

production and purchase of sheep's milk in EU countries has increased significantly, amounting to 2 116 000 tons in 2021. In the EU countries, the majority of sheep's milk is processed into various types of cheese, and 223 000 tons of cheese were produced in 2021 (Croatian Agency for Agriculture and Food - CAAF, 2023). In 2022, 2 231 355 kg of sheep's milk was purchased in the Republic of Croatia (CRO). According to the CAAF, 553 673 sheep were bred on 18 663 farms in the Republic of Croatia on 31.12.2022, while 425 breeders had 41 768 sheep in the selection. The interest in sheep milk and the import of highly selected dairy sheep breeds has also increased in the Republic of Croatia (Antunović *et al.*, 2022a). The rearing of Lacaune sheep in the Republic of Croatia has increased significantly in recent years (Antunović *et al.*, 2022a). This is also supported by data from the CAAF (2023), according to which the Lacaune sheep is the second most common rearing sheep in the Republic of Croatia (2521 sheep), just behind the Romanov sheep. In the Republic of Croatia, 21 sheep breeds are reared (9 domestic and 12 imported sheep breeds). Larger imports of East Friesian sheep took place in the 1980s at the instigation of the dairy industry in the areas of northwestern Croatia (Antunović *et al.*, 2012). The Travnik sheep (Dubska, Vlašićka) belongs to the breeds with combined production traits, which have significant milk and meat production. It is assumed that the Travnik sheep are about 10,000 animals that were kept on the territory of the Republic of Croatia after the war in Central Bosnia and Herzegovina, when the shepherds went into exile, in Western Slavonia (Voćin, Daruvar, Pakrac) and Lika (Otočac, Udbina), Korenica, Vrhovine), where their breeding was continued (Pavić *et al.*, 1999). Looking at the percentages of all breeds bred in the Republic of Croatia, imported dairy sheep breeds, namely Lacaune sheep, are represented with 6.04%, Travnik sheep with 0.63%, and East Friesian sheep with only 0.18%. Comparing only the imported sheep breeds reared in the Republic of Croatia, 26% are Lacaune, 2.7% are Travnik sheep and 0.8% are East Friesian sheep (CAAF, 2023). This article aimed to show the production potential and number of imported dairy sheep breeds reared in the Republic of Croatia, as well as the prospects for the development of this production sector.

MATERIAL AND METHODS

Data from the Sheep Breeding Program (Mioč *et al.*, 2011) and the annual reports of the Croatian Agency for Agriculture and Food (CAAF, 2020, 2022, and 2023) were used to investigate the number and production potential of imported dairy sheep breeds reared in the Republic of Croatia. Two imported sheep breeds with high milk production (Lacaune and East Friesian sheep) and the Travnik Pramenka, a combined sheep breed that is also reared for milk production in the Republic of Croatia, were included in the research. Data from previous studies published in several publications (Antunović *et al.*, 2013, 2020, 2022a,b,c and 2024a,b; Mioč *et al.*, 2004; Pavić *et al.*, 2002 and 1999; Antunac *et al.*, 2002) were used to assess the production potential of imported dairy sheep breeds reared in the Republic of Croatia.

RESULTS AND DISCUSSION

Table 1 shows the production potential and the population size of herdbook imported dairy breeds of sheep reared in the Republic of Croatia.

Table 1. Production potential and size of the population of herdbook imported dairy sheep breeds reared in the Republic of Croatia

Tablica 1. Proizvodni potencijal i veličina populacije uzgojno valjanih inozemnih mliječnih pasmina ovaca koje se uzgajaju u Republici Hrvatskoj

Indicator- Pokazatelj	Breed of sheep - Pasmına ovaca		
	East Friesian sheep Istočnofrizijska ovca	Lacaune sheep Lakon ovca	Travnik sheep Travnička pramenka
Production indicators ¹ - Proizvodni pokazatelji:			
Body weight of adult sheep, kg Tjelesna masa odraslih ovaca, kg	60-110	60-100	70-90
Withers height, cm Visina grebena, cm	60-80	55-75	55-75
Index of lambing ^{2*} Indeks janjenja	1.01	1.02	1.04
Litter size ^{2**} Veličina legla	1.24	1.03	1.09
Milk yield, l Količina mlijeka, l	250-400	200-250	130-180
Wool yield, kg Prinos vune, kg	4.0-6.0	2.0-3.0	2.5-4.5
Indicators of male lamb in field conditions (duration of 105 days) ² - Pokazatelji muške janjadi u terenskim uvjetima (105 dana trajanje):			
Lambing weight, kg Porodna masa, kg	-	4,1	4.1
Daily gain, g Dnevni prirast, g	-	320	290
Final weight gain, kg Završna tjelesna masa, kg	-	37.65	34.10 ³
Population size ² - Veličina populacije:			

