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TESTING THE INFLUENCE OF THE ENVIRONMENTAL CLIMATIC FACTORS UPON DONKEY MILK QUALITY

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Abstract

Our trial was conducted with the aim of emphasizing the influence of environmental factors acting as potential stressors upon donkey milk nutritional traits, within specific climatic conditions of North-West Romania. Milk from fifty jennies from four private farms, in different stages of lactation, from first up to the fifth, weekly collected during a three months period, February-April 2016, was qualitatively and quantitatively evaluated. In experimental areal, temperature, humidity, and wind velocity, were daily recorded. The average temperature of the experimental period (4.95°C±0.19°C) is with 0.8°C bigger compared to the average temperature of the experimental areal in 2010, suggesting the increase of the heat stress upon donkey milk production traits. Donkey milk content in lactose and fat, together with milk pH, increase from first to fifth lactation, while water and protein content decrease. We may consider the lack of correlations between donkey milk pH and fat content, and also between fat and lactose. Positive significant moderate correlations are identified between donkey milk lactose and protein, and also between lactose, protein, and donkey milk pH. Between fat and donkey milk water content, negative significant moderate correlation is identified. Temperature, humidity, and wind velocity have strong influence upon donkey milk fat, protein and water content, and moderate on donkey milk pH, and lactose. This study emphasizes the necessity of adopting suitable managerial practices in donkey rearing facilities, where the farmer is interested in valuating donkey milk. This assertion is based on the increasing of the temperature in the experimental areal, compared to the same period of the previous years, taking into account the negative influence of the heat stress on donkey milk quality.

Keywords: *protein, lactose, fat, water, pH, correlation, heat stress.*

1. INTRODUCTION

The donkey (*Equus africanus asinus* L.) is a member of the *Equidae* family. According to literature (Bökönyi 1991; Clutton-Brock, 1992; Eisenmann, 1995; Groves, 1986; Haltenorth and Diller, 1980; Kingdon, 1997), this specie originates from Africa, and it was domesticated in time, as result of a complex process (Bench, 2004).

From ancient times up to our days, traders and pastoralists use donkeys for transport, and/or pack animals, while sometimes farmers use donkeys for field and domestic works. Besides the small expenses needed of their maintaining, when we talk about their acquisition, we also speak of low cost (Marshall and Weissbrod, 2011).

The above mentioned low costs are the consequences of their perception as a single-use specie, compared to cattle, buffaloes, etc., which are used as multipurpose livestock, usually reared for meat, milk, but also for work and transport (Fernando and Starkey, 2004; Singh et al., 2005). Even they are not part of livestock species valuable due to their meat output, the jenny milk production become more and more interesting, in last decennials.

The donkey milk may be used instead of human milk, having better properties compared to cow milk (Fantuz et al., 2012; Salimei and Fantuz, 2012).

In Europe, the use of jenny milk as human milk replacer become a tradition, mostly because of its composition and physico-chemical traits (Aspri et al., 2016; Ragona et al., 2016; Trinchesea et al., 2015). The jenny milk composition is similar to human milk in terms of lactose, protein and fatty acids profiles, minerals (Bidasolo et al., 2012; Piovesana et al., 2015), and also other components, as shown in Table 1 (Guo et al., 2007).

Table 1. Composition of donkey milk compared to human milk (Guo et al., 2007)

Issue	Donkey milk	Human milk
pH	7.0-7.2	7.0-7.5
Protein (%)	1.5-1.8	0.9-1.7
Fat (%)	0.3-1.8	3.5-4.0
Lactose (%)	5.8-7.4	6.3-7.0
Ash (%)	0.3-0.5	0.2-0.3
Total solids (%)	8.08-11.7	11.7-12.9
Caseins (%)	0.64-1.03	0.32-0.42
Whey proteins (%)	0.49-0.80	0.68-0.83

Besides the properties already emphasized, the jenny milk has good palatability, valuable nutritional properties, reduced allergenicity, and clinical tolerability (Trinchesea et al., 2015). When adverse (Polidori and Vincenzetti, 2013).

Literature also mentions the utility of using donkey milk when allergy to cow milk, considered as one of the ”Big 8” allergens from food (Host, 2002), is recorded, because its proteins seem to be safer for infants' consumption (D'Alessandro and Martemucci, 2012; Polidori and Vincenzetti, 2013). Another use of jenny milk is in cosmetics (Consentino et al., 2014)

Even donkey maintaining seems to be easy, because they have no special maintaining and welfare requirements (Consentino et al., 2010; Consentino et al., 2012; Zakari et al., 2015), the environmental issues may affect their behavior and wellbeing (Lagat and Nyangena, 2016).

