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INFLUENCE OF THERMAL PROCESSES ON DONKEY MILK COMPOSITION

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Abstract

Currently, the extinction of donkeys (Equus asinus) worldwide is very limited, but donkey milk is recently getting popular in many countries due to its nutritional properties and chemical composition. For this reason, in our country, the farmers are encouraged to keep, to raise and increase the number of donkeys in their farms. Milk and donkey products are niche products, consumed by a small number of people, especially people suffering from various diseases (e.g. food allergies, children to whom breast milk should be substituted with milk similar in composition). Donkey milk brings benefits to consumers due to its chemical composition. Donkey milk storage depend on the chemical composition, antioxidant capacity and the biochemical degradation under heat treatment.

***Key words**: donkey milk, fat, protein, lactose, antioxidant capacity*

INTRODUCTION

Donkey milk has a high antioxidant capacity, delays the aging process and is rich in various compounds that stimulate the body's immunity (Ma et al., 2008). Milk is an important nutritious food with many essential components (vitamins, minerals, acids, amino acids, minerals, lysozyme) and compounds such as antioxidants. Antioxidants are a particular importance due to their positive effect by neutralizing and eliminating free radicals (Saxelin et al., 2003; Yazdanparast et al., 2007). At present, people pay a lot of attention to natural products that have antioxidant capacity. Antioxidants have ability to neutralize and eliminate free radicals, and bring benefits to the human body (Khan, 2019).The antioxidant capacity of donkey milk is higher than cow milk. For children, people with allergic problems, and cardiovascular diseases and diabetes the administration of donkey milk and powdered milk are better than cow's milk due to their nutritional properties and chemical composition (Ling et al., 2018). Donkey milk can substitute the breast milk, when this is not enough due to its chemical composition and the antioxidant capacity that reduces oxidative stress (Beghelli et al., 2016).The antioxidant capacity is also shown in the study reported by (Anuradha et al., 2019) on Halari and French Poitu donkeys. The chemical composition and antioxidant capacity of milk are influenced by processes applied to milk (e.g. processing, pasteurizing, boiling, packing, storage conditions) (Zygoura et al., 2004). Antioxidant capacity is a very important parameter and it should be analyzed in milk and dairy products. There are studies that highlight the presence of oxidants and the mechanism of defence of antioxidants (Halliwell, 1996). Pozzo et al. (2019) evaluated the activity of human milk, cow's milk, donkey milk, raw and after pasteurization. He observed a significant variations depending on species and the treatment applied. Human milk minimized the intake of food oxidative compounds compared to other infant formulas. Cloetens, 2013 used different methods to measure the total antioxidant capacity (TAC), similar compounds in human and animal milk, and the effect of antioxidants in vitro and in vivo studies.

The main components of donkey's milk play a very important role in improving the defence system for new-borns and young children, who cannot be fed with breast milk or have an allergy to milk from other animal species (e.g. cows). The importance of donkey milk due to due to its content in antimicrobial components was reported in various studies. In the last decade, the interest for donkey milk consumption has grown as a source of human food. The large amounts of antimicrobial components and defense factors present in milk provide protection against microbial infections. These characteristics make it different from other types of milk (Carminati et al., 2014; Sies et al., 2007). Clinical studies showed that donkey milk can be used in in treating allergies to cow's milk proteins or in food intolerance. In addition, it has benefits in terms of energy balance, lipid metabolism and disease prevention, which is considered a functional food (Martini et al., 2014). The purpose of this study was to evaluate the influence of thermal processes on the composition (fat, protein, lactose, pH, antioxidant capacity) of donkey milk. The milk was obtained of donkeys in the Transylvania area.

MATERIALS AND METHODS

Sterile containers were used for sample collection.
The samples were collected from donkeys maintained in traditional system. Farms were situated in Cluj and Salaj area. Milk production per animal/day was 900 ml -1.5 litters. Milk samples were collected from donkeys in lactations 1 and 2 and were manually milled. Physico-chemical analysis (fat, protein, lactose and pH) was performed by using Lactoscan. The antioxidant capacity of donkey milk was analysed by using the ACL (antioxidant capacity of lipid soluble compounds) method. Photochem was used to determine antioxidant capacity.

