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ANALYSIS OF PROFITABILITY OF RAW MILK PRODUCTION IN DIFFERENT TYPES OF FARMS

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Purpose: The purpose of the lower paper was to analyze the profitability of milk production in different types of dairy farms. The economic aspects of milk production in different types of cow farming were presented. The profitability of milk production was analyzed on the basis of the financial results obtained by dairy farms as a result of selling raw material to the dairy plant.
Design/methodology/approach: The results were collected using a face-to-face interview method with the owners of the farms participating in the survey. The information obtained from the farmers included general data about the farm (e.g., size, owner's education, number of dairy cows) and detailed data underlying the milk payment for the two study periods, i.e., 2019 and 2020.
Findings: Profits received on intensive farms were several times higher than on other farms (11 times higher than income from milk sales on relict farms, 9 times higher than on low-budget farms, and 5 times higher than that received on traditional farms).
Research limitations: The stoping of operations on extensive farms is the most important limitation in further research work, due to the inability to obtain data to perform analyses on the ecomics of milk production in traditional and low-cost milk production systems.
Practical implications: Analyze the actual state of profitability of different types of experimental farms and identify corrective measures that can be taken on the farms participating in the study to improve the economics of production. Among the most important measures that can be taken by owners of low-budget farms are the improvement of the basic distinguishing features of milk quality, which are also the determinants of charging for milk. The work is addressed to both dairy farmers and processing plants, buying raw material.
Originality/value: Analysis of the economics of milk production on very small farms, which are not usually the focus of research teams. The analysis made it possible to point out to breeders of animals kept in the system of extensive production, opportunities to improve the quality of the raw material (milk). Useful forms of support were indicated, such as programs from which funding can be obtained (EU Funds).
Keywords: economics of milk production, dairy farm types, raw milk.
Category of the paper: Research paper.

1. Introduction

The changes taking place in the dairy industry are in response to the growing expectations of consumers, who are increasingly interested in the composition of food and its potential impact on health (Schultz, 2016). As a result, a variety of dairy products are appearing on the market, such as high-protein, lactose-free, probiotic-enhanced, reduced sugar/salt, fat, high calcium and magnesium products (Ahmandi et al., 2019, Ranadheer et al., 2018; Bousbia et al., 2017; Trajenr, 2018). When choosing food products, consumers are also increasingly considering the origin of food and sustainable production, both at the farm level and at processing plants (Scozzafava et al., 2020; Kalač et al., 2011). Currently, there is a global trend of increasing importance of local food origin (Brodziak, Król, 2017) and organic products (Merlino et al., 2021; Dabrowska et al., 2018; Harwood et al., 2018). This trend is in contrast to the earlier emphasis on high agricultural productivity and intensive animal husbandry, which were often associated with the industrialization of the agrifood sector.

Biological advances in dairy farming, as well as technological advances in cattle feeding and maintenance, have increased milk yields in dairy cows (Ziętara, 2010). In addition, increased milk production has translated into a favorable Euro exchange rate, encouraging exports. The abolition of milk quotas and the acquisition of European Union (EU) funding for restructuring and rational use of farm resources also led to an increase in raw milk production (Bórawski, Zalewski, 2018).

In the context of the volume of milk production in the (EU), Poland ranks fourth in terms of milk production in EU countries. There was an increase in the share from 8,07 to 8,87% after the UK's exit from the EU. A study by Stanuch and Firley (2021) found that the average increase in milk production in Poland over the 2015-2019 period was 2,3%. According to the National Center for Agricultural Support (KOWR), Poland is among the top EU countries in terms of he size of its dairy herd - just after Germany and France (KOWR, 2023).