According to Smith and Pearson (2005), Dey et al. (2010), Zakari et al. (2015), Kumar et al. (2011), and Pandey et al. (2012) temperature is one of the most important environmental stressor upon livestock animals, generally speaking, and on donkey behavior and productions, particularly.

Thus, heat stress, together with solar radiation, both direct and indirect, accompanied by high humidity proofed to be environmental stressors, which have high potential of affecting donkey welfare and productions. The amount of this influence depends on both intensity of climatic inputs, and intrinsic thermoregulation mechanisms specific for each donkey breed.

In Romania, few studies were conducted upon the donkey milk composition and quality (Marchis et al., 2015a; Marchis et al., 2015b), and also upon the influence of climatic on donkey maintaining, and their dairy production (Coroian et al., 2016).

In order to contribute to the knowledge concerning the composition of the donkey milk, obtained from individuals traditionally reared in Romania, in specific climatic conditions, besides laboratory quantifications of milk traits (fat, protein, lactose, water pH), our study also shows the results of testing the intensity of the interaction between donkey milk composition, and environmental stress factors represented by temperature, humidity, and wind velocity, respectively.

2. MATERIAL AND METHODS

2.1. The experimental areal

The trial was carried out in four donkey private farms, located nearby one to each other, in North-West Romania, in the vicinity of the town of Huedin (46˚52'00''N, and 23˚02'00''E), County of Cluj, during February – April 2016.

2.2. The environmental monitoring

The experimental area is characterized by a temperate continental clime, with historic annual average temperature of 7˚C – 8˚C, which recorded an alarming increase of almost 1 ˚C, in last decade, from 7.9˚C, to 8.8˚C (Romanian National Administration of Meteorology. Climatic monitoring). Climatic data (temperature, humidity, and wind velocity) were daily recorded with an automatic meteorological data station, WE900 from WTW, placed in experimental area.

2.3. Sample collection

Milk samples were collected from the morning milking of 10 primiparous, and 40 multiparous jennies. The animals are maintained within the same conditions, and receiving the same feeding level and composition. The milk samples of an average volume of 300 mL were collected, weekly, in standard containers, and transported to the laboratory, maintained at 4°C.

2.4. Laboratory analysis

The physicochemical analysis was performed in the same day. Lactoscan MCC device, from Milkotronic Ltd. was used for laboratory determinations. The principle of pH, fat, protein, lactose, and water determinations is based on the direct measurement of the speed of the ultrasound in milk.

2.5. Statistical analysis

Data were statistically processed with IBM SPSS Statistics v. 20. Descriptive statistics was used for characterizing the milk traits. The Pearson simple correlations and multiregression analyze was implemented in order to emphasize the intensity of the relationships between milk traits, and the interrelations between the climatic factors characterizing the environment (temperature, ˚C; humidity, %; wind velocity, m/s) and each of the analyzed traits of the donkey milk (fat, protein, lactose, water, and pH), respectively.

3. RESULTS AND DISCUSSIONS

The monitoring of the environmental parameters characterizing the experimental field, emphasizes their means, calculated by the experimental period of three months, respectively. Thus, resulted a three months mean temperature of 4.95˚C, humidity of 67.92%, and wind velocity of 7.45 m/s (Table 2). The statistical analyze emphasizes a good representativeness of the humidity and wind velocity means, confirmed by the values of the coefficients of variation, CV = 16.44%, and CV = 25.77%, respectively (Merce and Merce, 2009). Not the same thing may be observed when we analyze the mean of the temperature in experimental field, when the variability expressed by the value of CV = 37.91%, over 30% (Merce and Merce, 2009), shows that the mean has no representativeness. This may be explained by the large variation of temperature, from a minimum of -5°C, to a maximum of +7°C (Table 2), because the experimental interval covers the end of winter and first two months of spring, when weather become warmer.

Temperature, which is one of the most important environmental parameter for donkey wellbeing, and milk production, because it may produce the heat stress that induces physiological disorders (Ayo et al., 2014; Zakari et al., 2015) recorded a mean increase of 0.8°C from 4.15°C in 2010 to 4.95°C in 2016, by a three months period, February – April, respectively (Fig. 1).

These results may be considered as part of the alarming phenomenon of climatic changes, which may be also encountered in the studied area.

Our trial shows different evolutions of donkey milk traits by lactation (Table 3).

