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Milk yield and quality of Cres sheep and their crosses with Awassi and East Friesian sheep

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Summary

The objective of this study was to establish the impact of crossing the indigenous Cres sheep with Awassi and, respectively, Awassi and East Friesian sheep on the milk yield and quality. For this purpose, through regular monthly milk yield recordings a total of 824 individual milk samples from 139 sheep in the second lactation of the same flock were collected, of which: 46 purebred Cres sheep, CS; 33 crosses with 50 % Cres sheep and 50 % Awassi, CA; 60 crosses with 50 % Cres sheep, 25 % Awassi and 25 % East Friesian, CAEF. The obtained results show a significant ($P<0.05$; $P<0.01$) impact of the genotype and the lactation stage on the yield and chemical composition of milk, and the somatic cell count. The most milk was yielded by CAEF crosses (690 mL/ewe/day, i.e., 133.8 L per lactation) and the least by CS (340 mL/ewe/day, i.e., 58.48 L per lactation). The content of total solids, fat and protein increased as lactation advanced, whereas the trend of the lactose content was opposite. The highest content of total solids, fat and protein were established in the milk of the indigenous Cres sheep. A positive correlation was established between the amount of yielded milk and the somatic cell count, whereas a negative correlation was established between the amount of milk and the content of solids, fat and proteins.

Key words: sheep milk, genotype, crossbreds, milk composition, stage of lactation

Introduction

Milk is lately an increasingly important sheep product in Croatia. Traditionally, sheep milk production is mostly represented in the coastal region and on the islands. The karst terrain and the Mediterranean climate of the Croatian coast and islands have favoured cheese production there, almost exclusively from sheep milk. The indigenous sheep breeds, adapted to karst and rocks, meagre vegetation and hot summer temperatures, are used for that purpose. The Cres sheep is the genuine Croatian breed originated and bred on the islands of Cres and Lošinj in the north of the Croatian littoral. Due to the rugged environment, the Cres sheep is small, brisk, tough, adaptable and hardy (Pavić et al., 2006). It belongs to the sheep breed of combined (milk/meat) properties, with the prevalence of one product or the other considerably changing over history, depending primarily on market demands. The production potential of Cres sheep is rather modest, with its milk yield in lactation amounting to barely 65 L (Mioč et al., 2007). Due to their low genetic potential in terms of milk yield the breeders intend to increase their milk and cheese output by crossing the Cres ewe with the ram of imported dairy breeds stemming from various climates.

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The objective of this study was hence to compare the yield and quality of milk of purebred Cres sheep with the milk of its crosses with the Awassi and, respectively, Awassi and East Friesian sheep. On the other hand, considering the fact that unbalanced milk yield and quality affects the quality and quantity of produced cheese, the objective of this study was to establish the impact of the lactation stage and the genotype on the milk yield and quality in the specific Mediterranean conditions of Cres Island.

Materials and methods

Single sheep milk samples were taken from sheep flocks on a family farm in the village of Vodice (44°58'N, 14°26'E), Cress Island. The island is situated in the north of the Croatian littoral. With its length of 66.5 km and area of 405.78 km^2 it is the second largest island in the Adriatic Sea. The island's climate is mild Mediterranean, vegetation lush, yearly mean air temperature 16.3 °C and annual precipitation 811.6 mm.

The measurement of the quantities of yielded milk and the analyses of its quality comprised 139 sheep, of which 46 Cres sheep (CS), 33 CA sheep (75 % Cres sheep and 25 % Awassi) and 60 CAEF sheep (50 % Cres sheep, 25 % Awassi and 25 % East Friesian). Daily milk yield was recorded once per month (every 28-32 days) during the evening (6 p.m.) and morning (6 a.m.) milking. The animals were hand milked, without utilizing any stimuli to induce the milk-let-down. Individual milk samples, consisting of proportional volumes of morning and evening milk, were taken after discharging the first streams of foremilk. A total of 824 individual milk samples were collected and examined for the trial. Milk samples were not conserved but they were kept in a refrigerator at a temperature of +4°C until analysis. In the first two months of lactation, lambs suckled and were separated from their dams 12 hours prior to milking. Individual milk yield per lactation was calculated by summing monthly milk yields using the method proposed by Thomas et al. (1999). Results were obtained by multiplying daily milk records by the number of days since lambing, for the first period, or by the number of days since the preceding milk recording day for subsequent recording days. Only lactation with at least three monthly records was included in the analysis. The beginning of lactation period covered the first 60 days, the midpoint stage lasted from day 61 to 120, and the final stage lasted from day 121 to the end of lactation period. Drying off took place when ewe's milk yield dropped to about 0.1 L per day. First milking control was taken in March and last in August 2005.