Milk production is also important for national agricultural production. During the coronavirus pandemic, which was particularly difficult for the economy, there was an increase of about 3% in dairy production and milk purchases, as well as maintenance of dairy exports from the previous year. The progress in the milk production market was noted in the context of an 8,2% decrease in gross domestic product (GDP) in the second quarter of 2020 (with an increase of 4,6% in the same period of 2019) (CSO, 2021). According to Rutkowski (2020), Polish dairying had a real impact on mitigating the decline in GDP. The work of Kobialka and Nowak (2022) proved that the dairy industry proved resilient to the past pandemic crisis. At the same time, it was pointed out that the conflict in Ukraine had a direct impact on the volume of exports, since before the outbreak of war in 2021, countries involved in hostilities, such as Ukraine, Belarus and Russia, absorbed 5% of the value of dairy exports worth almost 130 million euros. Now there are new challenges that the dairy industry will have

to face, namely: the implementation of the Green Deal in agriculture and the global economic crisis (IPCC, 2023). Therefore, there is an expectation, dictated by the reduction of CO_{2e} emissions directed additionally at intensifying herd milk yields to protect the climate (Sorley et al., 2024). This is the most important method of reducing the carbon footprint on dairy farms, even on organic farms where animal nutrition is based on a pasture-based diet (Taube et al., 2024). The introduction of the aforementioned measures, combined with the increase in the economics of dairy production in Poland, is leading to the cessation of operations in small farming units. According to Szajder (2024), the number of dairy farms keeping cows fell from 180.8 thousand in 2022 to 173,3 thousand in 2023.

Among these farms, it's worth taking a special look at farms that produce milk, similar to hay milk. In 2016, the European Union recognized hay milk product as a "traditional specialty guaranteed" (TSG) under the names Heumilch/Haymilk/Latte fieno/Lait de foin/Leche de heno (Europex Commission, 2016). Fermented feeds such as grass or corn silage and genetically modified feeds are prohibited in the innovative hay milk production chain. Hay milk comes from cows fed only fresh grass or hay and a limited proportion of concentrated feeds in the ration (max 25%) (Rizzo, Hack, 2019). Supplemental feeds fed on pasture or hay include forage and/or leaves from rapeseed, corn, rye and fodder beets, hay, alfalfa and corn pellets (Agropolska, 2023). In a study by Alothman et al. (2019) and Palmieri et al. (2021) showed that respondents are interested in the local origin of food, and that environmental issues play an important role in hay milk consumption motives.

In addition, the researchers emphasize that the respondents had a positive opinion of hay milk and highlighted some needs for marketing implications of a product based on said milk for the Italian dairy sector. According to van den Oever et al. (2021) in Austria, about 15% of milk is produced on farms using hay milk standards for hard cheese production, mainly due to the low content of spores of butyric fermentation bacteria. Hay milk producers are also found in Australia, Ireland, Italy. In Poland, hay milk is produced only by the Agricultural Company of Juchów, which creates a production niche in this area. According to the owners of the farm, hay milk is characterized by better taste, without the smell of silage, and has a high content of health-promoting FAs from the omega-3 group, CLA and vitamins A and E (Agropolska, 2023). In some Western European countries, such as Germany, Italy, Ireland, Australia, the Netherlands, and the United States (US), there are already legal regulations for labelling milk as "pasture milk" (Kühl et al., 2017; Elgersma, 2012). This type of certified milk is of great interest to consumers and also to farmers who raise dairy cows on pasture. Hay milk is also a raw material for the production of long-ripened cheeses (Brändle et al., 2016; McSweeney, 2007).

Information on the management of dairy farms in the traditional system of milk production, also in systems similar to hay milk production, can provide a basis for the resumption of such farms, just as organic production is currently experiencing a renaissance. According to the authors of the presented paper, the analysis of economic data, obtained from all dairy farms,

is necessary because it allows the comparison of economic returns in different types of dairy farming. Farms that feed animals with food obtained from grazing animals as well as, hay or straw as the only roughage, are unfortunately slowly ceasing their activities. There is therefore a basis for research in the area of the economics of milk production on different types of farms. This is a contribution that can be the basis for improving techniques for obtaining such milk, ensuring its high physicochemical, microbiological and health quality, among other things, in terms of the presence of fatty acids positively acting on the human body (Kowalska et al., 2024).

