Scientific Papers. Series D. Animal Science. Vol. LXIV, No. 1, 2021
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

BIBLIOGRAPHIC RESEARCH ON THE BIOLOGICAL VALUE OF MILK FROM DIFFERENT SPECIES OF DOMESTIC ANIMALS

Corina Maria DĂNILĂ, Gheorghe Emil MĂRGINEAN, Monica Paula MARIN, Carmen Georgeta NICOLAE, Livia VIDU

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: corina.maria1994@gmail.com

Abstract

The objective of the work is to carry out a bibliographic study on the biological value of milk from different animal species (cow, buffalo, goat, sheep, donkey). The quality of the milk and its composition varies depending on the breed, diet, feeding practices, management system, lactation stage and animal health. Milk and products obtained from it contain most of the nutrients needed by the human body, with a high biological value. Studies have shown that the milk with the highest fat content is sheep's milk, followed by buffalo milk, cow's milk, goat's milk and donkey's milk. In addition to the genetic variation between animal breeds, feeding fodder with a fat and fiber content can lead to an increase in the fat content of milk.

Key words*: biological value, chemical composition, milk, species.*

INTRODUCTION

Globally, consumers are paying attention to foods and their compositions due to a relationship between diet and human health (Rafiq et al., 2016). The history of milk and its products dates back to antiquity, from the time when man began to domesticate animals and raise them. 11,000 years ago, the first domestication of ruminants was attempted in the Middle East (Barłowska et al., 2011). Different regions around the world have adapted species to their area for milk production. Buffalo milk is often used in many parts of the world. The most recent nutritional finding refers to donkey's milk, which is similar to human milk in terms of protein composition (Barłowska et al., 2011). Milk is important in a healthy and balanced diet. It provides all the energy and nutrients needed to ensure proper growth and development (Pereira, 2014). The composition of milk is a necessary aspect that influences the quality of dairy products. The composition of milk varies significantly between different species. The quality of dairy products depends on the composition of the milk, which varies depending on the stage of lactation, milking methods, environment, season, diet, feeding system, breed and species (Kittivachra et al., 2007; Rafiq et al., 2016). Special nutritional characteristics have been identified for different types of milk. Underutilized resources are of great importance to dairy farmers, processors and consumers for designing innovative products with versatility, taste and functionality (Rafiq et al., 2016).

In Figure 1 milk production is dominated by 5 species of animals: cattle, sheep, goats, buffaloes and donkeys.

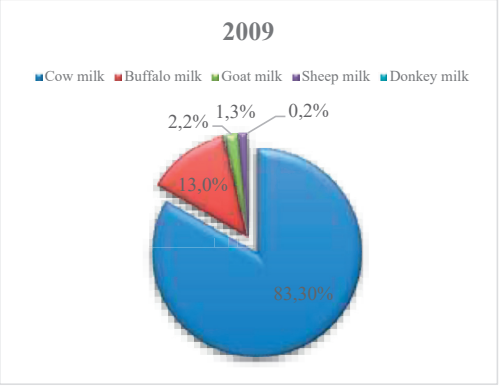

Figure 1. The proportion of milk globally in 2009, dominated by cattle, sheep, goats, buffalo, donkey. (Source: FAOSTAT, March 2021)

According to FAO statistical databases (2021) globally in 2009 of which 83.3% was in cow's

milk, 13% buffalo milk, 2.2% goat's milk, 1.3% sheep's milk and 0.2% milk of donkey.

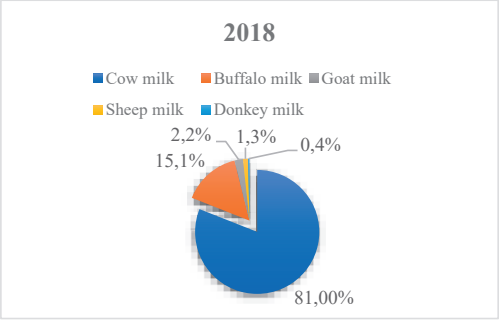

Figure 2. The proportion of milk globally in 2018, dominated by cattle, sheep, goats, buffalo, donkey. (Source: FAOSTAT, March 2021)

In 2018 it was 81.0% cow's milk, 15.1% buffalo's milk, 2.2 goat's milk, 1.3% sheep's milk and 0.4 donkey's milk. It is observed that buffalo milk increased and cow's milk production decreased slightly during this period (Figure 2).

