International Food Research Journal 20(2): 711-714 (2013)
Journal homepage: *http://www.ifrj.upm.edu.my*

Quality of donkey milk: correlations between electric conductivity, freezing point and composition parameters

Conte Francesca

Faculty of Veterinary Medicine, Dept. of Veterinary Public Health. University of Messina
Polo Universitario dell'Annunziata, viale Annunziata, 98168 Messina, Italy

Article history

Received: 26 September 2012
Received in revised form:
12 December 2012
Accepted:12 December 2012

Keywords

Donkey milk
electric conductivity
freezing point
correlations
quality

Abstract

The results obtained in this study verified the usefulness of electric conductivity (EC) and freezing point (FP) to evaluate their practical application to the assessment of physical and chemical donkey milk quality. Statistic correlations was performed between EC, FP and some physical and chemical parameters in donkey milk samples from two farms. Some interesting correlations are showed and some related considerations are reported. In conclusion FP would be considered as an important qualitative indicator more than EC, especially for its practical application.

Introduction

The electric conductivity (EC) was considered one of the most important parameters of milk with the aim to evaluate its chemical and physical characteristics (Redaelli *et al*., 1984) and for a fast evaluation of milk acceptance. Some studies concern the EC application for the evaluation of fat and total nitrogen contents in bovine milk and its derivatives and for ovine and goat milk (Lawton and Pethig, 1993). The EC is mainly considered a useful marker in cases of mastitis diagnosis (Redaelli *et al*., 1984).

This parameter can be influenced by milk composition, in particular for the presence of its ions. Furthermore, EC values could have a variation in relation to animal species, season, feeding, lactation stage, because these factors have an influence on the distribution between milk colloidal and solution phases, therefore, EC has an influence on the amount of free conductor ions in the milk (Prentice, 1962). An experimental study on bovine milk showed the significant correlations between the effects on EC values, lactation stage and mastitis. Furthermore, CE values for milk taken by healthy udders ranged between 5.3 mS/cm (35 days after birth) and 5.9 mS/cm (at the end of lactation). Milk from udders affected by mastitis had EC values that ranged between 5.4 mS/cm, at 25 gg. Postpartum; and 6.1 mS/cm at the end of lactation (Sheldrake *et al*., 1983). Pautzke e Schulz (2007) referred a significant correlation between plate count and mastitis indicators, somatic cell count, EC and lactose contents in bovine milk (9).

The impedometric method allow to verify the modifications of metabolic processes, allowing to evaluate lactic acid contents, as a lactose metabolite. EC measurement could be used to show milk bacterial spoilage, with a reduction of pH values. The metabolites produced by bacteria increase milk EC values (Pesta *et al*., 2007). FP is a parameter that is subject to limited variations of its values; for this reason it is indicated to show the cheat of water addition to milk. FP values could be influenced by the so called "natural" factors: animal breed and stage of lactation, feeding, number and time of milking, cow health status (Sotgiu *et al*., 1996). Seasonal and climatic differences would be strongly related to these factors (Casali *et al*.,1988). "Technological factors" influence the FP, as for example, the type of milking, milk storage at farm level (Conte,2005), water deriving from milking equipments and from bulk tank milk (Slaughuis, 2001), milk treatments at plants level (the so called "technological dilution" of milk) (Dillier-Zulauf, 1985).

In milk, as for every watery system, FP values depend from the concentration of components in

*Corresponding author.
Email: *fconte@unime.it*

solution. Lactose and chloride, as other salts, would be the main factors that cause a FP reduction; lactose would be the principal component of milk that is responsible for this effect (Lawton and Pethig, 1993; Shipe,1959; Slaghuis, 2001; Conte, 2005). As regard EC of donkey milk, Conte *et al*. (2008) showed some experimental data, together with further observations, could be useful to define the physiological indices for EC also for equids milk. It would be supposed the practical application of this parameter to an indirect evaluation of the product quality. The authors considered that EC would be useful for early diagnosis of mastitis because this pathology are very rare in donkey or they are in subclinic and cannot be diagnosed (Conte *et al*., 2003). Conte (2005) referred further results of a research carried out during one year on FP in donkey milk; lactose amount evaluation was also measured, because this disaccharide has a high percentage in this milk; it was choose as a target parameter to verify if it would have a certain influence on FP values, such as for cow milk was verified (Slaghuis, 2001). The results revealed mean values that were similar to bovine milk FP. A repeated relationship between FP and lactose was showed. Lactose could have a strong influence on the donkey milk FP.

