UDC: 637.12-116.42:631.115.1(497.751)
Professional paper

MILK PRODUCTION EFFICIENCY OF SMALL-SCALE DAIRY FARMS

Xheneta USEINI, Erhan SULEJMANI*

[*]Department of Food Technology, University of Tetova, 1200, Tetovo, North Macedonia
[*]Corresponding author:erhan.sulejmani@unite.edu.mk

Abstract

Smallholder farmers are the mainstay of the livestock division and a critical component in the development of the local economy and dairy group. Because farmers face numerous obstacles that prevent them from joining effectively in the evolution of the dairy, this research investigates the attitudes of smallholder farmers in the Municipality of Želina regarding the dairy sector, taking into account the following factors: animal welfare, cultural factors of dairy production, ethics and traditions. Farmers with a total of 106 cows were interviewed, producing a milk yield of 31,260 liters of milk per month and having monthly expenditures of up to 5,700 euros per month for concentrates and other expenses. The findings of the statistical correlation analyses showed a significant positive impact of agricultural training education and income, family size and number of cows. Also, a high positive correlation was shown between the number of heads and the cost of concentrate for animal feed, as well as higher production with the cost of concentrate. The difficulties and problems of farmers and competent public institutions regarding the efficiency of milk production should be solved through a comprehensive approach integrating food quality, animal health and the market. Finally, such a focus enables the development of farmers' basic income and the increase of domestic milk production.

Keywords: *dairy chain, small farmers, food safety, farmers economic, strategic marketing*

1. Introduction

Critical factor affecting the efficiency of milk production is animal health such as mastitis which can significantly reduce milk yield and economic losses (Katsande et al., 2013). The overall efficiency of milk production can be facilitated by improving animal health, establishing milk collection points facilitating better access to resources and markets, and linking smallholders with larger companies leading to higher productivity (Mavura et al., 2022; Sembada et al., 2019).

Management practices, animal health, and feed quality are factors that greatly influence milk efficiency in smallholder farmers who are crucial in contributing to milk production. Feed availability and quality are key challenges to milk efficiency with a cost of 50% to 60% of total milk production and self-produced fodder leading to unsatisfactory milk yields (Odhiambo et al., 2019; Musitini et al., 2019, Bartova et al., 2009, Atuhaire, 2014). In addition to these factors, the scale of farming operations also plays a role in production efficiency. Larger farms can lead to increased milk yields due to better management and resource allocation. However, many smallholder farmers operate with fewer than ten cows, limiting their ability to achieve similar efficiencies (Anzhany et al., 2022). Companies in the dairy industry in North Macedonia expanded by nine companies and peaked at 98 companies in 2022. The most important economic sector of North Macedonia is the agricultural and agribusiness sector, where out of a population of 2.1 million, almost half a million earn their living and part of their income in this sector. Various excellent opportunities in agriculture are created by the good natural conditions enriched with pastures in the high mountains with an altitude of over 2000 meters with a rich Mediterranean climate with water valleys. Value-added agricultural products as required by European markets in our country are growing very quickly thanks to the registration of more

https://doi.org/10.62792/ut.jftn.v8.i15-16.p2938

than 800 organic farmers https://investnorthmacedonia.gov.mk/export-agrobusiness-and-food-processing//. 56% of agricultural land in our country is pasture, which represents a significant raw material base that is the basis for the development of the agro-food sector as one of the critical sectors of the domestic economy and the third most important with a share of 18% in the gross domestic product (GDP) (Sulejmani & Iseni, 2023). The most important agricultural industry in North Macedonia is the dairy industry and white cheese is an indigenous product with an extensive history similar to cheeses from various countries in the Balkan Peninsula and is the most consumed dairy product in the country (Sulejmani et al, 2021; Mateva et al., 2019; Sulejmani et al., 2014). Milk production is one of the elderly agricultural subdivision in the territory of the municipality of Želino and most significant economic division however, small farmers trade milk through unofficially with less legal or health observation, as most of them do not have the necessary experience to produce milk to safety specifications. In recent years, the country was undertaking, it was an essential phase of transformation. Small farmers dial many confrontations at the regional level, despite the various development policies that the country is pursuing to advance agriculture in all its sectors. The relatively low productivity of milk in the Municipality of Želina is attributed to poor nutrition, substandard livestock, high cost of production and competition between dairy farms and other agricultural companies for small farms. The problem was aimed at detecting the factors as well as the possibility of training farmers on how to feed their cows better to increase the amount of milk. According to the author's current knowledge, there is no published report on the challenges of smallholder farmers in our country, so this research aims to investigate how smallholder farmers ensure the livelihood of their families by supporting food and nutrition sovereignty and maintaining food security. This study is considered part of several studies, which have delved into the expert opinion on the advancement of the dairy in the region, aiming to define the obstacles faced by farmers and expand to which food security is operated and to correlate them with the expert conclusion.