RESULTS AND DISCUSSIONS

Donkey milk due to its antioxidant capacity, has the ability to prevent lipid peroxidation and has a positive effects on people will consume this milk. Donkey milk is considered a nutritional and functional food due to its property and the general chemical composition (Beghelli, 2016). In our study, the correlation between fat content and TAC was observed in the analysed raw milk. In addition the whole milk and whey had a significant influence on TAC, caseins and albumin. Similar results with our study were obtained by Zulueta (2009), who observed a significant differences for TAC, whey and deproteinized samples when compared pasteurized milk and milk treated with UHT. In addition, Ling et al. (2018) informed in his study that the total antioxidant capacity of donkey milk ranged between 13.933±1.387 and 16.578±0.291 U/m, which are in the same range with values obtained in the present study.
Antioxidant activity increased significantly when increased the fat content in the milk. This result may be influenced by lipid involvement and antioxidant reactivity (Alaa et al., 2020). The antioxidant activity in cheese increased during the ripening period, and this was correlated with the degree of proteolysis (Gupta et al., 2009).Similar findings with our study was obtained by Khan (2019), who evaluated the antioxidant and nutritional capacity of milk and dairy products; determines the total antioxidant capacity of pasteurized milk and (UHT). TAC in donkey milk was not affected by lactation did, but this content may vary depending on the quality of the feed in the diet (Beghelli et al., 2016). Lipko-Przybylska et al. (2012) evaluated antioxidant activity in colostrum and mil, and reported dynamic changes regarding antioxidant capacity in the postnatal period. Protein in raw donkey milk was 1.97%, decreased to 1.92% in boiled milk and 1.90% in frozen milk. The lowest value of protein was registered in lyophilized milk (figure 1.a).
Fat showed the lowest values in boiled milk 2.75%, and in lyophilized milk 2.85% (figure 1.a). Lactose had the lowest values in lyophilized milk 6.85% and in boiled milk 6.90% (figure 1.b). Protein is a very important parameter in the composition of donkey's milk.
Protein is a very important parameter in the composition of donkey's milk, and an important factors in the diet and development of organisms (El-Hatmi et al., 2015). Ibrahim, 2015, realized study about the chemical composition of camel milk (fresh, dried and frozen). The content of total protein, casein, lactose and ash from skimmed and freeze-dried milk was higher

compared to camel milk completely freeze dried. The results indicated that the moisture content of completely dried and frozen camel milk was lower due to the freeze-drying process (Ibrahim, 2015). Similar results about the physico-chemical parameters were reported by Kumar and Mishra, 2004.

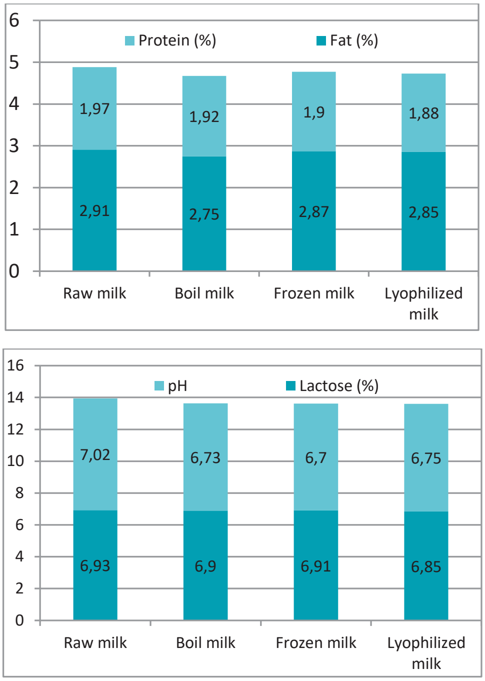

Figure 1. a., b. Physico-chemical composition of donkey milk (raw, boiled, frozen and lyophilized)

Figure 2 shows the results of TAC (U/ml) of donkey milk according to the applied process (boiling, freezing and lyophilization).