Freezing point (FP) could acquired a great importance as an useful parameter to verify donkey milk authenticity; its price (Conte, 2005) is elevated because it is used for infants intolerance to some bovine milk proteins or to multiple intolerance (Carroccio *et al*., 2000). On the basis of the above and in view of lack researches on this topic for donkey milk, the present work has the objective to verify the statistic correlations between EC, FP and some principal components of this milk, with the aim to evaluate the practical application of this two parameters for the assessment of physical and chemical milk quality.

Materials and Methods

Milk samples was taken from donkeys in two farms in Sicily. In the first farm (A) n.20 samples were collected; in the second farm (B) n. 10 samples were taken. The animals were manually drawn. All samples were put in a chilled cooler box and transferred to the laboratory. The samples were analysed for the measurement of the following indices: pH (potentiometric method; pHmeter 330i/set, WTW); electric conductivity (EC) (CON6/TDS meter, Eutech Instr./Oakton Instr.); somatic cell count (SCC) ((Milko Scan, FOSS Italy); lactose (LTS), fat (GRS), total nitrogen (TN) and dry matter (DM) percentages; freezing point (Lactostar; Funke Gerber, Germany). The statistical analysis of data were performed by Spearman's rho correlation coefficient ($P<0.01$).

Results and Discussion

Table 1 and Table 2 show the results of analysis for donkey milk in farm A and farm B, respectively. This data were used for the statistical elaboration. In the farm A the statistical analysis of data showed the following correlations (Table 3): a highly significant negative correlation between pH and FP; between TN and FP and between DM and FP ($P<0.01$), a highly significant between pH and LTS, TN and DM; between LTS and pH, TN and DM and between TN and LTS, DM ($P<0.01$) and a significant correlation between LTS and FP, DM.

Some considerations arose after the observation of these results. The correlation between FP and LTS could be justified by milk acidification during storage, when the lactose splits and lactic acid is formed; this phenomenon had a certain influence on freezing point values. The acidification explained also the relation between pH value and lactose. Furthermore, DM was affected by total nitrogen and lactose percentage. A negative correlation between pH and FC was explained with a probable increase of some ions during milk refrigeration, with particular reference to the acid groups derived from lactose splitting. The negative correlation between TN and FP was not in agreement with the hypothesis of Dillier-Zulauf (1985) on the absence of a quantifiable effect of fat and of soluble protein on freezing point. The negative correlation between PC and DM would be due to the effect of milk components that contribute to the dry matter percentage.

With reference to farm B, the following correlations were showed (Table 4): a significant negative correlation ($P<0.05$) between EC and FP, significant was the correlation ($P<0.05$) between EC and lactose; the latter had a highly significant negative correlation ($P<0.01$) with FP; the same correlation was between FP and pH, lactose, fat, TN and DM, a highly significant correlation ($P<0.01$) was observed between lactose and pH, TN and DM.

These correlations gave the opportunity to formulate some considerations. The negative correlation between EC and FP does not find a practical confirmation; these parameters are usually influenced by the presence of some ions in the milk; therefore it would have hypothesized a direct correlation between the parameters. The correlation between EC and lactose could be explained by the potential acidifying effect of lactose, causing ions formation that would

Table 1. Analytical data of donkey milk samples from farm A

Samples	EC (μS)	FP (°C)	pH	LTS (%)	GRS (%)	TN (%)	DM (%)	SCC (C/ml)
1	2,55	-0.513	6.87	6.09	1.77	1.87	8.02	3000
2	2,68	-0.52	6.86	6.19	2.68	1.90	8.15	1000
3	2,44	-0.52	6.87	6.19	3.18	1.90	8.15	4000
4	3,03	-0,51	6,77	5,98	3,03	1,84	7,89	11000
5	2,69	-0,51	6,80	5,93	3,14	1,82	7,81	3000
6	2,47	-0,51	6,86	6,09	1,93	1,87	8,01	2000
7	2,43	-0,52	6,88	6,24	3,24	1,91	8,21	11000
8	2,80	-0,51	6,82	6,06	2,97	1,86	7,98	6000
9	2,58	-0,52	6,86	6,26	2,86	1,92	8,24	3000
10	2,62	-0,53	6,86	6,38	1,96	1,95	8,40	2000
11	2,65	-0,51	6,83	6,14	2,68	1,88	8,08	3000
12	2,45	-0,54	6,89	6,44	2,82	1,98	8,48	2000
13	2,72	-0,54	6,90	6,38	2,88	1,96	8,40	4000
14	3,16	-0,51	6,78	6,06	3,43	1,86	7,99	7000
15	2,97	-0,52	6,81	6,19	3,39	1,90	8,15	2000
16	2,70	-0,53	6,82	6,28	3,51	1,93	8,26	1000
17	2,59	-0.53	6,80	6,31	3,39	1,94	8,31	2000
18	2,72	-0,54	6,87	6,46	2,72	1,98	8,49	3000
19	2,88	-0,53	6,91	6,31	2,71	1,93	8,30	4000
20	2,89	-0,55	6,92	6,63	3,15	2,03	8,72	3000
Mean	**2,70**	**-0.52**	**6,85**	**6,23**	**2,87**	**1,91**	**8,20**	**3850**
± s.d.	**0,20**	**0,11**	**0,043**	**0,17**	**0,49**	**0,05**	**0,22**	**2852**

