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The content of minerals and fatty acids in buffalo milk, depending on the rank of lactation

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Abstract

Buffalo breeding is important for mozzarella production, fresh cheeses, fresh and processed meat, and semen of high genetic level.The purpose of this research was to determine: quantity of milk per lactation (kg milk / total lactation); duration of lactation (days); % fat; % protein; micro and macro minerals; fatty acids. It was analyzed milk from 39 buffaloes with lactation between 1 and 3. After laboratory analysis data obtained were processed and were interpreted in accordance with the literature. The average of milk was between 1847.06 kg milk for buffaloes at 3th lactation and 1385.55 kg for buffaloes at the first lactation. The average of the protein content had variations between 4.67 and 4.04%. Between the lots of dairy buffaloes in the experiment are significant differences ($p < 0.05$). The content of calcium was in the highest proportion in the milk of buffaloes obtained from third lactation (1.21 g.kg^{-1}). Between the values of three lactation are significant differences ($p < 0.05$). In buffalo milk fatty acids with short chain carbon atoms are found in small quantity. The most important fatty acids are palmitic acid (16: 0) and oleic acid (18: 1).

Key words: buffalo, fatt acid, milk, minerals, protein

1. Introduction

The world production of milk has doubled in recent decades, and notable is that 12% of this is provided by the buffalo. India and Pakistan produce around 60 and 30% of buffalo milk. In both countries, buffalo milk contributes around 55 and 75% of local production (FAOSTAT, USDA [1], [2]).

The buffalo milk production is a tradition in many parts of the world such as the Caucasus, Asia, where the sour milk, butter and yogurt from buffalo milk are very popular. In Italy, the industry of buffalo milk is flourishing due to the popularity mozzarella cheese. Market demand for buffalo mozzarella cheese transforms farms in the profitable enterprises. These can be based on techniques and technologies operating in an organized manner (XUE & al. [3]).

In South America, in countries such as Brazil and Argentina buffalos are raised for both milk production and for the meat, and more recently, buffalo milk and milk products that have become very popular, and production of buffalo milk reached in countries that previously had no tradition in this production such as Germany, Ireland, UK, and even in USA.

The taxonomic point of view, river buffalo (*Bubalus bubalis*) is part of the family *Bovidae*, *Bovinae* subfamily, genus *bubalis* and species *arni* or *Indian river buffalo*. Animals are classified into two distinct classes, *river buffalo* and *swamp buffalo*. The cattle presents 60 pairs of chromosomes, while river buffalo only 50 and swamp buffalo 48 pairs chromosomes. Between the two classes buffalo may occur mating and result is fertile animals with 49 pairs of chromosomes. But any combination of buffalo and other animals of the family Bovidae is excluded (VELEA & al., ZICARELLI,[4], [5], [6]).

Buffalos are known as animals that are very suitable to pasture maintaining, but in terms of feed floral palette this is broader than in cattle. Buffalos used better than cattle lower quality of fibrous feed (straw, stalks). The buffalo unique ability to survive in difficult conditions of shelter and food made the difference in competition between dairy species in the area where they come. In addition, buffalos have a long productive life, a healthy buffaloes can be exploited for 9-10 lactations.

2. Material and Methods

The study was conducted at the Institute of Research and Development for Buffalo Breeding on a herd of 39 dairy buffaloes that completed lactation between August 2013 and August 2014. The animals were aged between 1-3 lactation. The data of production were obtained by performing the official control for milk production. The data on quality indicators of milk production resulted from analyzes performed in laboratory of Animal Science Faculty and in a private laboratory. The data were statistically analyzed and were interpreted in accordance with the literature. All data were processed and statistically interpreted using the multiple Student significance test.

The Institute of Research and Development for Buffalo Breeding was founded in 1981 and located in central Romania, Fagaras area in Transylvania. At present the farm of Research Institute has 458 buffaloes, of which milk buffalos and heifers are 35%.The buffalo breeding is done differently seasonal, the summer at the pasture and the winter in shelters. Milk buffalos are fed with forages on own land. The land surface is 335 ha which are cultivated for grain and pasture for grass and hay. The growth system of the buffaloes is based on the use in buffalo rations of feed volume only during the summer, and in winter when temperatures are very low buffaloes are given concentrates forages as supplements.

For the determination the micro and macro elements, and fatty acids composition of buffalo milk were collected 200 ml samples from 14 buffaloes at lactation 1, 10 buffaloes at 2 lactation and 15 buffaloes at 3 lactation.