Verification of management efficiency in agriculture and the dairy industry is relatively most objective in 2019-2020, prior to the pandemic and the outbreak of war in Ukraine, as these events have severely disrupted the Polish economy. Currently, the number of farms producing milk similar to "hay milk" limits the time of comparison, due to the negligible number of prosperous farms in 2024 that do not feed animals with fermented feed.

Taking into account the above presented aspects, the authors of the paper directed their research towards presenting the role, legitimacy, need and benefits that come from obtaining and producing milk from different types of farming, including extensive farming. Obtaining raw material from such a product has always been in line with consumer preferences. Taking this aspect into account and at the same time presenting the needs of dairy farmers and processors, the authors presented the problems to be confronted in the coming years.

2. Characteristics of the experimental farms included in the study

The differentiating factor between the farms that participated in the study, i.e. the experimental farms, was the type of roughage. The experimental farms were divided into research groups (A, B, C, D) with respect to the presence of pasture feeding, or TMR monodiet, and with respect to the presence and type of fermented fodder in the animal's feed ration (Table 1) On Group A (relict) farms, cows were fed without silage in the feed, on Group B (low-budget farms) grass haylage was present, and on Group C (traditional) and D (industrialized), corn silage was additionally present. On Group A, B, C farms, animals were fed in the traditional manner, along with summer pasture, while on highly industrialized (milk production of more than 400 thousand/year) Group D farms, balanced TMR feeding was used, in addition, herds were under the care of a zootechnician.

Table 1.
Characteristics of farms

Animal housing system	**Alkali-pasture,**						**Alkali**	
Feeding system	traditional		traditional		traditional		TMR	
Name of food group	relic		Low buget		traditional		industrialized	
Farm designation	A1	A2	B1	B2	C1	C2	D1	D2
Components of roughage								
Pasture greens	+	+	+	+	+	+	-	-
Haylage	-	-	+	+	+	+	+	+
Maize silage	-	-	-	-	+	+	+	+

Information on the volume of milk sales in a given year, milk yield, annual income, the amount of the protein surcharge and fat was obtained from the owners of the experimental farms by direct interview. The method of calculating the milk payment was a mapping of the Dairy Cooperative's Price List Regulations for 2019, 2020 and 2022, shown in Table 2.

Table 2.
Components of the milk price in relation to the Regulations on pricing raw milk from purchase at the Dairy Cooperative to which milk from the farms participating in the study is sold

Base components of the milk price in 2019 i 2020		**Value [PLN/L]**		**Base components of the milk price in 2022***		**Value [PLN/L]**
Chemical composition surcharges	per unit of fat (max 4,6%)	0,04		Surcharges or deductions for chemical composition	for a change in fat content ±0.1% from a level of 4.1%	±0,013
	per unit of protein (max 3,6%)	0,11			for a change in fat content ±0.1% from a level of 3.4%	±0,028
EXTRA quality surcharges	SCC <400.000/mL and/or TBC <100.000 cfu/mL	0,28		Deductions for out-of-class milk	SCC >400.000/mL and/or TBC >100 000 cfu/mL	0,74
Quantity surcharges	3-4,5 tys. l	0,10		Quantitative deductions	1-5 000 L	0,23
	>4,5-6,5.000 L	0,16			>5-10.000 L	0,13
	>6,5-9,5.000 L	0,18			>10-25.000 L	0,08
	>9,5-15.000 L	0,20			>25-50.000 L	0,07
	>15-300.000 L	0,22			>50-70.000 L	0,06
	>30-50.000 L	0,24			>70-100.000 L	0,04
	>50-100.000 L	0,26			>100-150.000 L	0,02
	>100.000 L	0,28			>150.000 L	-
Deductions for milk temperature	>6ºC	0,02		Deductions for milk temperature	>6ºC	0,02
Deductions for lack of up-to-date documentation		0,02		Deductions for lack of up-to-date documentation		0,02
				Deductions for chemical composition	Content of fat fat <3,1%	0,10
					Content of protein <2,8%	0,10

Cont. Table 2.

				Surcharge resulting from a cultivation contract		0,02
				Surcharge for continuity of milk supply		0,13
				Surcharge for control of milk performance		0,02
				Surcharge for the use of GMO-free feed		0,07
				Surcharge for kosher milk		0,02

* The base price of 1 l of raw milk calculated according to the GUS.