2. Methods

2.1. Research region: The investigation investigations were carried out in the Municipality of Želino. A study on the milk production of small farmers was completed in 18 villages in the summer of 2022 (Figure 1) The municipality of Želino includes the following villages: Želino and the villages: Cerova, Ciflik, Doberca, Grupcin, Kapazdolli, Llrca, Leshnica and Upper, Lower Leshnica, Lukovica, Merova, Novosella, Pallatica, Rogle, Sallareva, Strimnica, Trebosh, Uzurmisht.

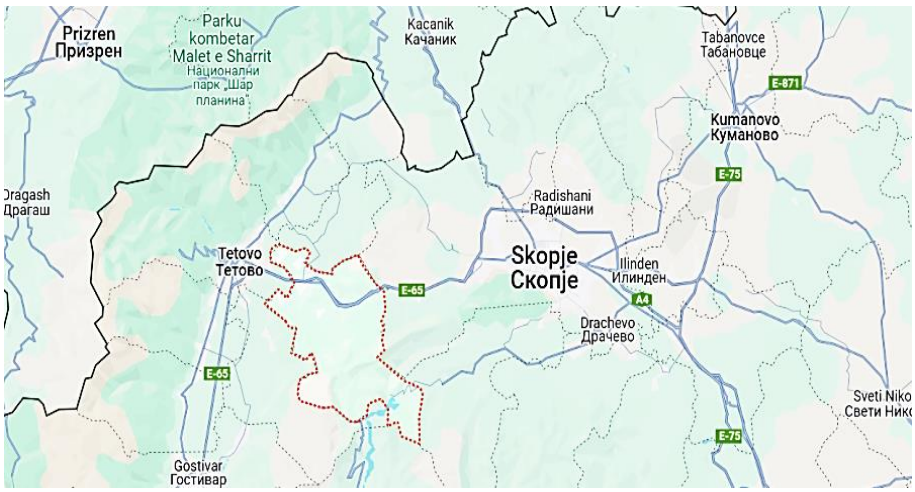

Figure 1. Research area map located (red line)

Although the exact number of active farmers is not known, the exact statistic of small farmers registered in the municipality of Želina is 336 farmers. However, even though they have a limited number of cows, they formally trade their raw milk and therefore, it is severe to realize the certain number of farmers in this sector. Deficit of education about modern improvement in milk markets, their production methods, difficulty in entering local and interdomestic markets as well as the lack of sophisticated utensil are the most common obstacles of small farmers.
This study relied on the convergence model in the tripartite design of the mixed method approach according to the author 2022. Research method design of surveys and interviews were conducted together using a mixed method design, respectively, qualitative and quantitative experimental report models were used. Report and information on the dairy sector in the analyzed municipality are published as results of interviews with dairy experts, discussing various factors. The report used in this study were collected in the Municipality of Želino. The questions were arranged and related to each other depending on the purpose of this research. Table 3 shows that the questionnaire is based on broad informative questions related to agro-climatic characteristics.

Table 1. Agro-climatic data for the Municipality (2022)

Earth surface	199 km³
Area of pastures	224 ha
Agrarian surface	1495 ha, Working land 603 ha
Climate	Average annual temperatures are 11˚C, average amount of precipitation reaches 800 mm
Number of inhabitants	24,390 inhabitants
Number of farmers	336 Farmers
Number of dairy cows	2814 Milk cow
Total milk production	450.24 tons

2.2. Survey and data collection: The research used report collected through a survey conducted in the Municipality of Želino. These localities were selected during previous research knowing the obstacles that occur and their adherence to food safety standards in milk production. In these villages, no special criteria have been established to select the farmers who should be interviewed. Most of the farmers were not very welcome, they had their doubts about the questions so that they were not misused. The questionnaire was based on open and closed questions, most of the participants in this survey are small farmers who depend on livestock raising as their primary income or secondary income in subsistence farming for their livelihood. These interviews were conducted on farms in the Albanian language, and the questions were logically arranged and interrelated depending on the purpose of this research. All interviews were face-to-face and all these questionnaires and surveys were completed during the interviews studies collected in some villages that were interviewed.