Contents of fat, protein, lactose and total solids were determined by routine laboratory procedures (IDF, 1990) using the automated infrared method (Milko Scan 4400; Foss Electric, Denmark). The somatic cell count (SCC) was determined with a Foss Electric Fossomatic 90 cell counter (IDF, 1995); pH value was established with a pH-meter (Mettler-Toledo) and a freezing point of milk was measured with a thermistor cryoscope CRYO-STAR, Funke Gerber, by a cryoscopic method (IDF, 2002.).

All the variables were tested for normal distribution using the Shapiro and Wilk (1965) test and milk SCC was converted into decimal logarithms to normalize their frequency distributions before performing statistical analysis. Data were analyzed using a general linear model procedure of SAS (1999) statistical software. Investigated animals were kept in similar environmental, handling, and feeding conditions throughout the experiment. For this reason, neither birth month nor season factors were included in the statistical analysis. Variation due to ewe genotype and to stage of lactation and their interactions was tested, having the replication within the genotype and stage of lactation as the error term. Interactions between genotype and stage of lactation were not statistically significant for any analyzed variable, so they were not presented in paper. Results are presented as the least square means of the ewes in each treatment, and variability of the data is expressed as the S.E. of the mean response over the whole study period. Finally, an analysis of correlation among all of the variables was performed using the CORR procedure (SAS, 1999). For all parameters, model effects were declared significant at $P<0.05$, unless otherwise noted.

Results and discussion

The study has established a significant ($P<0.05$ or $P<0.01$) impact of crossing the indigenous Cres sheep, with Awassi and East Friesian breeds on the

Table 1: Milk yield and lactation length regarding ewe genotype (LSM±S.E.)
Tablica 1: Utjecaj genotipa na proizvodnju mlijeka i trajanje laktacije

Parameter Svojstvo	Genotype Genotip C	 CA	 CAEF	P-value P-vrijednost
Daily milk yield (L) Dnevna proizvodnja mlijeka (L)	0.34[a]±0.11	0.48[b]±0.21	0.69[c]±0.10	**
Lactation milk yield (L) Proizvodnja mlijeka u laktaciji (L)	58.48[a]±4.7	89.51[b]±4.6	133.8[c]±3.9	**
Lactation length (days) Trajanje laktacije (dana)	172[a]±5.1	184[ab]±4.9	195[b]±4.0	*

[a,b,c]Means within the same row and not sharing the same superscript letter are significantly different (*P<0.05; **P<0.01)
[a,b,c]Vrijednosti u istom redu označene različitim slovima značajno se razlikuju (*P<0,05; **P<0,01)

Table 2: Influence of lactation stage on daily milk yield of investigated ewe genotypes (LSM±S.E.)
Tablica 2: Utjecaj stadija laktacije na dnevnu proizvodnju mlijeka u istraživanih genotipova ovaca

Parameter Svojstvo	Stage of lactation Stadij laktacije	Genotype Genotip CS	 CA	 CAEF	P-value P-vrijednost
Daily milk yield (L) Dnevna proizvodnja mlijeka (L)	Early Rana	0.46[a]±0.02	0.78[a]±0.04	0.98[a]±0.02	
	Mid Srednja	0.36[a]±0.02	0.51[b]±0.05	0.66[b]±0.02	
	Late Kasna	0.25[b]±0.04	0.31[c]±0.07	0.40[c]±0.03	**

[a,b,c]Means within the same columns followed by different letters differ significantly (**P<0.01)
[a,b,c]Vrijednosti u istoj koloni označene različitim slovima značajno se razlikuju (**P<0,01)

average daily and total milk yield in lactation and the length of lactation period (Table 1). The highest milk yield was found in the CAEF cross (690 mL/ewe/day i.e. 133.8 L per lactation), whereas the least milk yield had purebred Cres sheep (340 mL/ewe/day i.e. 58.48 L per lactation). The CAEF and CA crosses had 100 % and 41 % higher average daily milk yield, or as much as 129 % and 53 % higher total lactation milk yield than the indigenous Cres sheep. The lactation of the investigated crosses (CAEF and CA) was on the average 23 and 12 days longer than in CS (172 days). This matched the reports by Ugarte et al. (2001), according to which F_1 crosses Latxa x East Friesian sheep in Spain yielded about 50 % more milk than the purebred local sheep. The total milk yield of CAEF and CA crosses in the present study was less than that determined by Gootwine and Goot (1996) for the crosses of Awassi and East Friesian sheep in the Mediterranean breeding conditions (from 185 to 248 L milk in 179 to 202 lactation days). Likewise, the milk yield of the indigenous Cres sheep was smaller than that of other Croatian island sheep, such as Pag sheep (Vukašinović et al., 2008) and Brač sheep (Pandek et al., 2005). Mioč et al. (2004) pointed out that the milk yield of purebred East Friesian sheep