MATERIALS AND METHODS

To achieve the objectives of this study, 40 bibliographic sources from the literature were consulted. Scientific databases relevant articles identified by keywords were consulted: chemical composition, milk, species, biological value and we selected based on the available literature articles that discuss comparative nutritional value analyzes of milk. The research methods used in this study were observed, analyzed and interpreted graphically data from the literature on the biological values of milk from different animal species. This analysis covered different animal species used for milk production purposes (cattle, sheep, goats, buffaloes and donkeys). The period analyzed in this study was 1970-2020. Scientific research has established that milk has a complex chemical composition, especially in terms of casein fractions, whey proteins, amino acids.

RESULTS AND DISCUSSIONS

Comparative milk compositions of cattle, sheep, goats, buffalo and donkey species

The data shown in Table 1 show a substantial variability of the basic chemical composition of milk from different animal species. An analysis of data from the literature was applied for the 5 species of domestic animals of the greatest importance in world milk production. The four major components of milk regardless of species are proteins, fats, minerals and lactose (Gantner et al., 2015) and to some extent minimizes the impact of factors that change the composition of milk, such as race, feeding system, stage of lactation or time of year, milking interval, type of food, and climate (Haenlein, 2004; Claeys et al., 2014). The energy value of milk is closely linked to the concentration of certain compounds in the dry matter, in particular the amount of fat (Barłowska et al., 2011).

Table 1. Basic chemical composition of milk from different animal species

Species	Protein %	Fat %	Lactose %	Ash %
Cattle[a]	3.87	4.96	5.00	0.80
Sheep[a]	5.50	6.80	5.22	0.98
Goats[a]	3.48	4.73	4.88	0.99
Buffalo[a]	4.78	8.41	6.21	0.98
Donkey[b]	1.72	0.38	6.88	-

Source: Adapted and modified from: [a]Mahmood & Usman, 2010; [b]Barłowska et al., 2011. The values found in the literature for different species of domestic animals (Arman et al., 1974; Watson et al., 2017)

Milk Proteins

In 2010, a comparative study of the physico-chemical parameters of milk from cows, buffaloes, goats and sheep was published by Mahmood & Usman. In this paper Mahmood & Usman tested the ash, fats, proteins, lactose in milk. It was found that all parameters tested were higher in buffalo and sheep's milk than in cow's and goat's milk. The protein content of buffalo's milk was higher than that of cow's and goat's milk but lower than that of sheep's milk at one level ($p<0.001$). There was a difference ($p>0.05$) between the protein content of cow's and goat's milk. The results of this paper in terms of protein content of cow's milk were similar to the results of Imran et al. (2008); Enb et al. (2009); Ahmed & Zubeir (2007); Abd Elrahman et al. (2009). The protein content found in sheep's milk was lower (5.47%) than that reported by Pavić et al. (2002). The reduction could be caused by the difference in race, the health of the udder and the stage of lactation. The protein content found in goat's milk was similar to that reported by

Strzałkowska et al. (2009). The protein content found in buffalo milk was similar to the results of Imran et al., (2008). A higher protein content in buffalo milk was reported by Braun & Preuss (2008) and Fundora et al. (2001). Barłowska et al. (2011) found that sheep's milk (5.73%) and buffalo's milk (4.48%) are the highest in terms of protein content, including casein and fat. Roy et al. (2020) found that sheep's milk (4.5-7.0 g 100 ml^{-1}) and goat's milk (3.0-5.2 g 100 ml^{-1}) have a higher protein content compared to buffalo milk (2.7-4.7 g 100 ml^{-1}) and cattle (3.0-3.9 g 100 ml^{-1}). Sawaya et al. (1984) studied the chemical composition and nutritional value of goat milk from two breeds, Masri and Aardi from Saudi Arabia. In both, Aardi and Masri milk components, including fat (2.83%, 3.06%) and protein (3.28%, 3.41%) were slightly lower than those of other species.

Kapadiya et al. (2016) found that sheep's and buffalo's milk has a higher content of protein and fat than other animal species. Goat's milk in protein content was statistically ($p<0.05$) than in cow's milk. In the fat content of goat's milk was ($p>0.05$) than that of cow's milk as well as buffalo's milk. Regarding the lactose content of goat's milk was ($p>0.05$) than that of cow's milk as well as buffalo's milk, donkey's milk contains the highest lactose content. Sheep's milk had the highest ash content, followed by goat's milk, and cow's milk had the lowest ash content. The fat content of goat's milk had an average value of 3.84%, in cow's milk it was 4.88%, of 8.30% in buffalo's milk. The fat content of goat's milk was ($p>0.05$) higher than that of cow's milk as well as buffalo's milk. The average value in lactose content was 4.16% in goat's milk, cow's milk was 4.76% and the average value was 4.86% in buffalo's milk. The lactose content of goat's milk was statistically ($p>0.05$) higher than that of cow's milk and buffalo's milk. The average value of the ash content was 0.89% in goat's milk. Similarly, the average value in cow's milk was 0.76% and 0.81% in buffalo's milk. Sheep's milk had the highest ash content and the lowest ash content was found in cow's milk. The average value in cow's milk is 0.76%. The average value in buffalo milk was 0.81%. (Kapadiya et al., 2016).