The determination of minerals content was done by atomic absorption spectrometry method with flame (FAAS). We used laboratory reagents and equipment appropriate for the purpose established. For tapping, dilution and storage was used glassware class A. We followed linearity, working range, sensitivity, limit of detection, limit of quantification in accordance with international rules [7]. The method has as principle calcining the samples at 450°C with a gradual increase of temperature, dissolving the ash in hydrochloric acid and evaporation to dryness of the solution obtained, resolving final residue in nitric acid 1: 6 and determination of metals by atomic absorption spectrometry with the oven graphite.

To determine the fatty acids from milk gas-chromatographic method has been used. GC Shimadzu GC-17A equipped with a capillary column Chrompack with length of 25 m and a diameter of 0.25 mm, stationary phase (a derivative of polyethylene glycol) is filed in the column in the form of a thin film of 0.2 μm.

The working method consists of two steps:

- preparation of fatty acid methyl esters;
- analysis of fatty acid methyl esters by gas chromatography.

After studying chromatograms were obtained results

3. Results and discussion

We determined the following parameters:

- Quantity of milk per lactation (kg milk / total lactation);
- Duration of lactation (days);
- % Fat;
- % Protein;
- Micro and macro minerals;
- Fatty acids.

The quantity of milk: The average of quantity of milk for 39 buffaloes which ended lactation in analyzed period had range between 1847.06 kg milk for buffaloes at 3th lactation and 1385.55 kg for buffaloes at the first lactation. From the table 1, there is a large heterogeneity both within lactation and between lactation. The differences between the averages of three lactations is significant ($p < 0.05$). The average quantity of buffaloes milk in Research Institut for Buffalo Breeding Sercaia is higher than the value found by us in 2008 at buffaloes in Romania, respective 1356.33 kg milk, with 1320 kg in the south, in the valley of the Danube and 1420 kg in the North-West of Romania. Thus, Pucheanu (2000) [8] determined an average of 1109.27 kg milk per normal lactation in buffaloes in the Fagaras area with limits between 1047 kg at buffaloes first lactation and 1130 kg milk for multiparous. Romanian buffalo breed has a level of milk production by 1.4 to 2 times lower compared to other breeds worldwide. If we compare this production with the mean value recorded for the European breeds, we observed that the values found by us were situated after Italy -2175 kg milk and Bulgaria -1870 kg milk (PUCHEANU, BORGHESE [8], [9]).

Table 1. The dynamics of phenotypic parameters of buffalo milk depending on the lactation rank

Specification	Parameter	Lactation 1	Lactation 2	Lactation 3	Test of significance
n		14	10	15	
Quantity of milk (kg)	$X \pm S_X$	$1385,55^{a} \pm 120,3$	$1528,71^{b} \pm 56,66$	$1847,06^{ab} \pm 45,69$	*
	Max	2137	1861	2549	
	Min	657,6	853,2	1428	
% Fat	$X \pm S_X$	7,70±0,05	7,74±0,09	7,71±0,05	NS
	Max	7,97	8,1	8,08	
	Min	7,40	7,45	7,34	
% Protein	$X \pm S_X$	$4,19^{a} \pm 0,04$	$4,37^{ab} \pm 0,08$	$4,28^{b} \pm 0,05$	*
	Max	4,45	4,67	4,68	
	Min	3,88	4,04	3,83	
Duration of lactation (days)	$X \pm S_X$	$234,35^{a} \pm 15,7$	$251^{b} \pm 24,9$	$296,2^{ab} \pm 9,37$	*
	Max	307	318	356	
	Min	137	158	225	

The milk quality parameters: The fat and protein of milk are important for economic efficiency of buffalo milk production because by them depend on processing milk yield in different preparations. From our research we found that the highest *percentage of fat* was recorded in buffaloes in lactation 2 (7.74%), with a range between 7.45 and 8.1% (Fig. 1.). Milk buffaloes belong to the first lactation had a fat percentage of 7.70% and 7.71% for third lactation without statistical differences between average values. Regarding the distributed average fat content of buffalo populations in Romania, we noticed that in southern Romania the average value was 7.65%, in the North West -7.72% and in the central area -7.9%. In Bulgarian Murrah breed fat percentage is 7.04% at a quantity of 1800 kg milk, and in Italy it increased from 7.09% in the period 1977-1981 to 8.31% in 2001 year (BORGHESE [9]). Regarding *the protein content* we have noticed that group of animals belonging to the second lactation achieved an average of 4.37%, with variations between 4.67 and 4.04%. Between the three groups of dairy buffaloes in the experiment are significant differences ($p < 0.05$). In 2008, in southern Romania there has been registered the highest percentage of protein, respectively 4.96% and 4.52% for the buffalo population in the North-West of Romania. Comparing with the specialty literature data, these values are lower than those found by Pucheanu (2000) in dairy buffaloes from Şercaia area (4.69%) [8].