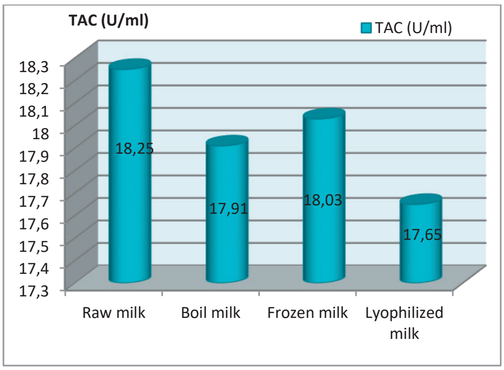

Figure 2. TAC (U/ml) of raw, boiled, frozen and lyophilized donkey milk

TAC - total antioxidant capacity;

The TAC values obtained in our study were higher than the values reported by Ling et al. (2018) on donkey milk. Khan (2017) reported the following values for TAC (%): for cow's milk and buffalo milk in raw milk 42.1%, pasteurized 41.3%, and boiled 40.7%. TAC (%) in buffalo milk presented the following values: in raw buffalo milk: 58.4%, pasteurized: 57.6%, and boiled 66.5%. We observe for TAC, significant changes also in milk that comes from other species.

Mann et al. (2016) studied the antioxidant capacity at different stages of lactation in cattle and buffaloes. TAC in milk was higher during early lactation compared to other lactation periods. The data suggested that they are removed from lactation to make time for dairy cows and buffaloes to have a higher content of antioxidants compared to other stages of lactation. Polidori and Vincenzetti (2013) investigated the protein profile of donkey milk, considered safe for the prevention and treatment of various human diseases. The influence of heat treatment on the protein fractions of donkey milk was also evaluated. Lyophilization is a method that can maintain the nutritional characteristics of milk (Polidori and Vincenzetti, 2013).

Silvestre et al. (2008) reported changes in the total antioxidant capacity of milk, when it was pasteurized at different temperature and different intervals of time. The antioxidant activity of cheese increased during the maturation period, and the antioxidant activities were correlated with the proteolysis degree (Gupta et al., 2009). Total antioxidant capacity also gives information about the antioxidant state of biochemical compounds, which has the ability to fight the free radicals produced. Antioxidant capacity is used as a new marker to evaluate oxidative stress (Sies et al., 2007). Vora et al. (2017) in his study recommended the use of natural antioxidants in order to extend the shelf life of products. For the human body, the natural antioxidants cause fewer side effects compared to synthetic. In the case of dairy products, such as ginseng yogurt, antioxidant capacity decreased during storage. These aspects were related in realized by Jung et al. (2016). Consumers prefer natural antioxidants obtained from various food sources instead of synthetic antioxidants, which can have toxic effects on the human body (Zambonin et al., 2012; Abdel-Hamed et al., 2014). People increase the interest on the milk and dairy products obtained from donkey, buffalo, cow and goat due to their potential for antioxidant capacity, the diversity of milk caseins and whey proteins (Pihlanto, 2006; Suetsuna et al., 2000). TAC has also been studied for cow's milk, camel, cow's and camel's yogurt (Niero et al., 2016; Santos et al., 2012; Shori, 2013; Shori and Baba, 2011).

Table 1 shows the average values for TAC in milk and colostrum of donkey obtained in the present study compared to other species.

