (kJ/kg)
Human	**87.6**	**12.4**	**3.38**	**1.64**	**6.69**	**0.22**	**2855.6**
Cow	**87.6**	**12.4**	**3.46**	**3.43**	**4.71**	**0.78**	**2983.0**
Donkey	**90.4**	**9.61**	**1.21**	**1.74**	**6.23**	**0.43**	**1939.4**
Mare	**90.5**	**9.52**	**0.85**	**2.06**	**6.26**	**0.35**	**1877.8**

The low caseins content in equine milks, around 40%–45% of total protein, is very close to the values determined in human milk (Table 2). In these two mammalian species, more than 50% percent of milk protein is represented by whey protein (Table 2), and for this reason, cheesemaking using equid milk is challenging [6][7][8]. Among whey proteins, a total amount of 1.0 mg/mL of lysozyme has been detected in donkey milk, while in bovine milk, a very reduced amount (trace)

has been determined [9]. Although β-lactoglobulin is present in the whey proteins of donkey milk, the sequence homology determined among β-lactoglobulin isolated from both donkey and cow milk is only 60 percent [10]. In 1990, the high similarity of milk proteins detected in both equine and human milk created the opportunity to test donkey milk in the treatment of children affected by severe IgE-mediated CMPA [11].

Table 2. Main proteins content in cow, donkey, and human milk (g/L).

Proteins	Cow	Donkey	Human
Total proteins	**32.0**	**13–18**	**9–15**
Total caseins	**27.2**	**6.6**	**5.6**
Total whey proteins	**4.5**	**6.5**	**8.0**
αs1-casein	**10.0**	**n.d.**	**0.8**
αs2-casein	**3.7**	**n.d.**	**n.d.**
β-casein	**10**	**n.d.**	**4.0**
k-casein	**3.5**	**Trace**	**1.0**
α-lactalbumin	**1.2**	**1.80**	**1.9–2.6**
β-lactoglobulin	**3.3**	**3.7**	**n.d.**
Lysozyme	**Trace**	**1.0**	**0.04–0.2**
Lactoferrin	**0.1**	**0.08**	**1.7–2.0**
Immunoglobulins	**1.0**	**n.d.**	**1.1**
Albumin	**0.4**	**n.d.**	**0.4**

The growth rate in human infants is slower compared to other animals, and the chemical composition of human milk reflects this [12]. The similar chemical composition determined among equine and human milk (Table 1 and Table 2) suggests that donkey milk can be used as a dietary alternative for children with IgE- and non-IgE-mediated CMPA when breast milk is not available. Bovine milk is considered the main replacement for human milk in infant nutrition, but it is remarkably different from human milk considering both macronutrients and micronutrients, with different contents of both vitamins and minerals [7][11]. Vitamin content in donkey milk has not been deeply investigated compared to its protein fraction or fat profile.

2. Nutrition and Health: Role of Milk and Dairy Products

Consumption of animal source foods can provide crucial nutritional benefits to a large amount of the population in developing countries, where most of the consumers cannot afford good-quality diets due to their low income. However, the rapid growth in animal-sourced food production and consumption may represent a risk for human and animal health, and for the environment as well. On the other hand, it can also offer opportunities for local farmers and small dairy industries. Milk provides several nutrients and can help consumers cover the daily requirements for minerals and vitamins [13].

Milk and dairy products are considered very important foods for healthy human nutrition, especially in childhood [14]. Milk is a complete food containing fat, proteins, carbohydrates, minerals, and vitamins. Some studies have evidenced the role of dairy foods as important macro- and micronutrient sources, considering their presence in a healthy diet to be positive [14]. Milk consumption is frequently associated with a reduction of the risk of osteoporosis, colorectal cancer, and of type 2 diabetes, but high amounts of dairy foods in the human diet have been reported to be responsible for increasing cardiovascular disease and prostate cancer [15]. Milk is also considered important in reducing moderate malnutrition in children, together with other dairy products, especially fermented milk (yoghurt), which is characterized by a similar chemical composition compared to fresh milk, apart from the reduced lactose content [16].

Food hypersensitivity is the most common cause of reduced absorption and slow growth rates in lactating children after weaning. Between 2%–7.5% of infant population is affected by CMPA, with an increased incidence compared to 1940, when 1 positive case was found for every 7500 subjects tested. Today, 1 positive case is detected for 200 subjects tested [17]. Remarkable progress has been registered in parenteral nutrition, significantly improving accuracy in prognosis, even if

the need to restart feeding process as soon as possible is considered the most important target to stimulate the correct functions of the damaged intestine [18]. Breastfeeding is the best strategy to achieve this target, but if human milk is not immediately available, it is necessary to look for other foods. Beverages containing soy formulas or hydrolyzed proteins can be responsible of severe hypersensitivity reactions [19]. Since 1992, several clinical trials have demonstrated that donkey milk can be safely used in the treatment of multiple food allergies, including CMPA [20]. The nutraceutical properties of donkey milk have been investigated in the last decades, finding important bioactive molecules with antimicrobial and antiallergenic functions [5].

Both caseins and whey proteins contribute to human health, performing a biological activity after enzymatic digestion. The molecules released after enzymatic digestion are named bioactive peptides because of their ability to modulate physiological functions [9][10]. In donkey milk, several bioactive peptides showing immunological-like properties with the ability to stimulate the functional recovery of the child's intestine have been determined, such as lysozyme, lactoperoxidase, and lactoferrin. These enzymes are active against protozoa, bacteria, and viruses, and are therefore also able to prevent infections in children's intestine [9][10].

It is outside the aim of this review to describe, in detail, bioactive peptides, specific studies on the bioactive molecules detected in donkey milk, and their positive effects on human health [3].

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