3. Analysis of the financial results obtained from the sale of milk to a dairy cooperative by experimental farms

The survey showed that farms belonging to specific categories (relict, low-budget, traditional, industrialized) differed in terms of farmland size. The average area of relict, low-budget and traditional farms ranged from 20 to 30 hectares. In contrast, industrialized farms were about 7 times larger, with an area of more than 150 hectares. As farm acreage increased, an increase in the size of dairy herds on farms was observed. The number of cattle in each group was as follows: group A - an average of 13,33 heads, group B - an average of 15 heads, group C - an average of 17 heads, group D - an average of 54 heads. The increase in the size of the dairy cattle herd also contributed to the occurrence of higher milk yields per dairy cow. Average daily milk yields per cow were: group A – 12,20 liters, group B – 13,20 liters, group C – 14,90 liters, group D – 24,90 liters. In addition, farms in group C sold 30% more raw milk than farms in groups A and B, which amounted to about 83.000 liters per year. Group D farms sold 8-9 times more raw milk than Group A and B farms, reaching sales of 429 thousand liters per year (Table 3).

Table 3.
*Selected determinants of profitability of experimental farm**

Characteristic of farms	**Food group**			
	A	**B**	**C**	**D**
Farm size (ha)	22,67	20,00	26,00	150,00
Age of farmers (years)	58,00	59,00	31,33	51,67
Number of people working on the farm	3,33	2,00	2,33	4,67
Income per person (PLN/person/year)	17.135,83	37.244,50	53.686,12	143.852,46
Number of milking cows on the farm (pcs)	13,33	15,00	17,00	54,00
Average daily milk yield per cow (L)	12,20	13,20	14,90	24,90

Cont. Table 3.

Average quantity of milk on the day of collection of raw material (L)	275,00	322,50	459,17	2373,33
Quantity of milk purchased during the year (L)	45.946,00	51.727,00	83.556,67	429.405,00
Average quantity of milk purchased per month (L)	3.828,83	4.310,58	6.963,06	35.783,75
Annual income (PLN)	57.062,33	74.489,00	125.088,67	671.791,67
Purchase price of milk (PLN/L)	1,22	1,44	1,49	1,56
Quantity of out-of-class milk (L)	23.788,67	1.529,67	2.293,67	0,00
Share of out-of-class milk (%)	57,05	3,00	3,33	0,00
Amount of deduction for out-of-class milk (PLN)	6.422,94	413,01	619,29	0,00
Fat content of milk (%)	4,00	4,18	4,25	4,14
Amount of aid oer fat (PLN)	16.606,00	18.419,00	28.914,00	153.871,33
Protein content of milk (%)	3,28	3,24	3,14	3,25
Amount of aid per protein (PLN/L)	7.375,67	8.649,33	14.200,67	71.134,00

* Calculations for food groups were made using the arithmetic mean of the data, using data from individual farms in 2019 and 2020.

The results obtained are consistent with the conclusions presented by Wysokiński and Jarzębowski (2013) and Skarżyńska (2020). The researchers proved that the more Polish farms are specialized in milk production, the higher the herd density, the higher the milk yield of animals, the greater the scale of milk production and the higher the prices obtained from sales. The work of Koloshych (2012) confirms that the lowest risk of decline in profitability of dairy farms occurs when the stocking density of dairy cattle is increased. Similar correlations between price and quantity of milk sold were also observed in the study. The lowest price for milk was obtained on farms in feeding group A. This was mainly due to the lack of a premium for the extra quality class and the weakest results in the physicochemical quality of milk, especially in terms of fat content (4,00%).

The highest prices and consistent high microbiological and hygienic quality of milk were obtained on industrialized farms, where the highest base price for milk sold was PLN 1,00/L (2019) and PLN 1,06/L (2020) (Table 2; Figures 1, 2).