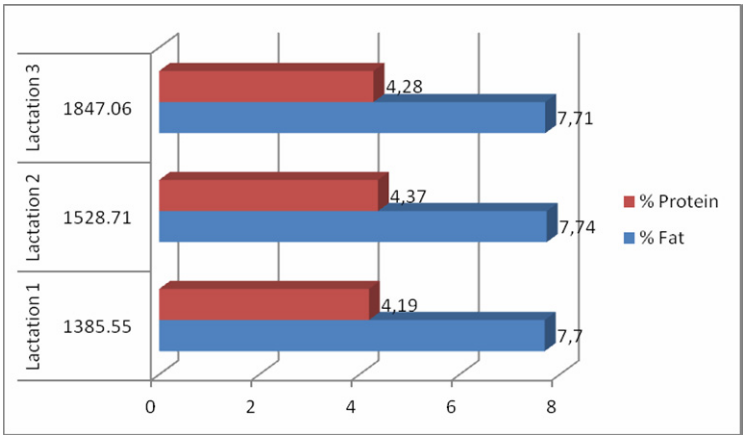

Figure 1. The average values of the main parameters of milk production in buffaloes studied

Duration of lactation is particularly important indicator that influences the milk production and reproductive activity. The dairy buffaloes belonging third lactation mean lactation duration was 296.2 days, with variation between 225-356 days. From the analysis of mean values we observe a fluctuating trend lactation period, demonstrated by high individual variability. Between the three groups of dairy buffaloes are significant differences ($p < 0.05$). Values calculated in 2008 had a similar distribution, thus at dairy buffalos in southern Romania the average value of the duration of lactation was 275 days, and 272 days Northwest. [5]. The average values for the period of lactation are similar to the European average, with values of 240 days in Greece, 270 days in Italy and 278 days for the dairy buffaloes in Bulgaria (BORGHESE [9]).

Buffalo milk minerals: The milk contains all the minerals necessary for human and animal being of 45 and accounting for 0.7-0.8% of dry matter. Among macroelements better

represented are calcium, potassium, sodium, magnesium, and the microelements iron, zinc, copper and phospho-calcium ratio is 1.00 / 1.25. Milk minerals are of particular importance, consisting of the following:

- They are indispensable for consumers because they are constituents of bones and teeth, especially calcium and phosphorus;
- Calcium play an active role in coagulation in the presence of rennet for cheese and fermented milk products;
- Ensures need for calcium of 75% and phosphorus 63% by consuming half a liter per day of the adult.

From Table 2 it is observed that the distribution of minerals depending on the lactation number variable. Thus, calcium is found in the highest proportion in the milk of buffaloes obtained from third lactation (1.21 $g.kg^{-1}$). Between the values of three lactation are significant differences ($p < 0.05$). Previous studies conducted in different breeds indicated the following distribution of calcium levels: Murrah -0.83 $g.kg^{-1}$, Mediterranea breed 0.99 $g.kg^{-1}$, Jafarabadi -0.95 $g.kg^{-1}$ and half-breed Murrah x Mediterranean -0.94 $g.kg^{-1}$. It also notes significant differences between mean values of phosphorus in milk buffaloes in first lactation (0.67 $g.kg^{-1}$), 2^{th} lactation (0.76 $g.kg^{-1}$) and 3^{th} lactation (0.59 g. kg^{-1}). Depending on the season the value of phosphorus distribution at Mediterranean buffalo breed ranged between 0.63 $g.kg^{-1}$ winter and 1.10 $g.kg^{-1}$ summer. (PATIÑO & al., [10]).

Table 2. Variation of the mineral of buffalo milk depending on the lactation rank