Table 2. Main economic report's collected from farmers in the Municipality of Želino

Farmer	Village	Number of cows	Experience years	Type of feed	Monthly milk/liter	Concentrates per month/cost	Concentrates per month/cost
1	Želino	5	30	Silage, Hay	2100	€ 350	€ 350
2	Strimnica	1	20	Silage , Hay	300	€ 25	€ 25
3	Strimnica	7	15	Silage, Hay	2200	€ 430	€ 430
4	Želino	3	30	Grassing	1200	€ 200	€ 200
5	Deberc	30	15	Silage, Grain	7000	€ 1,700	€ 1,700
6	Želino	5	40	Silage, Grain	1650	€ 320	€ 320
7	Leshnic	1	4	Grassing	570	€ 40	€ 40
8	Strimnica	3	20	Grassing	1500	€ 190	€ 190
9	Pallatica	15	15	Silage, Grain	5800	€ 750	€ 750
10	Pallatica	1	10	Silage, Grain	300	€ 33	€ 33
11	Upper Leshnic	10	15	Grassing	1000	€ 245	€ 245
12	Želino	12	30	Silage, Grain	2790	€ 700	€ 700
13	Trebosh	4	22	Silage, Grain	1800	€ 260	€ 260
14	Želino	5	25	Grassing	2000	€ 330	€ 330
15	Strimnica	4	8	Silage, Grain	1050	€ 110	€ 110

2.3. Data analysis: To investigate and clarify the results received in these questions, a systematic model is created that emphasize how the investigated variables conduct the fulfillment of the purpose and objectives of the investigation and to induce correlations that lead to essential report for the investigated topic. Descriptive analysis was performed and animal housing in the survey was divided into two sections animal stable with other animals or animal stable without other animals. To evaluate differences in means or proportions Chi-squared tests (for categorical data) were used. Input were tested with SPSS (IBM 21.0) and statistical significance in two-sided tests was set at a p-value = 0.05.

3. Results and discussion

Primary education was the primary level of education for most of farmer's household's heads in the general sample of farmers, which has been confirmed in most other investigations, emphasizing that farm efficacy can be increased through improved education and experience (Mishra et al. 2023). Education has long been proposed to have a strong impact on productivity in situations involving higher levels of technology. Some research found that four years of schooling improved agricultural yields by an average of 7.4%, while another study found that 44% of farmers with a university education implemented better practices on their farms (Alexanderson et al., 2024). Spearman correlation analysis was applied to analyze the data. Table 4.5 shows a positive correlation between the number of cows and the number of family's $r_s = 0.778$ ($p < 0.01$); thus, the correlation is statistically significant. The positive correlation coefficient indicates that this is a relationship between two variables in the same way; this means that the higher values of the number of family members correspond to higher values of the number of animals as well as the higher amount of milk production rs = 0, 647. Likewise, Table 3 shows that the correlation between grazing and income in milk is positive $r_s = 0.577$ ($p < 0.05$); thus, the correlation is statistically significant. The positive correlation coefficient indicates that this is a relationship between the two variables, which means that higher values

of grazing in the season are linked with higher values of milk income in the season. The positive correlation coefficient indicates that there is a relationship between higher values of grazing with higher values of milk income in the season. An important determinant of milk production and milk income is grazing as a natural and cost-effective way of providing essential nutrients that can contribute to higher milk fat and protein content (Reid et al., 2015; van den Pol, 2018). Animal health is also of paramount importance, resulting in higher milk yields and higher income (Ertl et al., 2014). Farms that have access to quality pasture typically see an increase in milk yield, as cows are feeding on a natural and balanced diet that supports lactation. Since grazing is a more natural and cheaper way of feeding cows compared to purchasing commercial feed, farms with higher grazing availability tend to have lower feed expenses. These savings can boost profitability. Cows that graze on high-quality pasture typically produce milk with a better composition, including higher fat content, more protein, and enhanced flavor. This can lead to increased prices for milk and improved feed efficiency, especially when the milk is marketed as organic or specialty products like grass-fed milk (Figure 2). As a result, this can significantly boost income for dairy farmers. However, compared to intensive dairy systems, pasture-based systems tend to produce lower milk yields per cow, especially in the winter and during drought when pasture quality is poor.