Proportions of major proteins

Milk proteins differ in composition and properties. They are divided into casein complexes and whey protein fractions. There are 4 main fractions of casein: αs 1 -, αs 2 -, β- and κ. Sheep's milk is the richest in the β-casein fraction 15.6-39.6 (g L^{-1}), followed by buffalo milk 12.6-20.9 (g L^{-1}). The smallest fraction of α s1-casein was recorded in goat laptops 0-13.0 (g L^{-1}) (Roy et al., 2020). Casein from cow's milk and buffalo milk is very abundant (38.4% and 30.2% of total casein, respectively, in the αs 1 fraction (Zicarelli, 2004). Goat's and sheep's milk has a lower casein-whey-protein ratio (82:18), as well as a relatively higher β-casein 0-29.6 (g L^{-1}); α s-casein 2.3-11.6 (g L^{-1}); compared to cow's milk (Roy et al., 2020). There are 2 types of major whey proteins β-Lactoglobulin and α-Lactalbumin. Sheep's milk was recorded with the highest concentration of β-Lactoglobulin 6.5-13.5 g L^{-1} and α-Lactalbumin 1-1.9 g L^{-1}, and its lowest concentration recorded in goat's milk 1.5-5.0 g L^{-1} β-Lactoglobulin and α-Lactalbumin 0.7-2.3 g L^{-1}. Milk casein micelles from different species differ in size, hydration and mineralization. Roy et al. (2020) reported that the size of casein micelles in goat's milk 180-301 nm, and sheep 180-210 nm, is larger than that in cow's milk 150-182 nm. It was considered that the hydration level of casein micelles was negatively correlated with the mineralization of micelles (Remeuf & Lenoir, 1986), i.e, when the mineralization of casein micelles increases, the degree of hydration of casein micelles decreases. The casein micelles in buffalo milk (Ahmad et al., 2008) and donkey milk are considered to be less hydrated and more mineralized than those in cow's milk. Thus, the differential between races, genetic variants and phosphorylation sites of caseins can be added to the variation of casein micelle characteristics and between species (Crowley, 2017).

Milk fat composition

Donkey's milk contains lower levels of saturated fatty acids, and proportions of polyunsaturated fatty acids than milk from other species. The highest cholesterol content was found in cow's milk between 13.1-31.4 mg/100 ml milk (Table 2).

One of the specific characteristics of ruminant milk is the presence of the CLA. The conjugated linoleic acid content and cholesterol content are higher in cow's milk than milk from other species. Sheep and goat milk fats are rich in short chain (responsibility for the distinctive flavor of these milks) and medium chain triacylglycerols (TAG); Similarly, buffalo fat contains higher proportions of medium-chain TAGs than cow's milk, which has higher proportions of long-chain TAGs (Ceballos et al., 2009; Ruiz-Sala et al., 1996; Jenness, 1980; Abd El-Salam, 2011).

Talpur et al. (2008) in their paper, the CLA content was subject to a variation ($p \leq 0.05$) depending on the milk of different species and season. The average CLA content was found to be between 0.40 and 1.10 g/100 g of total fatty acids, with a higher fat content of cow's milk between 0.45-1.10 g/100 g, followed of sheep 0.57-0.91 g/100 g, goat 0.41-0.64 g/100 g and fat from buffalo milk 0.39-0.63 g/100 g. Most of the CLA content contained the cis-9, trans-11 isomer which contributed to 84-92% of CLA, while trans-10, cis-12 accounted for 4-7% of CLA all animal species investigated in the study.

Donkey milk is characterized by a specific fatty acid profile. It contains several times more SFA (C8: 0, C10: 0 and C 12: 0), twice fewer fatty acids C 14: 0 and C16: 0. It contains very little stearic acid, C18: 0 (1.12%), while in the milk of other species it is about 12%. Oleic acid (C18: 1) deserves special attention among unsaturated fatty acids. In donkey milk the amount of oleic acid is three times less than in the milk of other species. As already mentioned, donkey milk is very rich in PUFA, C18: 2 and C18: 3, linoleic and linolenic (Barłowska et al., 2011).