Table 3: Influence of ewe genotype and stage of lactation on milk composition (LSM±S.E.)
Tablica 3: Utjecaj genotipa i stadija laktacije na sastav ovčjeg mlijeka

Parameter Svojstvo	Stage of lactation (S) Stadij laktacije	Genotype (G) Genotip			P-value P-vrijednost	
		CS	CA	CAEF	S	G
Total solids(%) Suha tvar (%)	Early Rana	17.63^{a}±0.24	16.62^{c}±0.38	16.68^{c}±0.16		
	Mid Srednja	19.34^{b}±0.24	18.81^{b}±0.40	17.47^{a}±0.17		
	Late Kasna	22.02^{c}±0.31	21.22^{a}±0.49	19.59^{b}±0.23		
	Mean Prosjek	19.36^{a}±0.17	18.41^{b}±0.25	17.86^{c}±0.11	**	**
Milk fat (%) Mliječna mast (%)	Early Rana	6.85^{a}±0.25	6,10^{c}±0.34	6.09^{c}±0.15		
	Mid Srednja	8.47^{b}±0.25	8,31^{b}±0.37	7.06^{d}±0.15		
	Late Kasna	10.61^{c}±0.31	9,82^{a}±0.44	8.81^{b}±0.17		
	Mean Prosjek	8.39^{b}±0.10	7.68^{a}±0.12	7.26^{a}±0.09	**	**
Proteins (%) Proteini (%)	Early Rana	5.53^{a}±0.07	5,15^{b}±0.11	5.24^{b}±0.04		
	Mid Srednja	5.82^{a}±0.07	5,55^{ab}±0.12	5.20^{b}±0.05		
	Late Kasna	6.53^{c}±0.10	6,28^{c}±0.13	5.70^{d}±0.05		
	Mean Prosjek	5.89^{a}±0.02	5.53^{ab}±0.04	5.37^{b}±0.02	**	**
Lactose (%) Laktoza (%)	Early Rana	4.69^{a}±0.03	4.85^{a}±0.05	4.74^{a}±0.02		
	Mid Srednja	4.45^{ad}±0.03	4.49^{ad}±0.05	4.58^{ad}±0.03		
	Late Kasna	4.02^{d}±0.05	4.23^{d}±0.08	4.20^{d}±0.04		
	Mean Prosjek	4.39±0.01	4.59±0.02	4.53±0.01	**	NS

^{a,b,c,d}Means within the same rows or columns followed by different letters differ significantly (** P <0.01)
^{a,b,c,d}Vrijednosti u istom redu i istoj koloni označene različitim slovima značajno se razlikuju (**P<0,01)
NS: not significant/NS: nije značajno

in Croatia is considerably higher than that of its crosses with Cres sheep in this study.

Lactation stage has a significant (P<0.05 or P<0.01) effect on the average daily milk yield (Table 2). Regardless of the investigated genotype, the average daily milk yield at the start of lactation was higher compared to the middle and the end of lactation. The differences between the average daily milk yields between lactation stages were particularly marked in the CA and CAEF crosses. Thus the average daily milk yield of the crosses (CA and CAEF) at the end of lactation amounted to about 40 % of average daily output in the early lactation stage, whereas in purebred Cres sheep it stood at 54 %.

The study has established a significant (P<0.05 or P<0.01) effect of the ewe genotype on the content of total solids, fat and proteins in milk (Table 3). Bencini and Pulina (1997) report that the high-yield dairy breeds (genotypes) of sheep yield milk with a relatively low percentage of milk fat and protein, whereas Flamant and Morand-Fehr (1982) emphasize a negative correlation between milk yield and its composition, with the conclusion that the genotype significantly affects the chemical composition of milk. Indeed, compared to the CA and CAEF crosses, during lactation the purebred Cres sheep had the lowest milk yield (daily average 340 mL per ewe), but they showed the highest average values of analyzed chemical composition, i.e., 19.36 % solids, 8.39 % milk fat and 5.89 % proteins. Compared to the milk composition of some Mediterranean dairy breeds (María and Gabina, 1993; Sevi et al., 2004), the milk of Cres sheep has a higher average content of fat, proteins and total solids. The established average chemical composition of purebred Cres sheep is similar to that of some other Croatian island breeds, such as Krk sheep (Mikulec et al., 2008) and Pag sheep (Pandek et al., 2005). According to the data presented in Table 4, lactose content is positively correlated (P<0.01) to milk yield. Consequently, the milk of CA and CAEF crosses had higher content of lactose (4.59 and 4.53