Specification	Parameter	Lactation 1	Lactation 2	Lactation 3	t
n		14	10	15	
Ca ($g.kg^{-1}$)	$X \pm S_X$	$1,10^{a} \pm 0,21$	$0,97^{b} \pm 0,32$	$1,21^{ab} \pm 0,29$	*
P ($g.kg^{-1}$)	$X \pm S_X$	$0,67^{a} \pm 0,23$	$0,76^{ab} \pm 0,16$	$0,59^{b} \pm 0,14$	*
Mg ($g.kg^{-1}$)	$X \pm S_X$	0,06 ±0,02	0,08± 0,02	0,08± 0,02	NS
K ($g.kg^{-1}$)	$X \pm S_X$	$1,11^{a} \pm 0,14$	$0,95^{b} \pm 0,28$	$0,91^{ab} \pm 0,28$	*
Na ($g.kg^{-1}$)	$X \pm S_X$	0,37± 0,03	0,34 ±0,08	0,31± 0,05	NS
Cu ($mg.kg^{-1}$)	$X \pm S_X$	$0,35^{ab} \pm 0,09$	$0,32^{b} \pm 0,09$	$0,26^{a} \pm 0,12$	*
Mn ($mg.kg^{-1}$)	$X \pm S_X$	0,26 ±0,10	0,27 ±0,13	0,27± 0,12	NS
Zn ($mg.kg^{-1}$)	$X \pm S_X$	4,04± 1,15	3,71± 1,34	3,98± 1,14	NS
Fe ($mg.kg^{-1}$)	$X \pm S_X$	$1,52^{a} \pm 0,99$	$1,58^{ab} \pm 0,42$	$1,37^{b} \pm 0,51$	*

Compared to cow's milk find that buffalo milk minerals are in higher quantity with 0.01%, is richer in calcium and phosphorus and poorer in chlorine and sodium salts (Fig. 2). (ABD EL-SALAM & al., TALPUR & al., [11], [12]).

In the buffalo milk minerals content is high and consequently increasing the buffering power which explains the slow development of acidity in dairy products therefore increased calcium content reduces coagulation times. (COROIAN, [13]).

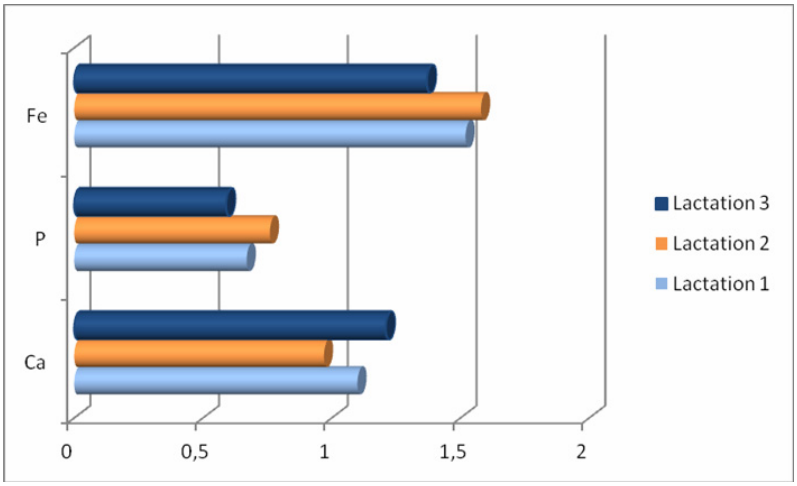

Figure 2. The representation of main mineral elements in buffaloes milk (Ca-g.kg^{-1}, P- g.kg^{-1}, Fe-mg.kg^{-1})

Volatile fatty acids from buffalo milk. In the buffalo milk is a larger quantity of volatile fatty acids as compared to cow's milk. The fatty acid composition of buffalo milk is influenced by many factors such as: lactation, genotype, breed, natural environmental factors and artificial.

The fat of buffalo milk has a melting point higher than that fat of cow's milk due the higher proportion of saturated fatty acids (77:23 saturated: unsaturated). The phospholipids and cholesterol are lower in buffalo milk. Instead the buffalo milk presents more resistant to oxidation. Compared to cow's milk fat, fat buffalo milk has a higher content of butyric acid, palmitic, stearic acid and polyunsaturated fatty acids and lower in medium chain fatty acids C6-C12 (GANGULI, [14]).

The ration fatty acids are predominantly derived from the long chain of carbon atoms (palmitic C16: 0, stearic C18: 0, oleic C18: 1, linolenic C18: 2, linolenic C18: 3). These fatty acids are biohydrogen by rumen flora.

In the buffalo milk are more saturated fatty acids than the food rations, which is explained by the proportion of different populations of microorganisms in the rumen of buffalo. (COROIAN, MIHAYLOVA & al., [13], [15]).

Cholesterol levels (total and free) in bufalo milk fat apear to be lower than in that of cow milk (AHMAD & al., [16]). Colostrum and mastic milk contained more cholesterol than normal milk. Cholesterol content in fore-milk is higher than instriping; also, it is higher in milk during the spring season (LAL & al., SOLIMAN & al., [17], [18]).