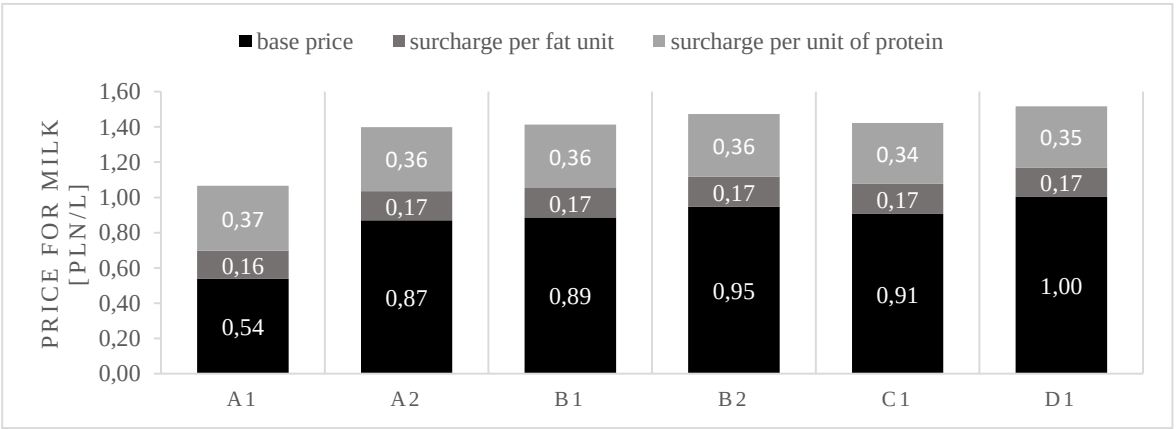

Figure 1. Milk farm gate prices for A1, A2, B1, B2, C1, D1, in 2019.

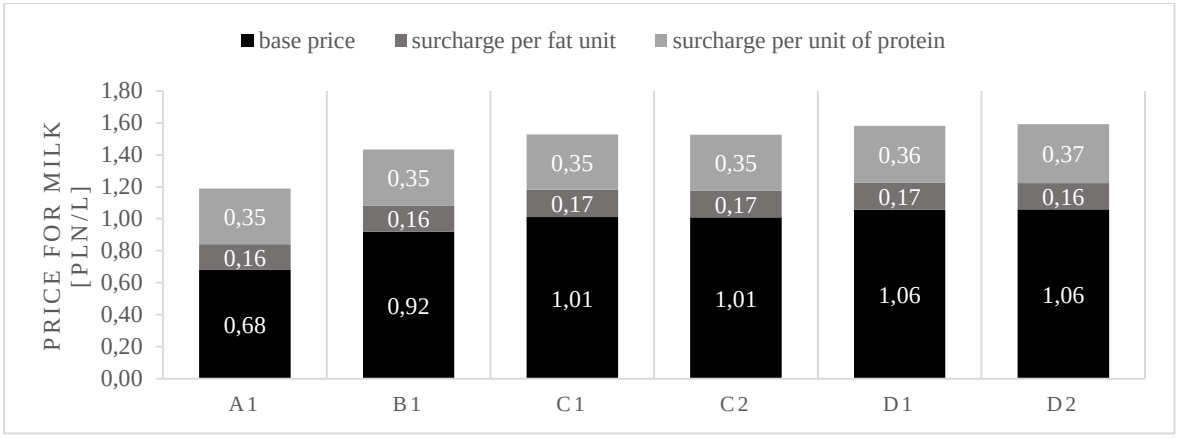

Figure 2. Milk farm gate prices for farms A1, B1, C1, C2, D1, D2, in 2020.

In the case of subsidies for fat content, it was noted that in the industrialized farms of group D, they amounted to more than 153 thousand in both the first and second years of the study, accounting for 12% of the total payment for milk (Figure 3, 4). The largest losses, due to improper microbiological and hygienic quality of milk, were observed in the farms of group A, which sold the most out-of-class milk to the cooperative (SCC > 400 thousand/mL, TBC > 100 thousand/mL). In the first year of the study, milk of improper microbiological and hygienic quality accounted for 92% of the milk sold from farm A1, 16% from farm A2 and 10% from farm C1. This generated serious financial losses, amounting to as much as PLN 10.000 a year for farm A1. On larger farms, problems with maintaining the microbiological and hygienic quality of milk were rare, and did not appear at all on farms with high production le vels - both in the first and second research seasons (Figure 1, 3).