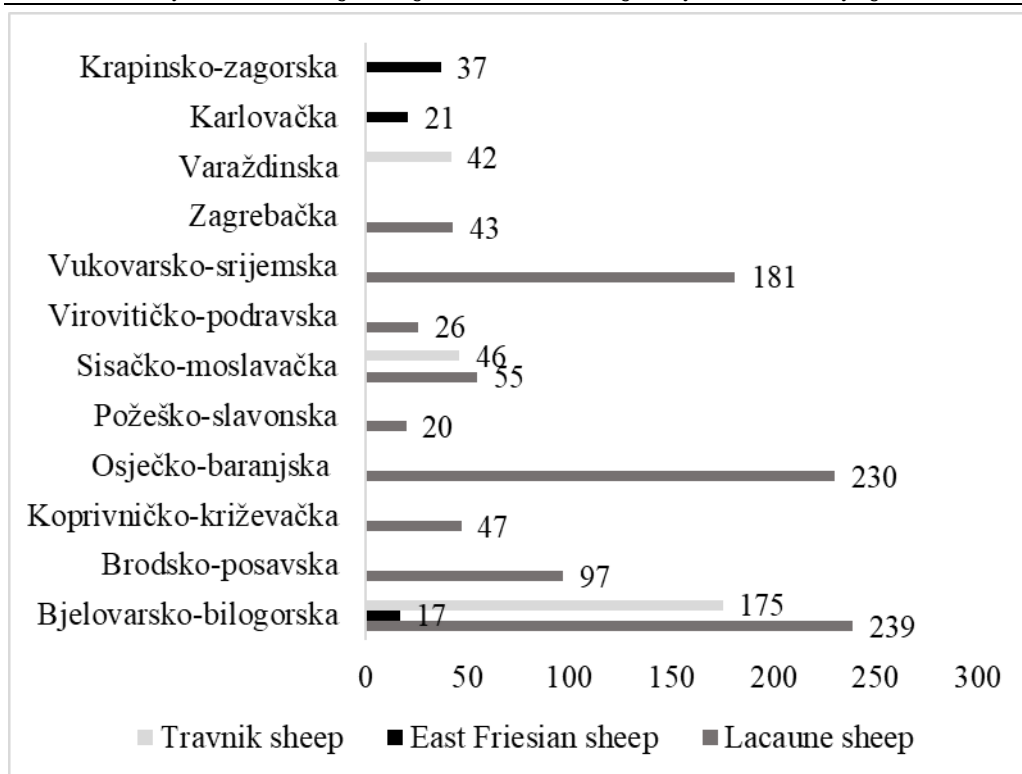
Number of herdbook sheep	75	2521	263
Broj uzgojnovaljanih ovaca			
Average flock size			
Prosječna veličina stada	25	180	88

¹Sheep breeding program in the Republic of Croatia - Program uzgoja ovaca u Republici Hrvatskoj; ²CAAF (2023); ³CAAF-a (2021); *Lambing index = number of lambs/number of ewes – Index janjenja = broj janjadi/broj ovaca; **Litter size = number of lambs/numbers of lambing – Veličina legal = broj janjadi/broj janjenja

The analysis of the results shown in Table 1 shows that in the Republic of Croatia, Lacaune sheep are reared from imported dairy breeds (a total of 2,521 herdbook head), while the breeding of East Friesian sheep (only 75 herdbook sheep) is much lower, and the rearing of the combined breed Travnik sheep, which is grown and intended for milk production, comprises 263 herdbook head. In terms of production potential, it should be noted that all three breeds have a similar body performance, with the milk yield of the East Friesian sheep being more pronounced, considering the data presented in the Sheep Breeding Program of the Republic of Croatia (Mioč *et al.*, 2011), but also a larger amount of wool. However, the ever-increasing genetic profiling of Lacaune sheep towards milk production has led to a significant increase in the number of Lacaune dairy sheep in the Republic of Croatia, amounting to almost 62% from 2018 to 2023. The significantly higher milk yield of Lacaune sheep in the Republic of Croatia is also confirmed by CAAF data (2023), which highlights the average milk yield in lactating Lacaune sheep according to the control of a total of 457.5 kg, which was achieved by monitoring 464 lactations. However, there has been a significant decline in the number of East Friesian sheep, as well as a stagnation in the number of Travnik sheep in the selection area. The reasons for this are manifold, but among others, it is certain that the weaker resistance and greater dedication required by the East Friesian sheep, but also the increasing depopulation of rural areas and the lack of labor, where most of the sheep breeding is stationed in the Republic of Croatia, including the breeding of Travnik sheep. This gives the Lacaune sheep a considerable advantage over the other two breeds mentioned, especially in the forage-rich continental regions of the Republic of Croatia. Graph 1 shows the distribution of herdbook sheep of the Lacaune, East Friesian, and Travnik sheep breeds by county in the Republic of Croatia.