Table 4: Physical properties and SCC in ewe milk, regarding genotype and stage of lactation (LSM±S.E.)
Tablica 4: Utjecaj genotipa i stadija laktacije na fizikalne osobine i broj somatskih stanica u mlijeku

Parameter Parametar	Stage of lactation (S) Stadij laktacije	Genotype (G) Genotip			P- value P-vrijednost	
		CS	CA	CAEF	S	G
Freezing point (°C) Točka ledišta (°C)	Early Rana	-0.5656±0.001	-0.5678±0.002	-0.5668±0.001		
	Mid Srednja	-0.5721±0.001	-0.5732±0.003	-0.5752±0.001		
	Late Kasna	-0.5778±0.002	-0.5783±0.004	-0.5793±0.002		
	Mean Prosjek	-0.5717±0.001	-0.5733±0.001	-0.5737±0.001	NS	NS
pH	Early Rana	6.76[c]±0.03	6,73[c]±0.06	6.73[c]±0.01		
	Mid Srednja	6.64[a]±0.03	6,67[a]±0.08	6.66[a]±0.01		
	Late Kasna	6.53[b]±0.04	6,58[b]±0.09	6.57[b]±0.03		
	Mean Prosjek	6.64±0.01	6.66±0.01	6.65±0.09	**	NS
SCC, log cells/mLx10[3] Broj somatskih stanica, log/mLx10[3]	Early Rana	5.07[a]±0.06	5.26[b]±0.07	5.58[c]±0.04		
	Mid Srednja	5.23[b]±0.07	5.26[b]±0.07	5.38[a]±0.04		
	Late Kasna	5.27[b]±0.08	5.41[c]±0.08	5.31[b]±0.06		
	Mean Prosjek	5.19[a]±0.02	5.30[ab]±0.03	5.43[b]±0.01	*	*

[a,b,c]Means within the same rows or columns followed by different letters differ significantly (*P<0.05; **P<0.01)
[a,b,c]Vrijednosti u istom redu i istoj koloni označene različitim slovima značajno se razlikuju (*P<0,05; **P<0,01)
NS: not significant/NS: nije značajno

%, respectively) than the less productive CS (4.39 %), although the differences were not significant (Table 3).

Lactation stage had a significant (P<0.01) effect on all the analyzed parameters of the milk chemical composition (Table 3). In the early lactation stage the content of total solids, protein and milk fat were significantly lower compared with the middle and the end of lactation irrespective of the studied genotype. A similar trend in the mentioned ingredients during lactation was found by Antunac et al. (2002) and Pavić et al. (2002) in the milk of Travnik sheep. However, in the Comisana breed of Mediterranean sheep (Sevi et al., 2004) brought forth in autumn the trend of milk fat content during lactation was opposite. During winter these ewes were fed only with hay, as pasture was not available. The opposite trend in relation to the other ingredients of milk composition was recorded for lactose, the highest content of which was found at the start of lactation (from 4.69 % to 4.85 %), the lowest in the late lactation stage (from 4.02 % to 4.23 %).

Among the physical properties the study established the pH value and the freezing point of milk (Table 4). The average pH values of milk between the studied genotypes showed no significant differences (from 6.64 to 6.66) and match the pH value of 6.63 reported by Antunac et al. (2007) for the milk of purebred East Friesian sheep. At the start of lactation the pH values of sheep milk in all the studied genotypes were significantly (P<0.01) higher compared to the middle and the end of lactation. However, Sevi et al. (2004) claim quite the opposite; that the pH value of milk increases as lactation advances.

The differences in the average freezing point values between the studied sheep genotypes were not significant (Table 4). The highest freezing point was found in the milk of Cres sheep (-0.5717 ºC), whereas the average freezing point values of the CA and CAEF crosses were very similar (-0.5733 and -0.5737 ºC respectively) and almost identical to the value (-0.5728 ºC) stated by Antunac et al. (2007) for the freezing point of the milk of purebred East Friesian sheep. In all the studied genotypes the highest freezing points were found at the start of lactation (from -0.5656 ºC to -0.5678 ºC), the lowest (from -0.5778 ºC to -0.5793 ºC) at the end of lactation, although the differences were not significant.