The fat content (Table 3) increases continuously from first to fifth lactation.

This result is opposite to the findings of Heinrichs et al. (2017) in USA, who state that milk fat in dairy herds decreases ”as the animal becomes older”.

The differences between the values correspondent to first, fourth and fifth lactation are statistically significant if compared to the mean by all lactations (Table 4).

Protein, lactose, water and pH have fluctuant evolutions, lactose and pH characterized by an increasing evolution, while protein and water by a decreasing tendency (Table 3, Fig. 2). The differences between these means, by lactation, and means by all lactations are not statistically significant (Table 4).

Table 2. Descriptive statistics concerning the evolution of the climatic parameters within the experimental areal, February – April, 2016

Parameter	N	Temperature (˚C)	Humidity (%)	Wind velocity (m/s)
Mean	92	4.95	67.92	7.45
Standard deviation	92	1.82	11.17	1.92
Standard error of mean	92	0.19	1.16	0.20
Minimum	92	-5.00	45.00	3.00
Maximum	92	7.00	96.00	11.00
Coefficient of variation	92	37.91	16.44	25.77

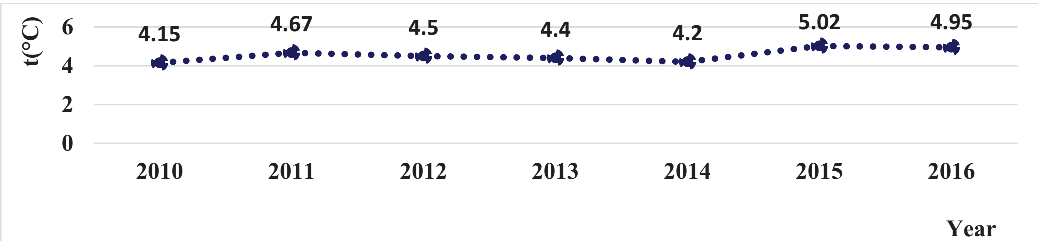


Figure 1. The evolution of the mean temperature by a three months period (February – April) in experimental area, 2010 - 2016

Table 3. Descriptive statistics concerning the evolution of donkey milk traits, function of lactation, February – April, 2016

Lactation	I	II	III	IV	V
Fat (%)					
N	10	10	10	10	10
Mean	0.86[a]	1.68[b]	1.97[b]	2.30[a]	2.46[a]
Standard deviation	0.03	0.03	0.02	0.07	0.05
Standard error of mean	0.11	0.11	0.06	0.21	0.16
Minimum	0.67	1.55	1.87	2.01	2.20
Maximum	0.94	1.83	2.03	2.55	2.60
Coefficient of variation (%)	12.72	6.29	3.21	9.32	6.36
Protein (%)					
N	10	10	10	10	10
$\bar{X}$	1.88	1.72	1.73	1.80	1.81
$s_{\bar{X}}$	0.03	0.01	0.01	0.02	0.02
s	0.10	0.04	0.04	0.06	0.07
Minimum	1.77	1.68	1.68	1.71	1.73
Maximum	1.98	1.78	1.79	1.87	1.89
CV(%)	5.42	2.41	2.42	3.23	3.60
Lactose (%)					
N	10	10	10	10	10
$\bar{X}$	6.80	6.72	6.78	6.77	6.80
$s_{\bar{X}}$	0.03	0.02	0.01	0.01	0.01
s	0.11	0.08	0.05	0.04	0.05
Minimum	6.68	6.61	6.71	6.70	6.73
Maximum	6.92	6.82	6.84	6.80	6.85
CV(%)	1.58	1.17	0.78	0.62	0.67
Water (%)					
N	10	10	10	10	10
$\bar{X}$	88.40	87.29	85.16	84.66	86.01
$s_{\bar{X}}$	0.22	0.50	0.60	0.55	0.67
s	0.71	1.60	1.90	1.75	2.11
Minimum	87.50	84.78	82.70	82.50	82.75
Maximum	89.10	89.01	87.10	87.20	88.20
CV(%)	0.80	1.84	2.23	2.07	2.45
pH					
N	10	10	10	10	10
$\bar{X}$	6.94	6.86	6.94	7.11	7.09
$s_{\bar{X}}$	0.03	0.04	0.04	0.03	0.03
s	0.11	0.15	0.15	0.09	0.09
Minimum	6.80	6.71	6.70	7.01	7.00
Maximum	7.10	7.10	7.10	7.20	7.20
CV(%)	1.64	2.25	2.19	1.22	1.23

a - $p < 0.01$; b - $p > 0.05$.