Table 2. Analytical data of donkey milk samples from farm B

Samples	EC(μS)	FP (°C)	pH	LTS (%)	GRS (%)	TN (%)	DM (%)	SCC (C/ml)
1	2,47	-0,50	6,82	6,02	1,58	1,84	7,92	4000
2	2,59	-0,53	6,92	6,31	1,56	1,93	8,30	3000
3	2,58	-0,52	6,91	6,20	1,92	1,90	8,16	2000
4	3,14	-0,61	7,,06	7,35	1,58	2,26	9,67	17000
5	2,38	-0,50	--	6,05	1,06	1,85	7,95	4000
6	2,73	-0,51	6,85	6,06	1,59	1,86	7,97	1000
7	2,60	-0,51	6,86	6,09	2,50	1,87	8,02	2000
8	3,05	-0,51	6,84	6,09	1,49	1,86	8,02	2000
9	2,39	-0,50	6,85	5,90	1,43	1,81	7,77	1000
10	2,70	-0,53	6,88	6,31	1,40	1,93	8,30	1000
Mean	**2,66**	**-0,52**	**6,88**	**6,24**	**1,61**	**1,91**	**8,25**	**3700**
± s.d.	**0,25**	**0,03**	**2,28**	**0,41**	**0,37**	**0,12**	**0,54**	**4808**

Table 3. Spearman's *rho* correlation coefficient between milk data from farm A

	EC	FP	pH	LTS	GRS	TN	DM	SCC
EC	1	0.083	-.0319	-0.111	0.299	-0.124	-0.113	0.233
FP		1	-0.633**	-0.984**	-0.038	-0.987**	-0.986**	0.298
pH		-0.633**	1	0.670**	-0.365	0.657**	0.657**	0.481
LTS		-0.984**	0.670**	1	-0.039	0.998**	0.999**	-0.311
GRS					1	-0.014	-0.025	0.186
TN		-0.987	0.657**	0.998**		1	0.998**	-0.325
DM		-0.986**	0.657**	0.999**			1	-0.313
SCC								1

*Correlation is significant at the 0.05 level (2 –tailed)
**Correlation is significant at the 0.01 level (2 –tailed)

have an influence on conductance values. Lactose relationship with pH, TN and DM was stackable with the same results obtained from farm A; the same was observed for the negative correlation between FR and pH, lactose, fat, TN and DM

Table.4. Spearman's *rho* correlation coefficient between milk data from farm B

	EC	FP	pH	LTS	GRS	TN	DM	SCC
EC	1	-0.622	0.268	0.646	0.479	0.622	0.646**	-0.56
FP		1	-0.903**	-0.985**	-0.470	-0.994**	-0.985**	-0.219
pH		-0.903**	1	0.852**	0.368	0.890**	0.852**	0.277
LTS	0.646*	-0.985**	0.852**	1	0.372	0.991**	1.000*	0.207
GRS					1	0.421	0.372	0.262
TN		-0-994**		0.890**	0.991**	1	0.991**	0.188
DM		-0.985		0.852**		0.991**	1	0.207
SCC								1

*Correlation is significant at the 0.05 level (2 –tailed)
**Correlation is significant at the 0.01 level (2 –tailed)

Conclusions

The present study allowed to reveal some differences between samples from farms A and B. The reason for these differences is easily understandable, considering that various factors can have an influence also on donkey milk composition, as for example farm management, lactation stage, animals age, etc. As regard the usefulness of EC for and indirect evaluation of milk physical and chemical quality, it would be conceivable that this parameter cannot be considered totally reliable, as the statistical analysis demonstrated. Despite this, in farm B the electric conductivity related to lactose content, that in donkey milk is highly represented; this was in agreement with some references that showed the influence of lactose on the conductance values of bovine milk. Prentice (1962) argued that the conductivity can modify in inversely proportion to the lactose concentration, as a consequence of an inverse relation between the disaccharide and the chlorine contents.