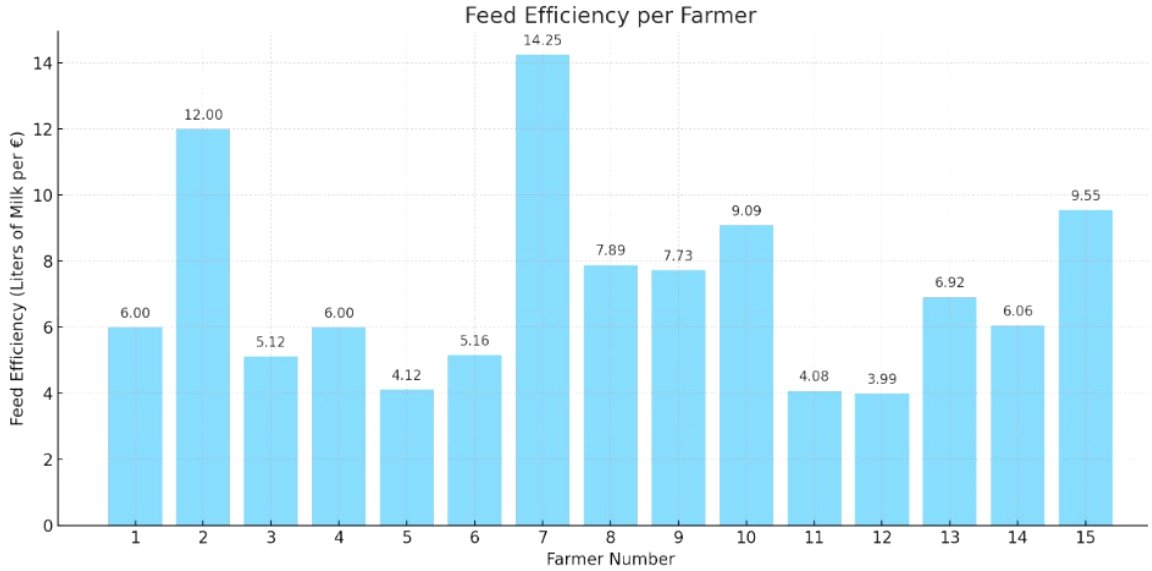

Figure 2. Feed Efficiency (L/€) for each farmer

It is more difficult to meet year-round milk production demands with a fluctuating output per cow and season, especially for large processors. Not all areas have sufficient or appropriate land to maintain year-round grazing systems, and limited land and poor land quality are a constraint on developing a pasture-based system in urban and arid regions, without substantial land use changes with significant environmental trade-offs. Pasture-based systems are considered by consumers to be more "natural" and better for the welfare of cows and the environment, and in Europe standards and targets are being set that will condition the grazing of dairy cows on pasture. As a result, we have an increase in dairy farms with pasture as a result of the rise in consumers who can pay more for milk produced in this way (Shortall, 2019). Pasture-based and improved farmer practices offer important solutions for more sustainable dairy farming, but they cannot be promoted everywhere and in all situations. Instead, they should be carefully assessed in their regional, economic and ecological contexts. This requires a careful assessment of local needs, production conditions and markets. Consumer demand for organic or grass-fed milk is growing, but it is still a niche and price-sensitive segment. In addition, there is also the risk of greenwashing, where the claims of superiority in production may not hold up to scrutiny,

potentially eroding any premium. Many governments offer subsidies, financial support, or technical assistance, and farmers with better education are more likely to be aware of and utilize these resources. Better financial and business planning education can improve a farmer's ability to manage finances, allowing them to budget more effectively, ensuring that profits from milk sales are maximized and save money on unnecessary expenditures. However, despite existing subsidies and assistance, the process of accessing them can be difficult. Farmers may face bureaucracy, unclear eligibility requirements, or uneven access, especially in areas with weak governance or institutional capacity. Farmers with education are more likely to adopt sustainable farming practices, such as efficient water usage, waste management, and eco-friendly feeding practices. These not only reduce costs but can also improve the long-term viability of their milk production. Educated farmers tend to be better at managing risks (e.g., disease outbreaks, fluctuating milk prices) and diversifying their income streams (Farooq et al. 2021). But in some cases, formal education could lead to over-reliance on external inputs or unadapted models.