Buffalo milk contains almost three times more C14: 0 myristic acid and twice as much C16: 0 palmitic acid as cow's, sheep's and goat's milk. A characteristic of goat's milk is a high concentration of short-chain fatty acids. Ceballos et al. (2009) reported that goat's milk fat compared to cow's milk fat contains 54.6% more C6:0, 69.9% C8:0, 80.2% C10:0 and 56.3% CLA and 75% less C4:0. The characteristic of sheep's milk is a higher concentration of butyric acid (C4:0) and conjugated linoleic acid (CLA) than cow's and goat's milk.

Table 2. Milk fatty acid profile of different animal species (% of total fatty acids) and cholesterol content

Fatty acids FA	Cattle	Sheep	Goats	Buffalo	Donkey
C 4:0[a]	3.54	4.06	2.46	3.90	0,60[b]
C 6:0[a]	2.21	2.78	2.40	2.33	1.22[b]
C 8:0[a]	2.32	3.13	2.53	2.41	12.80[b]
C 10:0[a]	3.52	4,97	11.07	2.40	18,65[b]
C 12:0[b]	3.83	3.35	4.45	3.09	10,67
C 14:0[a]	11.41	10.16	10.16	10.64	5,77[b]
C 16:0[a]	26,66	23.11	24.20	28.02	11.47[b]
C 17:0[a]	0.50	0.76	0.63	0.50	2.37[b]
C 18:0[a]	11.82	12,88	12.51	12.58	1.12[b]
Total ≤ C14:0[a]	31.37	28.42	31.37	24.76	
Total SFA (%)[c]	72,8	74,6	73,7	74	67,7
C 14:1 c9cis[a]	0.84	0.58	0.22	0.67	
C 16:1 c9 cis[a]	1.68	0.39	0.67	1.56	
C 18:1 c9 cis[a]	24.72	23.32	22.03	24.10	
Total MUFA (%)[c]	30,3	24.29	35,9	29.4	35.0
C 16:1 trans[a]	0.31	0.29	0.38	0.37	-
C 18:1 t11 trans[a]	2.01	2.69	1.69	2.00	-
C 18:2 t9, t12 trans[a]	0.45	0.44	0.50	0.49	-
Total TFAa	2.76	3.15	2.66	2.66	-
C 18:2 c9, t11 (CLA)[a]	0.59	0.60	0.43	0.39	-
C 18:2 t10, c12 (CLA)[a]	0.036	0.032	0.024	0.027	-
Total CLA (%)[b]	0,45	0,67	0,68	0,49	-
C 18:2 cis[a]	1.96	1.17	0.70	1.55	8.15[b]
C 18:3 n-3[a]	0.70	0.92	0.82	0.68	6,47[b]
C 20: 4 n-6[a]	0.21	0.20	0.32	0.35	0,07[b]
C 20:5 n-3[a]	0.15	0.09	0.11	0.18	0,27[b]
C 22:6 n-6[a]	0.08	0.08	0.09	0.12	0,30[b]
PUFA (%)[b]	3.20	2.45	4.08	2,67	16.60
Cholesterol (mg / 100 ml lapte)[c]	13.1-31.4	14 -29.0	10.7-18.1	4-18,0	-

Source: [a]Talpur et al. (2008); [b]Barłowska et al. (2011); [c]Roy et al. (2020).

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; CLA, conjugated linoleic acid, TFA, drawn fatty acids.

Cholesterol is present in the globular membrane of milk fats (MFGM) and accounts for 95% of sterols in milk fat (Parodi, 2004). Barłowska et al. (2011) recorded the lowest cholesterol content (6.5 mg/100 g milk), in buffalo milk and the highest cholesterol content was in cow's milk (25.60 mg/100 g milk).

The fat content was 7.70-7.74%, and the protein content was 4.19 to 4.37%. The calcium and phosphorus content is higher than in cow's milk. Palmitic acid and oleic acid are the most important fatty acids in buffalo milk. Compared to the fat in cow's milk, buffalo fat is higher in butyric acid, palmitic acid, stearic and polyunsaturated fatty acids and lower in medium chain fatty acids C6-C12 (Vidu et al., 2015).