Table 1. TAC for colostrum and donkey milk compared to other species

Sample	TAC[1]	References
Donkey milk (Italy)	31.2 (mmol/L)	Simos et al., 2011
Donkey colostrum (μ mol neut. HClO/ml)	L.P.1st (221.7) – L.P. 5th (210.9)	Beghelli et al., 2016
Human milk	816.3 (μmol/L)	Živković et al., 2015
Human colostrum	1061.6 (μmol/L)	Živković et al., 2015
Cow milk (pasteurized)	1246 (μmol/L)	Chen et al., 2003
Cow colostrum	3.92 (μmol/g)	Albera et al., 2011
Murrah buffalo milk	360.49	Mann et al., 2016
Murrah buffalo colostrum	393.42	Mann et al., 2016
Ewe milk	6.69 (μmol/g)	Lipko-Przybylska et al., 2010
Ewe colostrum	4.78 (μmol/g)	Lipko-Przybylska et al., 2010
Goat milk	35.8 (mmol/L)	Simos et al., 2011

TAC[1] - total antioxidant capacity; L.P. - lactation period

CONCLUSIONS

Antioxidant capacity is a very important parameter, because it gives us information about the benefits of donkey milk depending on the amount of TCA in milk. TAC in donkey milk was influenced by the boiling and lyophilization process. Donkey's milk can be used to obtain innovative and value-added products due to its nutritional and functional properties. This information can bring important financial benefits to both producers and consumers.

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REFERENCES

Abdel-Hameed, E.S., Nagaty, M.A., Salman, M.S., Bazaid, S.A. (2014). Phytochemicals, nutritionals and antioxidant properties of two prickly pear cactus cultivars (Opuntia ficus indica Mill.) growing in Taif, KSA. *Food Chem,* 160, 31-38.

Alaa, A.El-F., Mohamed, A., Hany, E., Ahmed E. (2020). Antioxidant Properties of Milk: Effect of Milk Species. Milk Fractions and Heat Treatments. *International Journal of Dairy Science, 15,1-9.*

Albera, E., Kankofer, M. (2011). The comparison of antioxidative/oxidative profile in blood, colostrum and milk of early post-partum cows and their newborns. *Reprod. Dom. Anim.*, 46, 763-769.

Alemayehu, L.A., Temam, A.H., Huligerepura, S.A. (2017). Antioxidant, Chemo-Protective role of buffalo colostrum and milk whey derived peptide against 2, 4-dinitrophenol induced-oxidative damage on human plasma, in vitro. *International Journal of Scientific & Technology Research*, 6, 73-83.

Anuradha, B., Parbha, K., Varij, N., Tanvi, S., Legha, R.A., Umesh, G., Yash, P., Hema, T., Tripathi, B.N. (2019). Estimation of Antioxidant Potential of Indigenous Halari and French Poitu Donkey Milk by using the Total Antioxidant Capacity and Ferric Reducing Antioxidant Power Essay. *Asian Journal Of Dairy and Food Research*, 38, 307-310.

Aparna, G., Bimlesh, M., Rajesh, K., Ram, B.S. (2009). Antioxidant activity of Cheddar cheeses at different stages of ripening. *Food Science & Technology,* 62 (3), 339-347.

Beghelli, D., Lupidi, G., Damiano, S., Cavallucci, C., Bistoni, O., De Cosmo, A., Polidori, P. (2016). Rapid Assay to Evaluate the Total Antioxidant Capacity in Donkey Milk and in more Common Animal Milk for Human Consumption. *Austin Food Sci*, 1(1), 1-4.

Carminati, D., Tidona, F., Fornasari, M.E., Rossetti, L., Meucci, A., Giraffa, G. (2014). Biotyping of cultivable lactic acid bacteria isolated from donkey milk. *Letters in Applied Microbiology, Lodi,* 299-305.

Chen, J., Lindmark-Månsson, H., Gorton, L., Åkesson, B. (2003). Antioxidant capacity of bovine milk as assayed by spectrophotometric and amperometric methods. *Int. Dairy J.,* 13, 927-935.

Cloetens, L., Panee, J., Åkesson, B. (2013). The antioxidant capacity of milk - the application of different methods in vitro in vivo. *Cellular & Molecular Biology,* 59 (1), 43-57.

El-Hatmi, H., Jrad, Z., Salhi, I., Aguibi, A., Nadri, A., Khorchani, T. (2015). Comparison of composition and whey protein fractions of human, camel, donkey, goat and cow milk. *Mljekarstvo, Gabes,* 159-167.