Table 3. Correlation table of factors affecting dairy farm efficiency

	Farmers education	Family number	Cow shelter	Experience	Cow number	Milk economic income
Farmers education	1	0.444	0.037	0.035	0.363	.606 *
		0.098	0.897	0.902	0.184	0.017
Family number		1	-0.192	-0.06	.778 **	0.383
			0.494	0.832	0.001	0.158
Cow shelter			1	-0.139	-0.063	0.111
				0.622	0.822	0.693
Experience				1	-0.043	0.182
					0.88	0.516
Cow number					1	0.474
						0.074
	Beef cattle	Grazing	Feed type	Milk production	Work force	Concentrate cost
Farmers education	0.298	0.318	0.404	0.372		0.345
	0.28	0.248	0.135	0.172	0.488	0.208
Family number	0.496	0.399	0.383	.647 **	0.092	.744 **
	0.06	0.141	0.158	0.009	0.744	0.001
Cow shelter	0.431	0.289	-0.111	0.029	0.08	-0.048
	0.109	0.297	0.693	0.92	0.777	0.865
Experience	-0.076	0.085	-0.095	0.019	0.003	0.061
	0.788	0.763	0.735	0.947	0.992	0.829
Cow number	.739 **	0.259	0.403	.917 **	-0.057	.974 **
	0.002	0.352	0.136	0	0.839	0
Economic income	0.492	.577 *	-0.167	0.435	-0.08	0.457
	0.062	0.024	0.553	0.105	0.777	0.087
Beef cattle	1	0.426	0.123	.775 **	0.207	.758 **
		0.113	0.662	0.001	0.459	0.001
Grazing		1	-0.289	0.319	-0.139	0.306
			0.297	0.247	0.622	0.267
Feed type			1	0.21	0.08	0.332
				0.453	0.777	0.226
Milk production				1	0.003	.938 **
					0.99	0

Work force					1	0.001
						0.997

This helps stabilize their income and reduce the dependency on raw milk sales alone. In contrast, farmers with less formal education may face challenges such as difficulty adopting new technologies or techniques that could boost productivity (O'Donoghue and Heanue, 2018).

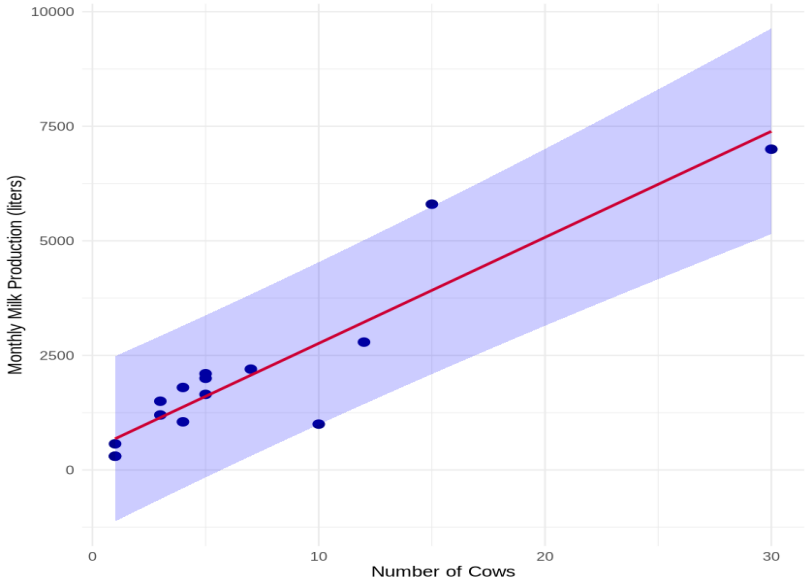

Figure 3. Regression analysis betwwen cows number and of milk yield

A **regression analysis** between **monthly milk production** and the **number of cows** would help determine how the number of cows on a farm influences the amount of milk produced in a given month (Figure 3). This kind of analysis can be useful for farmers to predict production levels and optimize farm management. The regression equation is: "y = 448.9 + 231.38x". This is a simple linear regression equation where: y is the dependent variable, x is the independent variable, 448.9448.9448.9 is the intercept, 231.38231.38231.38 is the slope (the amount by which y changes for each unit increase in xxx). For each unit increase in number of cows, the value of monthly milk production will increase by 231.3. While the number of cows is a critical factor in milk production, many other variables can influence the outcome such us cow breed where Some breeds produce more milk than others. Cow health is important since sick cows produce less milk. Whereas feeding and nutrition with adequate nutrition results in higher milk yields. Management practices also will influence milk production through improvement of milking frequency, hygiene, and care (Hennessy, 2020; Wilkinson, 2020).