Milk lipids

Lipids form inclusions, which gradually increase in size and eventually migrate to the top of the cell from where they are discharged as globules into the collecting lumen

(Barłowska et al., 2011). The fat in the milk of all species is present in the form of small spherical droplets, called globules. Milk fat globules have an average diameter of less than 0.1 μm to about 18 μm. The size of these fat globules varies between the milk of different species. Differences in the size of milk fat cells from different species can influence the digestion of their fat differently (Gantner et al., 2015; Claeys et al., 2014).

Table 3. Size of milk fat globules from different mammal species

Species	Cattle[a]	Sheep[a]	Goats[a]	Buffalo[a]	Donkey[b]
Fat globule diameter (μm)	3.95	3.78	3.19	8.70	1-10

Source: [a]Barłowska et al. (2011); [b]Roy et al. (2020)

Fat globules with the largest average diameter are found in buffalo milk (8.70 μm), the smallest in goat's milk (3.19 μm) (Table 3). Attaie & Richter (2000) observed that the mean globe of milk fat in goat's milk was 2.76 μm (ranging from 0.73 to 8.58 μm) and 3.51 μm for cow milk (with a range of 0.92 to 15.75 μm). The fat globules in goat's milk occupy an area of 21,778 cm^2/ml, while in holiday milk this area is 17,117 cm^2/ml. Approximately 90% of all goat's milk fat globules have a diameter of less than 5.21 μm, while 90% of cow's milk globules have a diameter of less than 6.42 μm (Barłowska et al., 2011).

Milk lactose

The lactose content obtained by Mahmood & Usman (2010) was in the range of 4.56-6.21% in buffalo milk, 4.01-5.00% in cow's milk, 3.70-4.88% in goat's milk and 4.37-5.22% in sheep's milk. The amount of lactose content in buffalo milk was higher than in cow's and goat's milk at one level ($p<0.001$). A difference ($p<0.01$) was obtained between the lactose content of buffalo milk and sheep's milk. Difference ($p>0.05$) between the amount of lactose content in cow's, goat's and sheep's milk. The lactose content found in buffalo milk was similar to that obtained by Imran et al. (2008) and Khan et al. (2007). The results of Samia et al. (2009) were similar to those of Mahmood & Usman (2010) and Lingathurai et al. (2009). The highest lactose content was obtained in buffalo milk (6.21%) followed by goat's milk (4.88%), the lowest being recorded in cow's milk (5.00%). The lactose content of goat's milk (4.88%) reported was similar to that reported by Imran et al. (2008), Strzałkowska et al. (2009), Bhosale et al. (2009) and Sawaya (1984). The lactose content reported by Mahmood & Usman (2010) in sheep's milk (5.22%) was similar to that reported by Pavić et al. (2002) and Bylund (1995).

Milk ash

The results of Mahmood and Usman (2010) in the ash content was in the range of 0.69-0.98% in buffalo milk, 0.40-0.80% in cow's milk, 0.56-0.99% in goat's milk and 0.78-0.98% in sheep's milk. Cow's milk in ash content was lower than in buffalo and sheep's milk at one level ($p<0.001$). The difference ($p<0.05$) was between the amount of ash in cow's and goat's milk. There was a difference ($p>0.05$) between the amount of ash in buffalo milk, goats and sheep. The amount of ash found in buffalo milk (0.98%) was in agreement with that reported by Enb et al. (2009), Khan et al. (2007), Imran et al. (2008) and Han et al. (2007). The amount of ash found in cow's milk (0.80%) was in line with that reported by Enb et al. (2009) and Imran et al. (2008). The amount of ash content found in goat's milk (0.98%) was consistent with the results of Bhosale et al. (2009) and Keskin et al. (2004). The ash content found in sheep's milk (0.98%) was similar to that reported by Adewumi & Olorunnisomo (2009) and Bylund (1995).

Milk mineral components

The main mineral compounds in milk are calcium and phosphorus. The high bioavailability of these minerals influences the unique nutrient of milk (Barłowska et al., 2011). The highest concentration of it and other minerals is specific to sheep's milk; whereas donkey's milk contains the smallest amounts of these compounds (Table 4). Goat's milk is characterized by the lowest concentration of iron, zinc and copper (Ljutovac et al., 2008).