Mean fat and protein contents from donkey milk resulted from our trial (Table 4), are bigger compared to the values (0.53% fat, and 1.63% protein) obtained by Martini et al. (2013) and (0.4% fat, 1.57% protein) obtained by Ragona et al. (2016) in Amiata donkey, but lactose content of donkey milk (Table 4) is lower compared to the same trials, where a mean of 7.12% is reported by Martini et al. 92013), and 7.23% by Ragona et al. (2016). Compared to the values obtained by Conti (2013) in Sicily, for donkey milk content in lactose (6.23-6.24%), and fat (1.61%) we report bigger values (Table 4).

If the protein mean content of the donkey milk analyzed in our trial (Table 4) frames with the range of variation of 1.5-1.8% mentioned by Guo et al.

(2007), similar with human milk protein content (0.9-1.7%), but smaller compared to cow milk, of 3.1-3.8% (Polidori et al., 2016), it is bigger compared to limits mentioned by Barłowska et al. (2011), of 1.59-1.74%.

The fat content (Table 4) is slightly over the range (0.3-1.8%) mentioned by Guo et al. (2007) and (0.28-1.82%) reported by Barłowska et al. (2011), but smaller compared to the limits mentioned by Polidori et al. (2016), for human milk (3.5-4%), and cow milk (3.5-3.9%). On the contrary, pH (Table 4) is slightly under the ranges mentioned by Guo et al. (2007) for donkey milk (7-7.2%), and human milk (7-7.5%). Lactose identified in our trial in donkey milk (Table 4) frames within the ranges mentioned by both Guo et al. (2007), 5.8-7.4%, respectively, and also by Barłowska et al. (2011), of 5.87-6.88%.

Table 4. Descriptive statistics for the evolution of donkey milk traits by all lactations, February – April, 2016

Parameter	N	Fat (%)	Protein (%)	Lactose (%)	Water (%)	pH
Mean	50	1.85[a,b]	1.79	6.77	86.31	6.99
Standard deviation	50	0.12	0.02	0.01	0.42	0.03
Standard error of mean	50	0.02	0.01	0.01	0.06	0.01
Minimum	50	0.67	1.68	6.61	82.50	6.70
Maximum	50	2.60	1.98	6.92	89.10	7.20
Coefficient of variation	50	31.82	4.74	1.04	2.42	2.14

a - $p<0.01$; b - $p>0.05$.

Except lactose (Fig. 2c), all investigated donkey milk traits exhibit differences between different stages of lactation (Fig. 2). Fat increases very significantly from the I[st] up to the V[th] lactation (Fig. 2a), while protein records a fluctuation between lactations, with significand differences at significance threshold of 5% (Fig. 2b). The milk pH has a positive trend from the first to the V[th] lactation, the differences being statistically significant at significance threshold of 5% (Fig. 2d).

Donkey milk water content records a negative trend from first to V[th] lactation, the differences between III[rd] and V[th] lactations being significant and distinctly significant (Fig. 2e).

Between the donkey milk traits positive and negative simple correlations, from very weak to moderate intensity may be emphasized (Table 5). Moderate significant ($p<0.01$) correlations, positive between the protein and lactose, fat and pH, and negative between fat and water are recorded. No significant correlations are found between the other studied traits (Table 5).

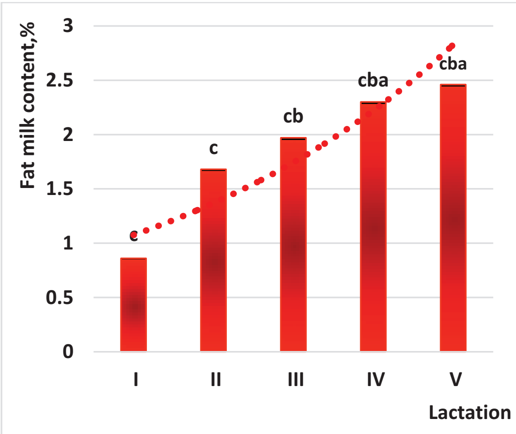
Negative weak correlation was observed between fat and protein, and positive moderate between water and protein. Positive weak and very weak correlations may be identified between lactose and fat, water, pH, and also between water and pH (Table 5).

Our data are not consistent with those obtained by Conty (2013), as result of an experiment performed in warm climate of Sicily, on milk from common donkey breed, where weak to moderate correlation ($R=0.372$) resulted between fat and lactose.