Conclusions

Farmers were and are the cornerstone of the agriculture and dairy sector in the study region. This research presents interviews with farmers showing their challenges, fears, perspectives, desires, helping to reach a common solution on how the dairy value chain should be developed. It helps agencies to implement plans for the development of the dairy sector by enabling high standards of food safety while influencing the cultural identity of small farmers. The results showed that the traditions that farmers have inherited are still crucial in the dairy sector which means that they do not have access to modern technology and they fear the increase in the number of large dairy producers despite the fact that they cannot meet the essential market demands. The research also represents the obstacles that farmers face is completely unsimilar.

As the results of the survey showed, the fodder deficiency and its parameters are the significant obstacles that farmers dial. Sufficient pastures is not enough, financial support to buy what is needed for the winter season also prove a gap between farmers and government and industry. Further investigations should assess how non-nutritional farm management conditions (eg reproduction and genetics) and seasonal effects and climatic conditions affect farm rankings based on other nutritional and economic indices. In conclusion, enhancing the milk production efficiency of small-scale dairy farmers requires a comprehensive approach that addresses feed quality, animal health, market integration, and the scale of operations. By focusing on these areas, it is possible to improve the income of smallholder farmers and increase their contributions to domestic milk production. The relationship between **milk economic income** and **farmers' education** is strong. Education equips farmers with the skills and knowledge necessary to improve their farming practices, leading to higher milk production, better management of resources, and more strategic marketing. Consequently, educated farmers are more likely to experience greater profitability and financial stability from their milk farming operations. The investigations and reports confirm that higher grazing values, particularly in well-managed grazing systems, are linked to increased milk income due to higher milk yields, reduced feed costs, and potential market premiums for milk produced from pasture-based systems. However, successful grazing requires good farm management practices, adequate land, and optimal pasture quality to realize these benefits.

Acknowledgements

This investigation was realized in during the BSc project: Evaluation of the economic efficiency of milk production among farmers in the municipality of Želina, North Macedonia. "AlbaVet" Veterinary ambulance and local representative of Ministry of Agriculture from municipality of Zelina are acknowledged.

References

[1]. Alexanderson, M. S., Luke, H., Lloyd, D. J. 2024. Regenerative agriculture e in Australia: the changing face of farming, Front. Sustain. Food Syst. 8, 1402849.
[2]. Anzhany, D., Despal, Toharmat T, Rofiah, N., Nuraina, N., Hamidah, A. N., Cusiayuni, A. (2022). IOP Conf. Ser. Earth Environ. Sci. 951 012023
[3]. Atuhaire, A.M., Mugerwa, S., Kabirizi, J.M., Okello, S. and Kabi, F., (2014) Production Characteristics of Smallholder Dairy Farming in the Lake Victoria Agro-ecological Zone Uganda. Front. Sci, 2014, 4(1), 1-8.
[4]. Bartova, L., Fellmann, T., M'barek, R., (2009). Modelling and Analysis of the European Milk and Dairy Market. Office for Official Publications of the European Communities, Luxembourg
[5]. Ertl, P., Knaus, W., Steinwidder, A. (2014). Comparison of zero concentrate supplementation with different quantities of concentrates in terms of production, animal health, and profitability of organic dairy farms in Austria. Org. Agric., 4, 233–242.
[6]. Farooq, U. Ashraf, A. Ullah, S. Neelum, M. I., Khattak, S. W. Ghafoor I. (2021) The role of formal education infarm productivity and farmer's socio-economic development in district SWAT. Multicultural Education Volume 7, 9, 52-57.
[7]. Hennessy, D., Delaby, L., van den Pol-van Dasselaar, A., Shalloo, L. (2020)**.** Increasing grazing in dairy cow milk production systems inEurope. Sustainability, 12, 2443.
[8]. https://investnorthmacedonia.gov.mk/export-agrobusiness-and-food-processing// (20.12.2021).
[9]. https://ourworldindata.org/grapher/milk-production-tonnes?tab=chart&region=Europe&country=
[10]. https://www.google.com/maps/place/Municipality+of+%C5%BDelino/data=!4m2!3m1!1s0x135407084a97d15b:0x84ae0c3d5759e861?sa=X&ved=2ahUKEwjlrb_7k-P8AhVpxosKHbpfB8wQ8gF6BAg7EAE .
[11]. https://zhelina.gov.mk/
[12]. Katsande, S., Matope, G., Ndengu, M. and Pfukenyi, D.M., (2013). Prevalence of mastitis in dairy cows from smallholder farms in Zimbabwe. Onderstepoort Journal of Veterinary Research 80: 1–7.