Table 4. Selected mineral content of milk from different species

Species	Parameters									
	Calcium (Ca) (mg / 100 g)[a]	Phosphorus (P) (mg/100 g)[a]	Magnesium (Mg) (mg /100 g)	Potassium (K) (mg/100g)[a]	Sodium (Na) (µg/100 g)[a]	Zinc (Zn) (µg/100 g)[a]	Iron (Fe) (µg/100 g)[a]	Copper (Cu) (µg/100 g)[a]	Manganese (Mn) (µg / 100 g)	Iodine (I) (µg / 100 g)
Cattle	122	119	16.54[b]	152	58	530	80	60	20	2.1
Sheep	195-200	124-158	18–21[a]	136-140	44-58	520-747	72-122	40-68	5.3-9	10.4
Goats	132	97.7	21.16[b]	152	59.4	370	60	80	6.53	-
Buffalo	112	99	21.40[b]	92	35	410	161	35	-	-
Donkey	67.67	48.7	3.73[a]	49.72	21.83	-	-	-	-	-

Source: [a]Barłowska et al. (2011); [b]Kapadiya et al. (2016).

The mineral content selected from goat's, cow's and buffalo's milk by Kapadiya et al. (2016) was as follows: the calcium content determined in five replicates had an average value of 129.08 mg/100 ml in goat's milk. In cow's milk, the average was 120.24 mg/100 ml, in buffalo milk 178.59 mg/100 ml. The calcium content of buffalo milk was higher ($p>0.05$) than that of goat's milk and cow's milk. The magnesium content had an average of 19.94 mg/100 ml in goat's milk, in cow's milk an average value of 12.65 mg/100 ml and an average value of 18.29 mg/100 ml in milk of buffalo. The magnesium content of goat's milk was higher ($p>0.05$) than that of cow's milk. The magnesium content of goat's milk was statistically insignificant ($p<0.05$) with buffalo's milk. The phosphorus content had an average value of 98.91 mg/100 ml in goat laptops, in cow's milk, an average value of 88.08 mg/100 ml and an average value of 109.22 mg/100 ml in buffalo milk. The differences in phosphorus content from three types of milk studied by Kapadiya et al. (2016) were found to be statistically insignificant ($p<0.05$). Regarding the chloride content, Kapadiya et al. (2016) obtained an average value of 0.16% in goat's milk, in cow's milk an average value of 0.13% and an average value of 0.11% in buffalo milk.

Belewu & Aiyegbusi (2002) published a comparative article on the mineral content of milk from humans, cows and goats. It was found that the highest content of Ca, Mg, P, Fe, Cu and Mn was identified in goat's milk and human milk, and milk from cows had the lowest content. The mineral content in goat's milk was as follows: Na (210.41 mg/100 g), K (1.55 mg/100 g), Ca (5.56 mg/100 g), Mg (2.30 mg/100 g), P (1.20 mg/100 g), Zn (0.80 mg/100 g). The mineral content in cow's milk was as follows: Na (51.92 mg/100 g), K (1.30 mg/100 g), Ca (4.03 mg/100 g), Mg (1.03 mg/100 g), P (0.92 mg/100 g), Zn (0.11 mg/100 g).

In the paper by Vidu et al. (2015) it was found that the distribution of minerals depends on the variable number of lactations. Calcium is found in the largest proportion in buffalo milk obtained from the third lactation (1.21 $g.kg^{-1}$). Previous studies on different breeds have shown the following distribution of calcium levels: Murrah -0.83 $g.kg^{-1}$, Mediterranean breed 0.99 $g.kg^{-1}$, Jafarabadi -0.95 $g.kg^{-1}$ and half Murrah x Mediterranean -0.94 $g.kg^{-1}$. Differences were found between the mean values of phosphorus in buffalo milk in the first lactation (0.67 $g.kg^{-1}$), the 2nd lactation (0.76 $g.kg^{-1}$) and the 3rd lactation (0.59 $g.kg^{-1}$). Depending on the season, the level of distribution of phosphorus in the Mediterranean buffalo breed varied between 0.63 $g.kg^{-1}$ in winter and 1.10 $g.kg^{-1}$ in summer.

CONCLUSIONS

Although milk from all mammals contains the same main components, the composition may vary between different species, between different breeding variants within the same species and between individual animals. Milk is a source of food with a high biological value. The highest protein and fat content is found in sheep and buffalo milk. In terms of lactose content, donkey's milk contains the highest amount. Goat's milk had the highest ash content, followed by buffalo's milk. Regarding the content in polyunsaturated and monounsaturated fatty stocks, the highest content was recorded in sheep's milk. The conjugated linoleic acid content and cholesterol content is the highest in cow's milk. The main mineral compounds in milk are calcium and

phosphorus. The highest concentration of these and other minerals is specific to sheep's milk.

REFERENCES

Abd El-Salam, M.H., & El-Shibiny, S. (2011). A comprehensive review on the composition and properties of buffalo milk. *Dairy science & technology*, 91(6), 663.