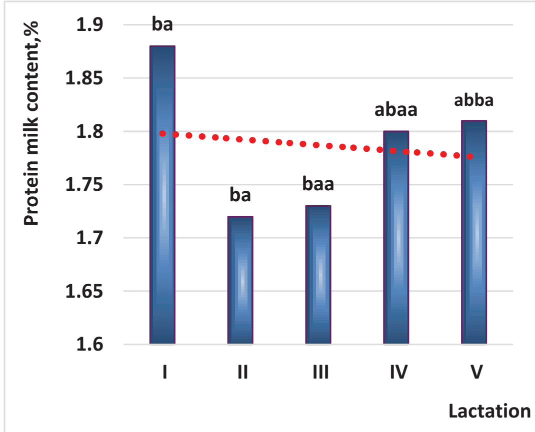
Table 5. The correlation matrix of the donkey milk traits Decriptive statistics for the the evolution of donkey milk traits by all lactations, February – April, 2016

Issue	Fat (%)	Protein (%)	Lactose (%)	Water (%)	pH
Fat (%)	-	-0.239	+0.060	-0.449[a]	+0.477[a]
Protein (%)	-	-	+0.451[a]	+0.370	+0.264
Lactose (%)	-	-	-	+0.242	+0.120
Water (%)	-	-	-	-	+0.089

a - $p<0.01$.



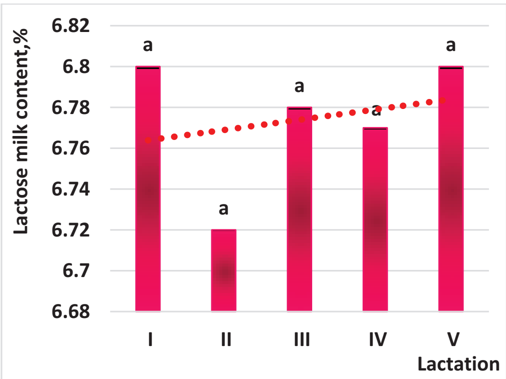
a - p>0.05; b - p<0.01; c - p <0.001;



a - p >0.05; b – p<0.05;

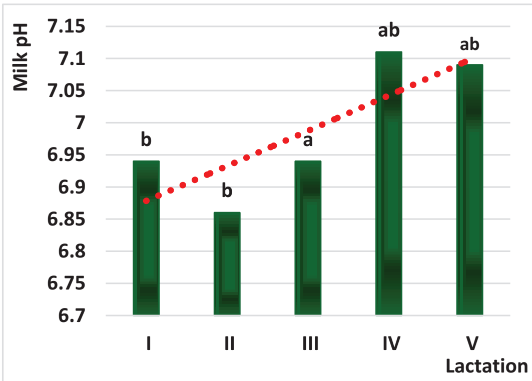
a. Fat (%)

b. Protein (%)



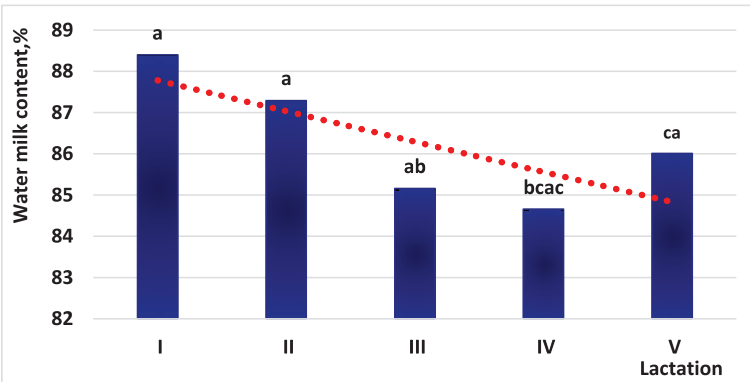
a - p>0.05;

c. Lactose (%)



a - p >0.05; b – p<0.05;

d. pH



a - p >0.05; b - p>0.01; c - p>0.05.

e. Water

Figure 2. The evolution of the donkey milk traits function of lactation

Between temperature, humidity and wind velocity and donkey milk fat, protein, and water, moderate to strong multiple correlations are reported, while between above mentioned climatic parameters, pH and lactose from donkey milk, moderate correlations may be mentioned (Table 6).

According to regression lines, temperature and humidity contribute to decrease of the donkey milk traits analyzed in the present study, while wind have a small positive contribution (Table 6). The correlation between fat and climatic factors explains 63.8% of the variability of this donkey milk trait, for protein they explain 52.70% of variability, while for water 58.50%.