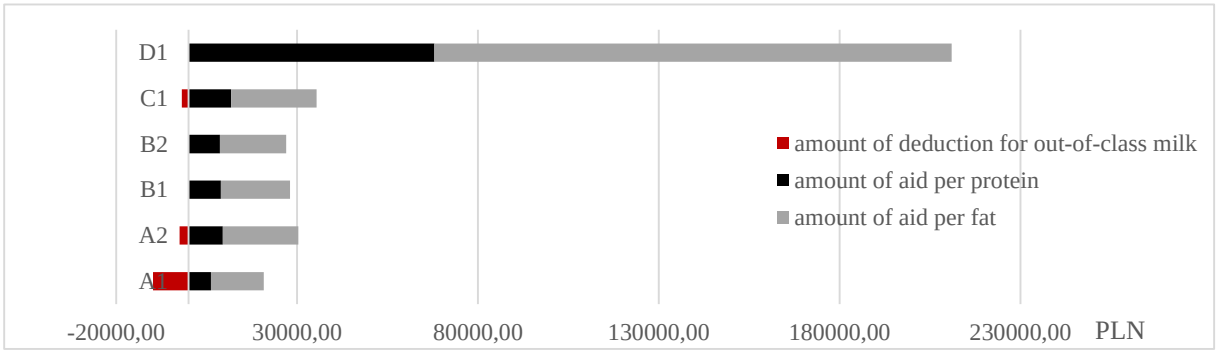

Figure 3. The amount of subsidies and quality deductions included in the price per liter of milk sold in 2019 in experimental farms A1, A2, B1, B2, C1, D1.

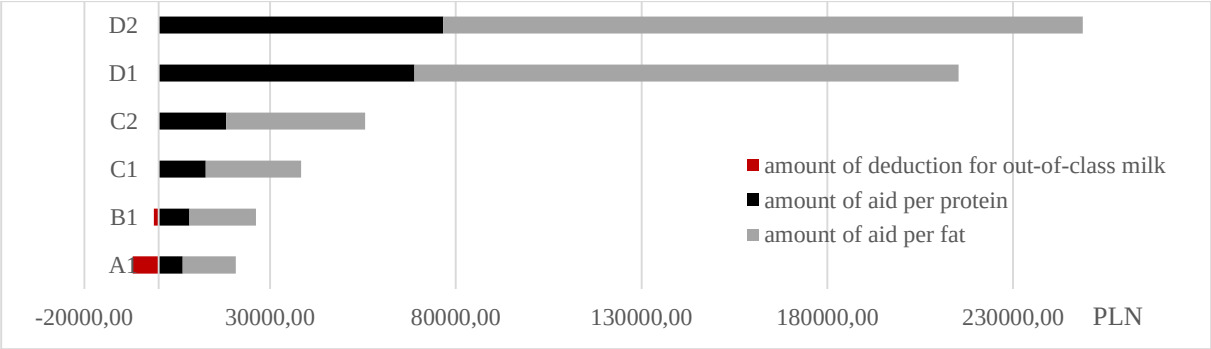

Figure 4. The amount of subsidies and quality deductions included in the price per liter of milk sold in 2020 in experimental farms A1, A2, B1, B2, C1, D1.

In 2023, of the eight experimental farms surveyed, only 3 dairy farms were operating, and their owners declared the presence of a successor. Due to the increase in the price of milk in Poland, published by the Central Statistical Office, by PLN 1,00/L in 2022 (CSO, 2022), the owners of the farms received a higher payment (the highest in farm B1 - Figure 5).