[13]. Mateva, N., Levkov, V., Srbinovska, S., Santa, D., Mojsova, S., & Sulejmani, E. (2019). Characteristics of Traditional Cheeses Produced in the Republic of North Macedonia. In *Traditional Cheeses from Selected Regions in Asia, Europe, and South America*. (pp 1-52). Sharjah, Bentham Science Publishers.
[14]. Mavura, F., Pandhare, S. M., Mkoba, E., and Nyambo, D. G. (2022). Rule-based engine for automatic allocation of smallholder dairy producers in preidentified production clusters. Sci. World J. 2022, e6944151. doi: 10.1155/2022/6944151
[15]. Mishra, A. K, Louhichi K, Genovese G and Gomez Y, Paloma S (2023) Insights into land sizeand productivity in Ethiopia: What do data and heterogenous analysis reveal? Front.Sustain. Food Syst. 7:1057674. doi: 10.3389/fsufs.2023.1057674
[16]. Musitini, T, Muroiwa A M (2019). Market access and extent of commercialization among the smallholder dairy farmers in Zimbabwe Journal of Economics and Sustainable Development , volume 10 , issue 8 , p. 102 - 110
[17]. O'Donoghue, C., Heanue, K. (2018). The impact of formal agricultural education on farm level innovation and management practices. J. Technol. Transf. **43**, 844–863
[18]. Odhiambo, C.O., Ogindo, H.O., Wasike, C.B. and Ochola, W.O. (2019). Adaptation of Smallholder Dairy Farmers in South Western Kenya to the Effects of Climate Change. Atmospheric and Climate Sciences, 9, 456-478. https://doi.org/10.4236/acs.2019.93031
[19]. Reid, M., O'Donovan, M., Murphy, J.P., Fleming, C., Kennedy, E., Lewis, E. (2015). The effect of high and low levels of supplementation on milk production, nitrogen utilization efficiency, and milk protein fractions in late-lactation dairy cows. J. Dairy Sci.,98, 5529–5544.
[20]. Sembada, P., Duteurtre, G., Purwanto, B. P. Suryahadi, (2016). Improved milk production performance of smallholder farms in West Java (Indonesia). Trop. Anim. Health Prod. 48: 793-799
[21]. Shortall, O. (2019). Cows eat grass, don't they? Contrasting sociotechnical imaginaries of the role of grazing in the UK and Irish dairy sectors. J. Rural Stud., 72, 45–57.
[22]. Sipahi, C. (2022). The Effect of Different Environmental Factors on Milk Yield Characteristics of Holstein Fresian Cattle Raised with Different Production Scale on Teke Region of Turkey. *Sustainability (Switzerland)*, *14*(21).
[23]. Sulejmani, E. (2014). *Study on the specific chemical and biochemical changes in the beaten cheese during ripening*. Ss. Cyril and Methodius University.
[24]. Sulejmani, E., Beqiri, L., and Popeski-Dimovski, R. (2021). Effect of vegetable fat on the texture, colour and sensory properties of Macedonian white brined cheese. *Mljekarstvo, 71* (1), 25-34.
[25]. Sulejmani, Erhan., Iseni, Miranda. (2023). Sustainability and perspectives of the North Macedonian dairy industry. Journal of Agricultural Sciences (Belgrade) Vol. 68 , No. 1, Pages 19 – 41
[26]. van den Pol, A.; Becker, T.; Fernandez, A.B.; Hennessy, T.; Peratoner, G. (2018). Social and economic impacts of grass based ruminant production. In Sustainable Meat and Milk Production from Grasslands, Proceedings of the 27th General Meeting of the European Grassland Federation, Cork, Ireland, 17–21 June;Horan, B., Hennessy, D., O'Donovan, M., Kennedy, E., McCarthy, B., Finn, J.A., O'Brien, B., Eds.; European Grassland Federation EGF: Cork, Ireland, 2018; pp. 697–708.
[27]. Wilkinson, J.M., Lee, M.R.F., Rivero, M.J., Chamberlain, A.T. (2020). Some challenges and opportunities for grazing dairy cows on temperate pastures. Grass Forage Sci., 75, 1–17.