The variability of donkey milk pH and lactose content is explained in a less extent by the interaction with considered climatic factors (Table 6).

Table 6. The multiple correlations (R) and determination coefficients (R^2) reported between the climatic factors characterizing the environment (temperature, humidity, wind velocity) and donkey milk traits

Traits	R (R^2)	Regression line
Fat (%)	R = 0.799 (R^2 = 0.638)	Fat (%) = 4.038-3.251t(˚C)-2.597H(%)+0.133v(m/s)
Protein (%)	R = 0.726 (R^2 = 0.527)	Protein (%) = 2.466-1.429t(˚C)-0.527H(%)+0.073v(m/s)
Lactose (%)	R = 0.590 (R^2 = 0.348)	Lactose (%) = 7.286-1.178t(˚C)-0.354H(%)+0.034v(m/s)
Water (%)	R = 0.765 (R^2 = 0.585)	Water (%) = 87.084-0.283t(˚C)-0.685H(%)+0.047v(m/s)
pH	R = 0.530 (R^2 = 0.281)	pH (%) = 9.356-1.366t(˚C)-1.988H(%)+0.156v(m/s)

Concerning environmental influence on fat and protein from donkey milk, our results are consistent to those emphasized, in cow milk, by Milani et al. (2015), and also Linn (1988).

Linn states that in summer, when heat and humidity record high values, a decrease of fat and protein from cow milk is noticed. Barash et al. (2001) also noticed the negative influence of temperature upon protein content in cow milk.

4. CONCLUSIONS

Because of hypoallergenic and nutritional traits, together with composition similar to human milk, donkey milk is a very good candidate for replacing human milk. Our study emphasizes, besides the heat, humidity, and wind velocity influence on qualitative donkey milk traits (fat, protein, lactose, water, and pH), the variation of these traits function of lactation and also, the interactions between them. Majority donkey milk traits, fat, lactose and pH, respectively, exhibit increasing tendency from first to fifth lactation, while protein and water content, a decreasing one. The evolutions of fat and lactose contents in donkey milk, and water and pH, respectively, may be considered not correlated. Noticeable significant positive moderate correlations are identified between fat and donkey milk pH, and protein and lactose, while between donkey milk water content and fat, the correlation, even significant and moderate, is negative, suggesting the divergent evolution of these parameters.Between protein, fat and water from donkey milk and climatic factors (temperature, humidity and wind velocity) strong interrelationships are reported. Donkey milk pH and lactose content is less influenced by the above mentioned climatic factors. Temperature and humidity recorded within the experimental areal have bigger influence on the donkey milk traits discussed in this study, contributing to decrease of all studied traits, while wind have a weak positive influence upon the increase of these traits. Within the climatic landscape of the experimental areal characterized by a noticeable warming, meaning about 0.8°C during a 6 year period, and taking into consideration the importance of heat stress upon donkey milk qualitative traits, this study suggest farmers interested in valuating donkey milk for consumption, the urgency of adopting appropriate managerial conditions in order to diminish the potential effects of increased heat stress upon fat, and protein milk content.

REFERENCES

D'Alessandro, A.G., Martemucci, G., 2012. *Lactation curve and effects of milking regimen on milk yield and quality, and udder health in Martina Franca jennies (Equus asinus)*. Journal of Animal Science, 90, 669-681.

Aspri, M., Economou, N., Papademas, P., 2017. *An overview on functionality, technology, and future prospects*. Food reviews international, 33(3), 316-333.

Ayo, J.O., Dzenda, T., Olaifa, F., Ake, S.A., Sani, I., 2014. *Diurnal and Seasonal Fluctuations in Rectal Temperature, Respiration and Heart Rate of Pack Donkeys in a Tropical Savannah Zone*. Journal of Equine Science, 25(1), 1-6.

Barash, H., Silanikove, N., Shamay, A., Ezra, E., 2001. *Interrelationships Among Ambient Temperature, Day Length and Milk Yield in Dairy Cows Under a Mediterranean Climate*. Journal of Dairy Science, 84, 2314-2320.

Barłowska, J., Szwajkowska, M., Litwinczuk, Z., Król, J., 2011. *Nutritional Value and Technological Suitability of Milk from Various Animal Species Used for Dairy Production*. Comprehensive Reviewsin Food Science and Food Safety, 10, 291-302.