Abd Elrahman, S.M., Ahmad, A.M., El Owni, A.O., & Ahmed, M.K. (2009). Microbiological and physicochemical properties of raw milk used for processing pasteurized milk in blue nile dairy company (Sudan). *Australian Journal of Basic and Applied Sciences*, 3(4), 3433-3437.

Adewumi, O.O., & Olorunnisomo, A.O. (2009). Milk yield and milk composition of West African dwarf, Yankasa and crossbred sheep in southwest of Nigeria. *Livestock Research for Rural Development*, 21(3), 1-8.

Ahmad, S., Gaucher, I., Rousseau, F., Beaucher, E., Piot, M., Grongnet, J.F., & Gaucheron, F. (2008). Effects of acidification on physico-chemical characteristics of buffalo milk: A comparison with cow's milk. *Food Chemistry*, 106(1), 11-17

Ahmed, M.I., & El Zubeir, I.E. (2007). The compositional quality of raw milk produced by some dairy cows farms in Khartoum State, Sudan. *Research Journal of Agriculture and Biological Sciences*, 3(6), 902-906.

Arman, P., Kay, R.N.B., Goodall, E.D., & Sharman, G.A. M. (1974). The composition and yield of milk from captive red deer (Cervus elaphus L.). *Reproduction*, 37(1), 67-84.

Attaie, R., & Richter, R.L. (2000). Size distribution of fat globules in goat milk. *Journal of dairy science*, 83(5), 940-944.

Barłowska, J., Szwajkowska, M., Litwińczuk, Z., & Król, J. (2011). Nutritional Value and Technological Suitability of Milk from Various Animal Species Used for Dairy Production. *Comprehensive Reviews in Food Science and Food Safety*, 10 (6), 291-302.

Belewu, M.A., & Aiyegbusi, O.F. (2002). Comparison of the mineral content and apparent biological value of milk from human, cow and goat. *Journal of Food Technology in Africa*, 7(1), 9-11.

Bhosale, S.S., Kahate, P.A., Kamble, K., Thakare, V.M., & Gubbawar, S.G. (2009). Effect of lactation on physico-chemical properties of local goat milk. *Veterinary world*, 2(1), 17.

Braun, P.G., & Preuss, S.E. (2008). Nutritional composition and chemico-physical parameters of water buffalo milk and milk products in Germany. *Milchwissenschaft*, 63(1), 70-72.

Bylund, G. (1995). Dairy processing handbook. *Tetra Pak Processing Systems AB*. Sweden.

Ceballos, L.S., Morales, E.R., de la Torre Adarve, G., Castro, J.D., Martínez, L.P., & Sampelayo, M.R.S. (2009). Composition of goat and cow milk produced under similar conditions and analyzed by identical methodology. *Journal of food Composition and Analysis*, 22(4), 322-329.

Claeys, W.L., Verraes, C., Cardoen, S., De Block, J., Huyghebaert, A., Raes, K., ... & Herman, L. (2014). Consumption of raw or heated milk from different species: An evaluation of the nutritional and potential health benefits. *Food Control*, 42, 188-201.

Crowley, S.V., Kelly, A.L., Lucey, J.A., & O'Mahony, J.A. (2017). Potential applications of non-bovine mammalian milk in infant nutrition. In Handbook of Milk of Non-Bovine Mammals (pp. 625-654). *John Wiley and Sons Ltd.*, Oxford, UK.

Enb, A., Abou Donia, M.A., Abd-Rabou, N.S., Abou-Arab, A.A.K., & El-Senaity, M.H. (2009). Chemical composition of raw milk and heavy metals behavior during processing of milk products. *Global Veterinaria*, 3(3), 268-275.

Gantner, V., Mijić, P., Baban, M., Škrtić, Z., & Turalija, A. (2015). The overall and fat composition of milk of various species. *Mljekarstvo/Dairy*, 65(4).

Haenlein, G.F.W. (2004). Goat milk in human nutrition. *Small ruminant research*, 51(2), 155-163.

Han, B.Z., Meng, Y., Li, M., Yang, Y.X., Ren, F.Z., Zeng, Q.K., & Nout, M.R. (2007). A survey on the microbiological and chemical composition of buffalo milk in China. *Food Control*, 18(6), 742-746.

Imran, M., Khan, H., Hassan, S.S., & Khan, R. (2008). Physicochemical characteristics of various milk samples available in Pakistan. *Journal of Zhejiang University Science B*, 9(7), 546-551.