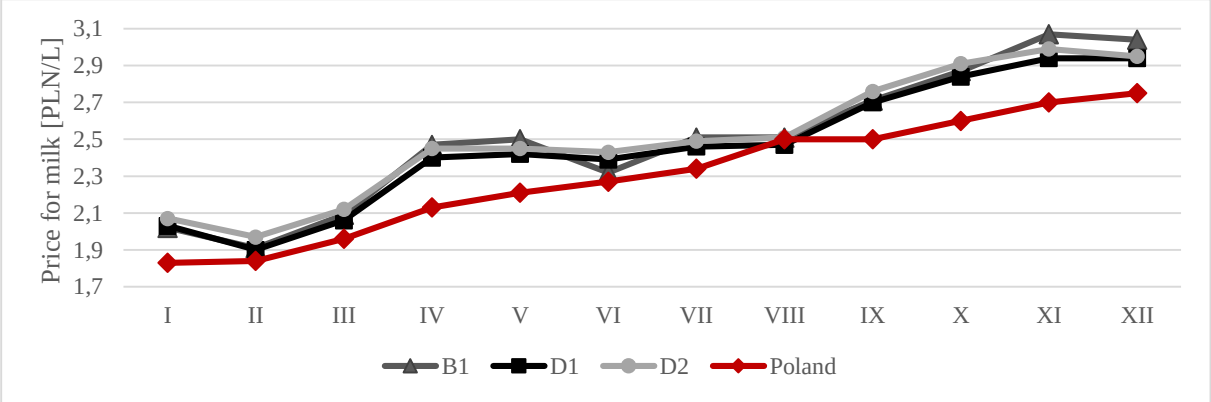

Figure 5. Variability of milk prices in selected experimental farms B1, D1, D2 in 2022 in comparison with prices quoted in Poland by the Central Statistical Office for the given period.

In 2023, difficult economic conditions caused five of the eight experimental farms to cease operation by April 2023. The price of milk fell sharply during this period, amounting to PLN 2,45/L in January, PLN 2,27/L in February and PLN 2,22/L in March (GUS, 2023). In addition, the dairy cooperative to which suppliers gave their milk made changes to the charging rules in 2022. There were modifications to the terms and conditions of milk sales that affected suppliers. Among other things, this was related to changes in surcharges for milk fat units. Starting in 2022, deductions were possible from the base fat content. Subsidies for the volume of milk sold were withdrawn, and deductions for small deliveries were introduced. The sale of 150.000 liters of milk per month entailed a reduction in the price per liter of milk by PLN 0,02/L. Milk of abnormal microbiological and physicochemical quality also lost its price value.

In the current difficult economic situation, it is crucial for dairy farmers to maintain high raw milk quality parameters and maximize the milk yield of their animals, which can help offset the negative financial impact associated with the drastic drop in milk prices in 2023 and the

deterioration of purchasing conditions in the cooperative. Propescu and Angel (2019) suggest that breeders should strive to improve milk quality, as this affects the price of milk. This can be achieved through the use of breeding programs, maintaining a short calving interval for animals, and proper management of reproduction and mating. The authors also recommend producing high-quality feed and a balanced diet to increase the milk yield of cows and obtain milk with high fat and protein content. It is also important to take care of the health of dairy cattle through proper milking hygiene, ensuring animal welfare, regular and rigorous control of the incidence of *mastitis* in the herd, and keeping the level of somatic cells count (SCC) and total bacteria cout in milk (TBC) below the maximum thresholds set by law.

According to Prospecu and Angel (2019), managing a dairy cattle farm requires certain skills of the owner, such as managerial ability, knowledge and practical experience in the technologies used, such as cultivation, breeding, reproduction, feeding, reproduction and milk yield of animals. The owner of the farm should also take into account financial aspects, such as gross income, production costs and the level of profit earned, when making decisions about the operation of the farm.

According to GUS data (2023) on farm prosperity in the second half of 2022, individual farm owners reported that the material situation had deteriorated for 43% of the farms surveyed. The main factors limiting the development of farms according to the owners were too high production costs (26,5%) and too low selling prices (18,1%). Other limiting factors were indicated by 37,8% of the surveyed farms, of which unfavorable weather conditions were mentioned most often (GUS, 2023). Popescu and Angel (2019) indicate that there are also external factors that affect the price of milk. These include the geographic area where the farm is located, due to specific climatic and soil conditions.