It can be seen that the largest number of Lacaune sheep are reared in Osiječko-Baranjska (230) and Vukovarsko-Srijemska (181) counties, East Friesian sheep in Krapinsko-Zagorska and Travnik sheep in Bjelovarsko-Bilogorska county (175).

Table 2 shows the external characteristics of imported dairy breeds of sheep reared in the Republic of Croatia.



Graph 1. Distribution of herdbook sheep of the Lacaune, East Frisian and Travnik sheep breeds by county in the Republic of Croatia (CAAF, 2023).

Grafikon 1. Raspored uzgojno valjanih ovaca pasmine lakon, istočnofrizijska i travnička pramenka po županijama u Republici Hrvatskoj (HAPIH, 2023).

The analysis of the results of body mass and body measurements of Lacaune sheep and Travnik sheep carried out in the Republic of Croatia shows that they are different. Namely, the Lacaune sheep has a lower body weight, height at the withers, body length, chest girth, and width than the Travnik sheep, which is also a characteristic of the breed, considering that the Travnik sheep is a combined breed with a stronger body frame. In the available literature, there is no research related to the external characteristics of East Frisian sheep, but we have provided data from the Sheep Breeding Program in the Republic of Croatia (Mioč *et al.*, 2011). Comparing the external characteristics of Dubska pramenka sheep (Travnik sheep) in research conducted in the area of western Herzegovina, Bosnia and Herzegovina, Dokso *et al.* (2011) determined a higher withers height (74.57 cm) and shorter body length and chest girth (79.37 and 110.11 cm). This mostly indicates somewhat weaker physical performance. The authors associate this with the failure to carry out systematic selection in the selected flocks of Dubska sheep.

Table 2. External characteristics of imported sheep dairy breeds in the Republic of Croatia

Tablica 2. Odlike vanjštine inozemnih mliječnih pasmina ovaca koje se uzgajaj u Republici Hrvatskoj

Characteristic Odlika	Breed of sheep - Pasmína ovaca		
	East Friesian sheep ³ Istočnofrizijska ovca	Lacaune sheep ¹ Lakon ovca	Travnik sheep ² Travnička pramenka
Body weight, kg	60-110	60.94	66.20
Tjelesna masa, kg			
Withers height, cm	60-80	68.05	69.80
Visina grebena, cm			
Body length, cm	-	78.49	85.70
Dužina trupa, cm			
Chest girth, cm	-	94.82	117.00
Opseg prsa, cm			
Širina prsa, cm	-	20.86	27.40
Chest width, cm			
Circumference of shin bone, cm	-	8.68	9.00
Opseg cjevanice, cm			
Head length, cm	-	20.04	24.20
Dužina glave, cm			
Head width, cm	-	12.97	13.10
Širina glave, cm			

¹Antunović *et al.* (2022b); ²Antunović *et al.* (2013); ³Sheep Breeding Program in the Republic of Croatia- Program uzgoja ovaca u Republici Hrvatskoj

Table 3. Lactation characteristics of imported dairy breeds of sheep reared in the Republic of Croatia

Tablica 3. Laktacijska svojstva inozemnih mliječnih pasmina ovaca koje se uzgajaj u Republici Hrvatskoj

Indicator - Pokazatelj	Breed of sheep - Pasmína ovaca		
	East Friesian sheep ¹ Istočnofrizijska ovca	Lacaune sheep ¹ Lakon ovca	Travnik sheep Travnička pramenka
Number of recorded lactations	40	464	-
Broj zaključenih laktacija			
Lactation length, days	237	183.4	240 ² ; 235 ³
Dužina laktacije, dani			

Milking period, days	181	139.8	-
Razdoblje mužnje, dani			
Milk yield in lactation, kg	389.9	457.5	137 ²
Mlijeko u laktaciji, kg			
Milk yield in suckling period, kg	124.3	128.4	-
Posisano mlijeko, kg			
Milk yield in milking period, kg	265.6	329	-
Količina mlijeka u razdoblju mužnje, kg			

¹CAAF (2023); ²Pavić *et al.* (2002); ³Antunac *et al.* (2002)

Analysis of the results from Table 3 shows that Lacaune sheep produced a higher average total milk yield (457.5 kg) in lactation of shorter duration (183.4 days) compared to East Friesian sheep (389.9 kg and 237 days) and Travnik sheep (137 kg and 240 days). In East Friesian sheep in Macedonia, Paćinovski *et al.* (2007) determined that 346 L of milk was produced in a lactation of 232 days, with an average milk fat content of 5.01% and protein content of 4.68%.