Bench, R., 2004. *The history and spread of donkeys in Africa*. http://www.atnesa.org/donkeys/donkeys-blench-history.pdf

Bidasolo, I.B., Ramos, M., Gomez-Ruiz, J.A., 2012. *In vitro simulated gastrointestinal digestion of donkeys' milk. Peptide characterization by high performance liquid chromatography–tandem mass spectrometry*. International Dairy Journal, 24,146–152.

Bökönyi, S., 1991. *The earliest occurrence of domestic asses in Italy*. pp. 178-216. In: Meadow R.H. and Uerpmann H.P. (eds), Equids in the Ancient World Volume II. Ludwig Reichert, Wiesbaden, Germany.

Clutton-Brock, J., 1992. *Horse power: a history of the horse and the donkey in human societies*. Harvard University Press, Cambridge, Massachusetts, USA. 192p.

Conte, F., 2013. *Quality of donkey milk: correlations between electric conductivity, freezing point and composition parameters*. International Food Research Journal 20(2), 711-714.

Coroian, A., Miresan, V., Odagiu, A., Andronie, L., Raducu, C., Marchis, Z., Coroian, C.O., 2016. *Influence of Season on Physico-Chemical Composition of Donkey Milk from Primiparous and Multiparous*. ProEnvironment 9(28), 400-403.

Cosentino, C, Freschi, P., Paolino, R., 2010. *Biodiversita zootecnica nei territori montani: l'allevamento asinino, una possibile alternativa. Quaderno SoZooAlp n.6 Zootecnia e montagna: quali strategie per il futuro?* Bolzano, 6, 231–238.

Cosentino, C., Freschi, P., Paolino, R., 2012. *La multifunzionalita dell'allevamento asinino nella gestione del paesaggio rurale*. Paysage Topscape, 9, 1250–1255.

Cosentino, C., Paolino, R., Freschi, P., Musto, M., Adduci, F., Valentini, V., Miglionico, P., Pecora, G., 2014, *Biodiversity and innovation: the consumer perception on ono-cosmetic product*. X Convegno Nazionale sulla Biodiversita, Roma 3–5 Settembre 2014. On line at: http://sito.entecra.it/portale/public/documenti/atti_xbio_2014.pdf.

Dey, S., Dwivedi, S.K., Malik, P., Panisup, A.S., Tandon, S.N., Singh, B.K., 2010. *Mortality associated with heat stress in donkeys in India*. Veterinary Records, 166, 143–145.

Eisenmann, V., 1995. *L'Origine des ânes: questions et réponses paléontologiques*. Ethnozootechnie, 56, 5-26.

Fantuz, F., Ferraro, S.. Todini, L., Piloni, R., Mariani, P., Salimei, E., 2012. *Donkey milk concentration of calcium, phosphorus, potassium, sodium and magnesium*. International Dairy Journal, 24, 143-145

Fernando, P., Starkey, P., 2004. *Donkeys and development: socio-economic aspects of donkey use in Africa*. http://www.atnesa.org/donkeys/donkeys-fernando-socioeconomic.pdf.

Groves, C.P., 1986. *The taxonomy, distribution and adaptations of recent equids*. pp. 11-51 In: Meadow R and Uerpmann H P (eds), Equids in the Ancient World. Reichert, Weisbaden, Germany.

Guo, H.Y., Pang, K., Zhang, X.Y., Zhao, L., Chen, S.W., Dong, M.L., Ren, F.Z., 2007. *Composition, physiochemical properties, nitrogen fraction distribution, and amino acid profile of donkey milk*. Journal of Dairy Science, 90, 1635–1643.

Haltenorth, T., Diller, H., 1980. *A field guide to the mammals of Africa, including Madagascar*. Collins, London, UK.

Heinrichs, J., Jones, C., Bailey, K., 2017. *Milk Components: Understanding the Causes and Importance of Milk Fat and Protein Variation in Your Dairy Herd*. file:///C:/Users/Anto/Downloads/DAS%2005-97.pdf

Host, A., 2002. *Frequency of cow's milk allergy in childhood*. Ann. Allergy Asthma Immunology, 89, 33–37.

Kingdon, J.A., 1997. *The Kingdon field guide to African mammals*. Academic press, San Diego. 465p. ISBN 0-12-408355-2.

Kumar, S., Kumar Ajeet, B.V., Meena, K., 2011. *Effects of heat stress in tropical livestock and different strategies for its amelioration*. J. Stress Physiol. Biochemistry, 7, 45–54.