Gupta, S., Prakash, J. (2009). Studies on Indian green leafy vegetables for their antioxidant activity. *Plant Foods Hum Nutr.,* 64(1), 39-45.

Halliwell, B. (1996). Antioxidants in human health and diseases. Annu Rev Nutr., 1-2, 33-50.

Ibrahim, A.H., Khalifa, S.A. (2015). Effect of freeze-drying on camel's milk nutritional properties, 2015. *International Food Research Journal,* 22(4), 1438-1445.

Jung, J., Paik, H.D., Yoon, H.J., Jang, H.J., Jeewanthi, R.K.C., Li, X., Lee, N.K., Lee, S.K. (2016). Physicochemical Characteristics and Antioxidant Capacity in Yogurt Fortified with Red Ginseng Extract. *J Food Sci An.,* 3, 412-20.

Khan, I.T., Nadeem, M., Imran M., Ayaz, M., Ajmal, M., Ellahi, M.Y., Khalique, A. (2017). Antioxidant capacity and fatty acids characterization of heat treated cow and buffalo milk. Lipids in Health and Disease, 16, 163.

Khan, I.T., Nadeem, M., Imran, M. (2019). Antioxidant properties of Milk and dairy products: a comprehensive review of the current knowledge. *Lipids Health Dis*., 18, 41.

Kumar, P. Mishra, H.N. (2004). Yoghurt powder-a review of process technology storage and utilization. *Food and Bioproducts Processing,* 82 (C2), 133-142.

Ling, L., Xinfeng, L., Hong, G. (2018). The nutritional ingredients and antioxidant activity of donkey milk and donkey milk powder. *Food Sci Biotechnol.*, 27(2), 393-400.

Lipko-Przybylska, J., Kankofer, M. (2012). Antioxidant defence of colostrum and milk in consecutive lactations in sows. *Ir Vet J.,* 65(1), 4.

Lipko-Przybylska, J., Albera, E., Kankofer, M. (2010). Comparison of antioxidant defence parameters in colostrum and milk between Berrichon du Cher ewes and Uhrusk ewes. *J. Dairy Res.*, 77, 117-122.

Ma, L., Su, D.Q., Ji, C.F., Ding, Y.S., Zhang, L., Yu, D. (2008). Study on health protection efficacy of fresh donkey's milk. *Food Science*, 29(5), 423-426.

Mann, S., Shandilya, U.K., Sodhi, M., Kumar, P., Bharti, V.K., Verma, P., Sharma, A., Mohanty, A., Mukesh, M. (2016). Determination of Antioxidant Capacity and Free Radical Scavenging Activity of Milk from Native Cows (Bos Indicus), Exotic Cows (Bos Taurus), and Riverine Buffaloes (Bubalus Bubalis) Across Different Lactation Stages. *Int J Dairy Sci Process*., 3(4), 66-70.

Martini, M., Altomonte, I., Salari, F., Caroli, A.M. (2014). Short communication: monitoring nutritional quality of Amiata donkey milk: effects of lactation and productive season. *Journal of Dairy Science*, 97(11), 6819-6822.

Niero, G.M., Penasa, S., Currò, A., Masi, A.R., Trentin, M., Cassandro, M. (2016). Development and validation of a near infrared spectrophotometric method to determine total antioxidant activity of milk. *Food Chemistry*, 220**,** 371-37**.**

Pihlanto, A. (2006). Antioxidative peptides derived from milk proteins. *Int. Dairy J.,* 16, 1306-1314.

Polidori, P., Vincenzetti, S. (2013). Effects of thermal treatments on donkey milk nutritional characteristics. *Recent Pat Food Nutr Agric.,* 5(3), 182-7.

Pozzo, L., Cirrincione, S., Russo R., Karama, M., Amarowicz R., Coscia, A., Antoniazzi, S., Cavallarin, L., Giribaldi, M. (2019). Comparison of Oxidative Status of Human Milk, Human Milk Fortifiers and Preterm Infant Formulas. *Foods*, 8, 458.