Table 4. Milk quality of imported dairy breeds of sheep reared in the Republic of Croatia in available research

Tablica 4. Kvaliteta mlijeka inozemnih mliječnih pasmina ovaca koje se uzgajaj u Republici Hrvatskoj u dostupnim istraživanjima

Indicator - Pokazatelj	Breed of sheep - Pasma ovaca		
	East Friesian sheep ¹ Istočnofrizijska ovca	Lacaune sheep ² Lakon ovca	Travnik sheep ³ Travnička pramenka
Basic milk chemical composition, % - Osnovni kemijski sastav mlijeka, %			
Milk fat	5.68	5.3	7.43
Mliječna mast			
Milk protein	4.92	5.9	5.70
Bjelančevine			
Lactose	4.59	4.5	4.33
Laktoza			
Dry matter without fat	-	1.,29	11.10
Suha tvar bez masti			
Total dry matter	-	17.40	18.45
Ukupna suha tvar			
Mineral composition mg/kg DM - Sadržaj minerala, mg/kg ST:			

Calcium	-	2373	1838-1993
Kalcij			
Phosphorus	-	1634	1485-1851
Fosfor			
Potassium	-	1330	1224-1435
Kalij			
Sodium	-	662	567-517
Natrij			
Magnesium	-	183	179-200
Magnezij			

¹Mioč *et al.* (2004); ²Antunović *et al.* (2024b); ³Antunović *et al.* (2020); ST-suha tvar - DM-dry matter

Analyzing the quality of milk of imported dairy breeds of sheep reared in the Republic of Croatia from the available research, it is evident that Travnik sheep, in particular, had a significantly higher content of fat and dry matter in their milk compared to Lacaune sheep and East Friesian sheep. The milk of Lacaune sheep had a higher calcium and sodium content, while the content of other macroelements (phosphorus, potassium, and magnesium) was similar compared to the milk of Travnik sheep. We did not find any research on the mineral composition of milk East Friesian sheep in the available literature.

CONCLUSION

Increased demand for sheep milk on the market and an increased interest in the purchase of the high-milk Lacaune breed indicate that the development of the dairy sector in sheep production has good prospects in the Republic of Croatia. In addition, previous research conducted in the Republic of Croatia with Lacaune sheep indicates high milk yield, good milk quality, and adaptability. It is to be expected that the above will contribute to the further development of the dairy sheep sector.

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PROIZVODNI POTENCIJAL I ZASTUPLJENOST INOZEMNIH MLIJEČNIH PASMINA OVACA U REPUBLICI HRVATSKOJ

Sažetak

Cilj ovoga rada bio je prikazati proizvodni potencijal i zastupljenost inozemnih uzgojno valjanih mliječnih pasmina ovaca koje se uzgajaju u Republici Hrvatskoj (RH) te perspektive razvoja ovoga proizvodnog sektora. U istraživanje su uključeni podaci iz istraživanja provedenih s inozemnim pasminama, istočnofrizijskom i lakon ovcom, koje su mliječne pasmine ovaca te travničkom pramenkom, kombiniranom pasminom, koja se u RH koristi i za proizvodnju mlijeka. Analizom brojnosti ovih pasmina utvrđeno je povećanje broja lakon pasmine, a smanjenje broja istočnofrizijske ovce, dok je broj travničke pramenke standardan. U RH se uzgaja 2521 uzgojno valjana lakon ovca, 75 istočnofrizijskih ovaca te 263 uzgojno valjane travničke pramenke. Razlozi su višestruki, ali između ostalih, slabija otpornost i veća posvećenost koju zahtijevaju istočnofrizijske ovce, ali i sve veća depopulacija ruralnih prostora i nedostatak radne snage gdje je stacionirana većina uzgoja ovaca u RH. Navedeno daje značajnu prednost lakon ovci, osobito u kontinentalnim krajevima RH bogate krmnom bazom. Razvoj mliječnog sektora u ovčarskoj proizvodnji ima dobre perspektive u RH s obzirom na pojačanu potražnju za ovčjim mlijekom što prati i povećan interes za nabavkom lakon ovaca, ali i da dosadašnji rezultati istraživanja s lakon ovcom provedenim u RH, ukazuju na visoku mliječnost te dobru kvalitetu mlijeka.

Ključne riječi: *mliječne inozemne pasmine, ovca, proizvodni potencijal, veličina populacije, Republika Hrvatska*