Furthermore the trend of EC and lactose for donkey milk was in agreement with the results of Rodica and Benscik (2001); in the opinion of these authors, the EC increases also with milk acidification, after a lactic acid production. The trend of EC values in donkey milk samples, and their relation with physical and chemical parameters, were in contrast with the opinion of Redaelli (1984) about the usefulness of this parameter to verify the quality of cow milk. The correlations between FP and the other parameters of donkey milk samples showed that the FP measurement in this milk is more adequate than EC when an indirect evaluation of quality of donkey milk is necessary. This is in agreement with the opinion of Hanuš *et al*. (2009) that considered the freezing point as an important quality indicator. It is necessary to study deeply the topic with the aim to give a contribution to daily practice.

References

Carroccio, A., Cavataio, F., Montalto, G., D'Amico, D., Alabrese, L. and Iacono G. 2000. Intolerance to hydrolised cow's milk protein in infants: clinical characteristics and dietary treatment. Clinical and Experimental Allergy (30): 1597-1603,

Casali, D., Contarini, G., Francani, R., Toppino, P.M. and Carini, S. 1988. Indagine sul punto crioscopico del latte prodotto in Lombardia nell'anno 1986. Il Latte (13):584 - 592

Conte, F., Mazzullo, G., Lo Verde, V., Monsù, G., Scatassa, M.L. and Macrì D. 2003. Mastite nell'asina: descrizione di tre casi in Sicilia. Valutazioni qualitative sul latte, reperti citologici e considerazioni igienico-sanitarie. Large Animals Review 9 (5): 63 - 68

Conte, F. 2005. Osservazioni sul punto crioscopico del latte d'asina. Il latte (12): 42 - 45

Conte, F., Finocchiaro, A. and Monsù, G. 2008. Osservazioni sulla conducibilita' elettrica del latte d'asina. Archivio Veterinario Italiano (59): 59-74

Dillier-Zulauf, A. 1985. Crioscopia del latte – Situazione delle conoscenze. Scienza e Tecnica Lattiero Casearia, (36) (Supplemento): 473 - 507

Hanuš, O., Genčurová, V. , Kučera, J. , Vyletělová, M. and Třináctý, J. 2009. Analyse of relationships between freezing pint and selected indicators of udder health state among cow, goat and sheep milk. Acta Universitatis Agriculturae et Silviculturae Mendeleianae Brunensis 57(5) :103-110

Lawton, B.A. and Pethig, R. 1993. AC conductivity determination of the relative composition of sodium hydroxide solutions containing either carbonate or aluminate as the dominant impurity. Measurement Science and Technology (4): 226-229.

Pautzke, M. and Schulz,J. 1997. Hygiene and diagnostic aspects of bacterial count in quarter milk samples from cows. Praktische Tierarzt .(78) 7, 1 : 587-594

Pesta, M., Williams, P., Zampa, N., Garry, E. and Ouattara, G. 2007. The effects of raw milk storage conditions on freezing point, pH, and Impedance. IFT (7) : 1-8. Advanced Instruments Inc.

Prentice, J.H. 1962. The conductivity of milk – the effect of the volume and degree of dispersion of the fat. Journal of Dairy Research (39):131-139,

Redaelli, G., Riboldi, F., Zecconi, A. and Brunner, F. 1984. Osservazioni pratiche e sperimentali sull'applicazione dei valori di conducibilità elettrica del latte al monitoraggio dello stato sanitario e funzionale della mammella. Archivio Veterinario Italiano (2): 41-52

Rodica Caprita, A. and Benscik Caprita, I. 2001. The electric conductivity as a parameter for milk quality appreciation Annals of West Univ. Timisoara, series Chemistry, 10(2): 375-378, - Acta Veterinaria Scandinava Supplement 98 – 2003

Sheldrake, R.F., Hoare, R.J.T. and Mc Gregor, G.D. 1983. Lactation stage, parity, and infection affecting somatic cells, electrical conductivity, and serum albumin in milk. Journal of Dairy Science (66): 542-547

Shipe, W.F. 1959. The freezing point of milk. A review. Journal of Dairy Science (42): 1745 – 1762

Slaghuis, B.A. 2001. The feezing point of authentic and original farm bulk tank milk in the Netherlands. International Dairy Journal (11) : 121 – 126

Sotgiu, M.R., Piroddi, A.M., Cerrone, A. and Puddu, G.F. 1996. Indagine sull'indice crioscopico del latte prodotto nello stabilimento di arborea. Il Latte (21) 5: 86 - 90