Lagat, P., Nyangena, J., 2016, *The effects of climate variability on livestock production in Kenya*. Journal of Agricultural Policy, 1(1), 58-79. On line at: http://sito.entecra.it/portale/public/ documenti/ atti_xbio_2014.pdf.

Linn, J.G., 1988. *Factors affecting the Composition of Milk from Dairy Cows*. In: Designing Foods: Animal Product Options in the Marketplace, Committee on Technological Options to Improve the Nutritional Attributes of Animal Products, National Research Council. https://www.ncbi.nlm.nih.gov/books/NBK218175/pdf/Bookshelf_NBK218175.pdf.

Marchis, Z., Negrea, O., Stan, A., Coroian, A., Coroian, C.O., 2015. *The influence of lactation on SCC and TNG of the donkey milk*. ABAH Bioflux, 7(2), 208-212.

Marchis, Z., Muresan, G., Stan, A., Coroian, A., Coroian, C.O., 2015. *Donkey milk chemical composition and the influence of lactation*. ABAH Bioflux, 7(2), 196-201.

Marshall, F., Weissbrod, L., 2011. *Domestication processes and morphological change*. Current Anthropology, 52, 397–413.

Martini, M., Altomonte, I., Salari, F., 2014. *Amiata Donkeys: Fat Globule Characteristics, Milk Gross Composition and Fatty Acids*. Italian Journal of Animal Science, 13(1), 123-126.

Merce, E., Merce, C.C., 2009. *Statistics – established paradigms and unifiering paradigms*. AcademicPres Publishing House, Cluj-Napoca.[In Romanian].

Milani, M.R.M., Hense, A., Rahmani, E., Ploeger, A., 2015. *A Pilot Investigation of the Relationship between Climate Variability and Milk Compounds under the Bootstrap Technique*. Foods, 3, 420-439.

Pandey, N., Kataria, N., Kataria, A.K., Joshi, A., 2012. *Ambient stress associated variations in metabolic* *responses of Marwari Goat of arid tracts in India*. J. Stress Physiol. Biochem., 8, 120–127.

Piovesana, S., Capriotti, A.L., Cavaliere, C., La Barbera, G., Samperi, R., Chiozzi, R.Z., Laganà, A., 2015. *Peptidome characterization and bioactivity analysis of donkey milk*. Journal of Proteomics, 119, 21-29.

Polidori, P., Vincenzetti, S., 2013. *Use of Donkey Milk in Children with Cow's Milk Protein Allergy*. Foods, 2, 151-159.

Polidori, P., Beghelli, D., Mariani, P., Vincenzetti, S., 2016. *Donkey milk production: state of art*. Italian Journal of Animal Science. 8(Suppl.2), 677-683.

Ragona, G., Benedetti, M., Salari, F., Martini, M., 2016. *Amiata donkey milk chain: animal health evaluation and milk quality*. Italian Journal of Food Safety, 5, 173-178.

Romanian National Administration of Meteorology. *Climatic monitoring*. On line at: http://www. meteoromania.ro/anm2/clima/monitorizare-climatica/ [In Romanian].

Salimei, E., Fantuz, F., 2012. *Equid milk for human consumption*. International Dairy Journal 24, 130–142.

Singh, M.K., Gupta, A.K., Yadav, M.P., 2005. *The donkey: its role and the scope for better management*. Livestock International, 9, 18–20.

Smith, D.G., Pearson R.A., 2005. *A review of factors affecting the survival of donkeys in semiarid regions of sub-Saharan Africa*. Tropical Animal Health Production, 37, 1–19.

Trinchesea, G., Cavalierea, G., Cananib, R.B., Matamorosc, S., Bergamod, P., De Filippoa, C., Acetoa, S., Gaitaa, M., Cerinoa, P., Negrib, R., Grecob, L., Canic, P.D., Mollicaa, M.P., 2015. *Human, donkey and cow milk differently affects energy efficiency and inflammatory state by modulating mitochondrial function and gut microbiota*. Journal of Nutritional Biochemistry, 26, 1136-1146.

Zakari, F.O., Ayo, J.O., Rekwot, P.I., Kawu, M.U., 2015. *Influence of season on daytime behavioral activities of donkeys in the Northern Guinea Savanna zone of Nigeria*. Journal of Equine Science, 26(4), 105-111.

Zakari, F.O., Ayo, J.O., Kawu, M.U., Rekwot, P.I., 2015. *The effect of season and meteorological stress factors on behavioral responses and activities of donkeys (Equus asinus) – a review*. Annals of Animal Science, 15(2), 307-321.