Jenness, R. (1980). Composition and characteristics of goat milk: review 1968-1979. *Journal of Dairy Science*, 63(10), 1605-1630.

Kapadiya, D.B., Prajapati, D.B., Jain, A.K., Mehta, B.M., Darji, V.B., & Aparnathi, K.D. (2016). Comparison of Surti goat milk with cow and buffalo milk for gross composition, nitrogen distribution, and selected minerals content. *Veterinary world*, 9(7), 710.

Keskin, M., Avşar, Y.K., BiÇER, O., & Güler, M.B. (2004). A comparative study on the milk yield and milk composition of two different goat genotypes under the climate of the Eastern Mediterranean. *Turkish Journal of Veterinary and Animal Sciences*, 28(3), 531-536.

Khan, M.A.S., Islam, M.N., & Siddiki, M.S.R. (2007). Physical and chemical composition of swamp and water buffalo milk: a comparative study. *Italian Journal of Animal Science*, 6(sup2), 1067-1070.

Kittivachra, R., Sanguandeekul, R., Sakulbumrungsil, R., & Phongphanphanee, P. (2007). Factors affecting lactose quantity in raw milk. *Songklanakarin J. Sci. Technol*, 29 (4), 937-943.

Ljutovac, K.R., Lagriffoul, G., Paccard, P., Guillet, I., & Chilliard, Y. (2008). Composition of goat and sheep milk products. *Small Ruminant Res*, 79, 57-72.

Mahmood, A., & Usman, S. (2010). A comparative study on the physicochemical parameters of milk samples collected from buffalo, cow, goat and sheep of Gujrat, Pakistan. *Pakistan Journal of Nutrition*, 9(12), 1192-1197.

Parodi, P.W. (2004). Milk fat in human nutrition. *Australian Journal of Dairy Technology*, 59(1), 3.

Pavić, V., Antunac, N., Mioč, B., Ivanković, A., & Havranek, J.L. (2002). Influence of stage of lactation

on the chemical composition and physical properties of sheep milk. *Czech journal of animal science*, 47(2), 80-84.

Pereira, P.C. (2014). Milk nutritional composition and its role in human health. *Nutrition*, 30 (6), 619-627.

Rafiq, S., Huma, N., Pasha, I., Sameen, A., Mukhtar, O., & Khan, M.I. (2016). Chemical composition, nitrogen fractions and amino acids profile of milk from different animal species. *Asian-Australasian journal of animal sciences*, 29 (7), 1022.

Remeuf, F., & Lenoir, J. (1986). Relationship between the physico-chemical characteristics of goat's milk and its rennetability. *Bulletin-Fédération Internationale de Laiterie*, (202), 68-72.

Roy, D., Ye, A., Moughan, P.J., & Singh, H. (2020). Composition, Structure, and Digestive Dynamics of Milk From Different Species - A Review. *Frontiers in Nutrition*, 7.

Ruiz-Sala, P., Hierro, M.T.G., Martinez-Castro, I., & Santa-Maria, G. (1996). Triglyceride composition of ewe, cow, and goat milk fat. *Journal of the American Oil Chemists' Society*, 73(3), 283-293.

Sawaya, W.N., Safi, W.J., Al-Shalhat, A.F., & Al-Mohammad, M.M. (1984). Chemical composition and nutritive value of goat milk. *Journal of Dairy Science*, 67(8), 1655-1659.

Strzałkowska, N., Jóźwik, A., Bagnicka, E., Krzyżewski, J., Horbańczuk, K., Pyzel, B., & Horbańczuk, J. O. (2009). Chemical composition, physical traits and fatty acid profile of goat milk as related to the stage of lactation. *Animal Science Papers and Reports*, 27(4), 311-320.

Talpur, F., Bhanger, M.I., Khooharo, A.A., & Memon, G.Z. (2008). Seasonal variation in fatty acid composition of milk from ruminants reared under the traditional feeding system of Sindh, Pakistan. *Livestock Science*, 118(1-2), 166-172.

Vidu, L., Chelmu, S., Bacila, V., & Maciuc, V. (2015). The content of minerals and fatty acids in buffalo milk, depending on the rank of lactation. *Romanian Biotechnological Letters*, 20(1), 10076-10084.

Watson, R.R., Collier, R.J., & Preedy, V.R. (Eds.). (2017). Nutrients in dairy and their implications for health and disease. *Academic Press*.

Zicarelli, L. (2004). Buffalo milk: its properties, dairy yield and mozzarella production. *Veterinary research communications*, 28, 127.