Most strongly represented fatty acids in milk for primiparous buffaloes but also for the multiparous are palmitic acid (16: 0) and oleic acid (18: 1) 27.1% (PATIÑO & al., GEORGESCU & al., [19], [20]). The fatty acids with shorter carbon chains (12 to 12 carbon atoms) are in small quantities in milk buffaloes (table 3).

Table 3. The composition of fatty acids in buffalo milk

Fatty acids	Parameter	Lactation 1	Lactation 2	Lactation 3
n		14	10	15
4:0	$X \pm S_X$	5,15±0,12	5,21±0,11	5,14±0,11
6:0	$X \pm S_X$	3,11±0,09	3,52±0,07	3,21±0,09
8:0	$X \pm S_X$	1,17±0,26	1,49±0,24	1,49±0,24
10:0	$X \pm S_X$	2,56±0,41	2,66±0,42	2,58±0,41
12:0	$X \pm S_X$	2,95±0,09	3,21±0,08	3,14±0,09
14:0	$X \pm S_X$	11,32±3,12	11,41±2,78	11,61±2,99
14:1*c*9	$X \pm S_X$	0,33±0,02	0,41±0,02	0,67±0,03
15:0	$X \pm S_X$	1,27±0,26	1,37±0,24	1,34±0,19
16:0	$X \pm S_X$	25,79±4,11	27,11±4,23	27,41±4,12
16:1*c*9	$X \pm S_X$	1,91±0,37	1,87±0,37	1,870,28
17:0	$X \pm S_X$	0,80±0,09	0,81±0,09	0,80±0,09
18:0	$X \pm S_X$	10,67±2,24	10,58±2,25	10,61±2,24
18:1*c*9	$X \pm S_X$	18,60±3,11	18,77±2,29	18,64±2,28
18:1*t*9	$X \pm S_X$	0,12±0,01	0,15±0,01	0,09±0,01
18:1*t*11	$X \pm S_X$	0,39±+0,04	0,38±0,04	0,39±0,04
18:2*t*9 *t* 12	$X \pm S_X$	0,35±0,02	0,29±0,01	0,31±0,02
18:2*c*9 *t* 11	$X \pm S_X$	0,40±0,03	0,41±0,04	0,39±0,03
18:2*t*10*c*12	$X \pm S_X$	0,18±0,02	0,14±0,02	0,14±0,02
18:2*c*9*c* 12	$X \pm S_X$	1,70±0,21	1,72±0,20	1,69±0,19
20:4 n-6	$X \pm S_X$	0,12±0,01	0,13±0,01	0,13±0,01
20:0	$X \pm S_X$	0,22±0,09	0,22±0,09	0,21±0,09
SFA	$X \pm S_X$	75,14±5,63	76,21±6,11	76,41±7,23
MUFA	$X \pm S_X$	29,7±3,93	28,11±3,79	25,64±3,45
PUFA	$X \pm S_X$	3,57±0,12	3,71±0,16	3,72±0,16
CLA	$X \pm S_X$	0,35±0,05	0,38±0,06	0,38±0,06

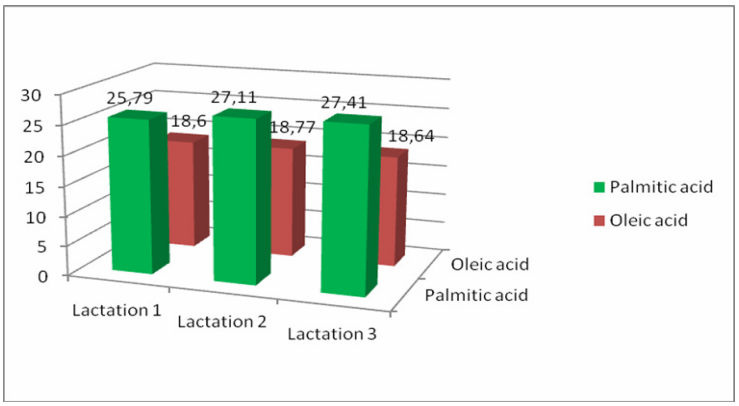

Figure 3. Variation of palmitic an oleic acid content in the buffaloes milk

4. Conclusions

The dairy buffaloes from the Research Institute for Buffalo Breeding achieved the level of milk production between 1847.06 kg and 1385.55 kg. The fat content was 7.70-7.74% and the protein content was from 4.19 to 4.37%. Calcium and phosphorus content is higher than in cow's milk and between lactations there are significant differences. Palmitic acid and oleic acid are the most representative fatty acids in milk of buffaloes.

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