Santos, R.M.F., Clement, D., Lemos, L.S.L., Legravre, T., Lanaud, C., Schnell, R.J., Pires, J.L., Lopesuv, Micheli F., Gramacho, K.P. (2012). Identification, characterization and mapping of EST-derived SSRs from the cacao *Ceratocystis cacaofunesta* interaction. *Tree Genet Genomes.*

Saxelin, M., Korpela, R., Mayra-Makinen, A. (2003). Introduction: classifying functional dairy products. Functional dairy foods. Boca Raton, FL, USA.: CRC Press, 1-16.

Shori, A. (2013). Antioxidant activity and viability of lactic acid bacteria in soybean-yogurt made from cow and camel milk. *Journal of Taibah University for Science*, 7, (4) 202-20.

Shori, A.B., Baba, A.S. (2011). Antioxidant activity and inhibition of key enzymes linked to type-2 diabetes and hypertension by *Azadirachta indica*-yogurt. *J. Saudi Chem. Soc.*

Sies, H. (2007). Total antioxidant capacity: appraisal of a concept. *J of Nutr.*, 137, 1493-5.

Silvestre, D., Miranda, M., Muriach, M., Almansa, I., Jareño, E., Romero, F.J. (2008). Antioxidant capacity of human milk: effect of thermal conditions for the pasteurization. *Acta Paediatr*., 97, 1070-1074.

Simos, Y., Metsios, A., Verginadis, I., D'Allesandro, A.-G., Loiudice, P., Jirillo, E., Charalampidis, P., Kouimanis, V., Boulaka, A., Martemucci, G., Karkabounas, S. (2011). Antioxidant and anti-platelet properties of milk from goat, donkey and cow: An in vitro, ex vivo and in vivo study. *Int. Dairy J.*, 21, 901-906.

Simos, Y., Metsios, A., Verginadis, I., D'Allesandro, A.G., Loiudice, P., Jirillo, E., Charalampidis, P., Kouimanis, V., Boulaka, A., Martemucci, G., Karkabounas, S. (2011). Antioxidant and anti-platelet properties of milk from goat, donkey and cow: An in vitro, ex vivo and in vivo study. *Int. Dairy J.,* 21, 901-906.

Suetsuna, K., Ukeda, H., Ochi, H. (2000). Isolation and characterization of free radical scavenging activities peptides derived from casein. *J. Nutr. Biochem.*, 11, 128-131.

Vora, J., Srivastava, A., Modi, H. (2017). Antibacterial and antioxidant strategies for acne treatment through plant extracts. *Medicine unlocked*.

Yazdanparast, R., Ardestani, A. (2007). *In vitro* antioxidant and free radical scavenging activity of *Cyperus rotundus*. *J Med Food.,* 10, 667-74.

Zambonin, L., Caliceti, C., Vieceli Dalla Sega, F., Fiorentini, D., Hrelia, S., Landi, L., Prata, C. (2012). Dietary phenolic acids act as effective antioxidants in membrane models and in cultured cells, exhibiting proapoptotic effects in leukaemia cells. *Oxidative Med. Cell. Longevity,* 20, 839-898.

Živković, J., Sunarić, S., Trutić, N., Marko, D., Kocić, G., Jovanović, T. (2015). Antioxidants and Antioxidant Capacity of Human Milk. *Acta Facultatis Medicae Naissensis*, 32 (2), 115-125.

Zulueta, A., Maurizi, A., Frígola, A., Esteve, M.J., Coli, R., Burini, G. (2009). Antioxidant capacity of cow milk, whey and deproteinized milk. *International Dairy Journal*, 19, 6-7, 380-385.

Zygoura, P., Moyssiadi, T., Badeka, A., Kondyli, A., Savvaidis, I., Kontominas, MG. (2004). Shelf life of whole pasteurized milk in Greece: effect of packaging material. *Food Chem.,* 87, 1-9.