4. Support aimed at owners of dairy farms

For smaller dairy farmers, the European Union has proposed a systemic solution under the Common Agricultural Policy for 2023-2027, called area-based ecoschemes (RMRiRW, 2023). Ecoschemes are paid agrotechnical practices that adapt to national conditions and needs, and their effectiveness is evaluated by the European Commission in terms of achieving environmental and climate goals. Paid agrotechnical practices include the protection of soil, water, climate, animal welfare and biodiversity resources in agricultural production. There are 5 surface ecoschemes and 1 animal welfare ecoscheme. The conditions for sustainable agriculture are aimed at small farms, and farmers can receive subsidies of up to 4.000 PLN per hectare of farmland by meeting the program's objectives (RMRiRW, 2023). This can help improve the economic situation of participating farms.

Another existing financial support program is the subsidy for organic farming, which takes into account the area of farmland and the premium for sustainable crop-animal production. This program covers both the period of conversion of farms from conventional to organic systems and the period after conversion. According to the Ministry of Agriculture and Rural Development (MRiRW) (2023), payments per hectare of farmland are on average 35% higher compared to the rates in effect in 2021, and up to 85% higher compared to the rates in 2015. Organic payments in 2023 and proposed subsidy rates depend on crop group and conversion/post-conversion period (MRiRW, 2023).

Dairy cooperatives have the opportunity to regulate milk quality parameters through additional payments. The dairy cooperative's price list can include subsidies for the use of certified non-GMO feed, premiums for selling milk that meets kosher requirements, premiums for signing a supplier contract with the cooperative, and subsidies for the use of dairy performance monitoring in the herd. In some countries, dairy producers receive additional compensation for milk from pasture-grazed cows, such as in the Netherlands (Elgersma, 2012). In Brazil, subsidies paid by dairy cooperatives for low SCC) and TBC content have contributed to significant improvements in raw milk quality (Botaro et al., 2013). In Austria, price subsidies operate for both organic milk production and hay milk. In 2018 in Austria, the price of conventional milk was €36,84 per 100 kg, hay milk €43,7/100 kg, organic milk €50,5/100 kg, and organic hay milk €55.3 per 100 kg (Zooassets, 2023). In Germany, there is a surcharge for "pasture milk" (labeled with the EPRO PASTURELAND certificate). Pasture milk can be sold year-round under the EPRO PASTURELAND certification, even if cows are on pasture for at least 6 hours a day for 120 days a year (Breeding and Raising Cattle, 2023).

Studies by Rembeza and Seremak-Bulge (2010) and Szajner (2017) indicate that providing up-to-date information on milk procurement prices to dairy farm owners and dairy cooperatives makes it possible to forecast and monitor milk prices. The work of Śmigielska (2023) describes a model for predicting milk procurement prices, which is based on an analysis of price quotations for basic dairy products. The study showed that the price of raw milk depends on the prices of skimmed milk, butter and Edam cheese in more than 85% of cases.

5. Conclusions

A price analysis of the payment for milk sold received by the owners of the farms participating in the experiment found that industrialized farms made significantly higher profits from milk production than relic, low-income and traditional farms. Profits on industrialized farms were 11, 9 and 5 times higher than on the other farm types, respectively. The price per liter of milk was highest on industrialized farms due to additional subsidies associated with the high volume of milk sold and the high physicochemical and microbiological quality of raw

milk. High standards of quality and hygiene on dairy farms and high milk yields of dairy cows were key to favorable economic results. On Group A farms, lower profits from milk sales were due to poor hygienic and microbiological quality of milk, which resulted in the deduction of part of the payment, i.e. PLN 0.27/liter of off-grade milk, by the dairy, which meant a loss of 20% of the milk payment.

In general, it should be stated that owners of extensive farms, in order to survive unfavorable economic conditions, should first of all take care to improve the microbiological and hygienic quality of milk. The primary means to achieve this is to improve animal health and milk yield.

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