Table 5: Coefficients of correlation between analyzed variables (n=830)
Tablica 5: Koeficijenti korelacija između analiziranih varijabli (n=830)

	Milk fat Mliječna mast	Proteins Proteini	Lactose Laktoza	Total solids Suha tvar	pH	Freezing point Točka ledišta	SCC Broj somatskih stanica
Daily milk yield Dnevna proizvodnja mlijeka	-0.54**	-0.47**	0.46**	-0.58**	0.12*	0.05	-0.14*
Milk fat Mliječna mast	-	0.67**	-0.70**	0.97**	0.03	-0.07	-0.05
Proteins Proteini	-	-	-0.61**	0.78**	0.02	-0.03	0.10*
Lactose Laktoza	-	-	-	-0.36**	0.05	0.06	-0.22*
Total solids Suha tvar	-	-	-	-	-0.23**	-0.07	-0.05
pH	-	-	-	-	-	0.33*	0.15*
Freezing point Točka ledišta	-	-	-	-	-	-	-0.03

*P<0.05; **P<0.01.

In the milk of CAEF crosses a significantly (P<0.05) higher average of SCC (log 5.43) was found than in the milk of purebred Cres sheep (log 5.19), as shown in Table 4. The average SCC in the milk of CA sheep (log 5.30) varied between the values established with CS and CAEF sheep, but the differences were not significant. In the CS and CA group, as lactation was advancing, log SCC in milk was increasing significantly (P<0.05). Towards the end of lactation an increased somatic cell count was found in the milk of Comisana sheep in Italy (Sevi et al., 2004). However, in CAEF sheep the lowest log SCC was found in the middle lactation stage, while the highest log SCC was found at the end of lactation period.

The correlation coefficients among the variables studied are shown in Table 5. Although different in size, significant correlations in the same direction as in this study have been reported previously. In Latxa ewes, María and Gabiña (1993) reported correlations of -0.27 between milk yield and fat and -0.24 between milk yield and protein. Pavić et al. (2002) reported a correlation of 0.96 between total solids and fat, 0.70 between total solids and protein and 0.62 between fat and protein in milk of Travnik sheep. The lactose content is inversely proportional to fat and protein that is in accordance with the statements given by Ochoa-Cordero et al. (2002). With the increased SCC the pH value also went up, which corresponds to the reports by Raynal-Ljutovac et al. (2007).

Conclusions

The crossing of the indigenous Cres sheep with Awassi and East Friesian sheep has led to a significant increase in the average daily and total milk yield in lactation and, as a result of it, the total yield of solids, milk fat and proteins. A significant impact of the genotype was found on the chemical composition of milk and the somatic cell count, but not on the pH and freezing point of milk. The indigenous Cres sheep yielded the lowest amount of milk in lactation, but with the highest amount of total solids, fat and proteins, as well as less of SCC, which is especially important for the production and quality of cheese.

Proizvodnja i kakvoća mlijeka creskih ovaca i njihovih križanaca s avasijem i istočnofrizijskom ovcom

Sažetak

Cilj ovog istraživanja bio je utvrditi utjecaj križanja izvorne creske ovce s avasijem, odnosno s avasijem i istočnofrizijskom ovcom na proizvodnju i kakvoću mlijeka. Redovitim mjesečnim kontrolama mliječnosti prikupljeno je ukupno 830 pojedinačnih uzoraka mlijeka od 139 ovaca u drugoj laktaciji koje potječu iz istog stada (46 čistokrvnih creskih ovaca; 33 križanke creska (75 %) x avasi (25 %), CA; i 60 križanki creska (50 %) x avasi (25 %) x istočnofrizijska (25 %), CAEF). Genotip i stadij laktacije značajno su utjecali na proizvodnju i sastav mlijeka, kao i na broj somatskih stanica u mlijeku. Najviše mlijeka proizvele su križanke CAEF (690 mL po ovci dnevno, odnosno 133,8 L u laktaciji), a najmanje čistokrvna creska ovca (340 ml po ovci dnevno, odnosno 58,48 L u laktaciji). Sadržaji suhe tvari, mliječne masti i proteina povećavali su se s odmicanjem laktacije, dok je sadržaj laktoze imao suprotan trend. Najviši sadržaj suhe tvari, masti i bjelančevina utvrđen je u mlijeku creskih ovaca. Pozitivna korelacija utvrđena je između količine proizvedenog mlijeka i broja somatskih stanica u mlijeku, dok su negativne korelacije utvrđene između proizvodnje mlijeka i sadržaja suhe tvari, masti i proteina u mlijeku.

Ključne riječi: ovčje mlijeko, genotip, križanci, sastav mlijeka, stadij laktacije

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