Article

Organic milk production sector in Poland: driving the potential to meet future market, societal and environmental challenges

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Abstract: During the pandemic, health and environmental issues were re-evaluated stimulating interest in organic food. Organic milk is more beneficial than conventional milk in terms of the health-promoting substances (e.g. vitamins, fatty acids), particularly regarding protein fraction and lipid fraction. Poland is the main producer of cow's milk in the EU, but only 0.2% of this production is organic. To identify the antecedents and obstacles to increasing organic milk production in Poland, the aim of this study is to explore the low level of organic cow's milk output in Poland compared with sector leaders in the EU. We analyzed statistics on milk production, including unpublished data collected by Agricultural and Food Quality Inspection, Poland with the use of descriptive statistics and frequency distributions. Over the period 2010-2020, the number of farms producing and selling organic milk and the number of farms with organic pastures and meadows decreased significantly in Poland. Limited number of certified farms sell their milk as organic. If all production of organic milk was sold as organic, the supply would have increased by 56% in 2020. Organic milk processing is highly concentrated which is an obstacle to the development of organic milk farming. Due to high instability and spatial differences in the locations of sellers (producers) and buyers (processors) and inconsistent production volumes, the supply of organic cows' raw milk does not meet the demand from Polish dairies. Cooperation between producers and processors is essential. Providing organic dairy farms with production and market advice and technical support is crucial for the development of farms and organic milk sector as a whole as is to a certain extent evidenced by Austria. The specific nature of the raw milk market requires the procurement of organic milk on a lasting basis regarding guarantees of purchase and farmgate prices. In this way, the continuity of organic raw milk supply would be secured and the sector of organic dairy products should grow.

Keywords: organic dairying; raw milk production; milk processing; market potential; cow's milk

1. Introduction

The COVID-19-pandemic-related lockdowns caused food supply chain disruptions across the world but also resulted in positive health and environmental shifts in food consumers' behaviors and preferences [1–4]. Both the health and environmental issues associated with food supply were re-evaluated during this crisis situation which has stimulated interest in organic food in several European countries including Poland and the United Kingdom (UK) [5]. As a result, there was a rapid increase in the sales of organic food and drink in some countries, including the UK [6,7].

On the European Union (EU) Organic Day, 23 September 2022, the EU Agriculture Commissioner, Janusz Wojciechowski, stressed that organic production can increase the resilience of a food system by making it less dependent on unsustainable inputs (e.g., artificial and fossil-fuel-derived fertilizer) from unreliable trade partners, a concern in these unstable times [8]. He referred to the economic, social and environmental benefits of organic food production, a sustainable food system, which lies at the center of the European Green Deal (EGD) and the Farm to Fork strategy. The development of the organic farming systems fits with the President of the European Commission, Ursula von der Leyen's, vision for a greener Europe: "Climate change, biodiversity, food security, deforestation and land degradation go together. We need to change the way we produce, consume and trade. Preserving and restoring our ecosystem needs to guide all of our work" [9]. This vision underpins the proposal for the EGD, the Biodiversity Strategy 2030, the Farm to Fork strategy and the European Climate Law [10]. Under these schemes, the action plan for organic production foresees that 25% of the EU's farmland will be under organic agriculture by 2030 [11,12].

It is expected that the conversion to organics is stimulated at EU and national member state level. Encouraging action by potential stakeholders has a profound significance to effect change, even if this seems to be unrealistic given the targets. Three different driving forces have been identified for the adoption of organic farming systems: (1) the pull of consumers and market i.e., conscious consumers having a strong influence over the 'demand' for organic production; (2) the stimulation of environmental goods and services through EU subsidies for organic agriculture to provide environmental goods and services; and (3) farmers self-selecting and converting to organic farming to improve their family health, farm economies and/or self-reliance [13]. Organic farming is more efficient in its use of non-renewable energy, maintains or improves soil quality, which is important in the context of worldwide land multi-degradation [14], and has a less detrimental effect on water quality and biodiversity [15–17]. However, organic farmers should be open to new emerging technologies and methods to further improve their performance regarding their efficiency achieved in agricultural, crop and animal production, which is usually lower than the result obtained in conventional farms [18].

The proportion of organic dairy production has increased globally [19]. The EU and one former EU member state's (MS) production of organic cow's milk has been growing steadily. Over the period of 2007–2021, it increased by 164% to 6.4 million tons [20,21]. In 2021, over 41.7% of the EU's organic agricultural land was covered by permanent grassland [7] and this is essential for the further development of organic dairy cattle farming [22–24]. However, there is a trade-off between environmental issues related to greenhouse gas emissions (GHGEs) from the production of milk, human health and economic issues. In 2021, the volume of organic cow's milk production in the EU and the UK accounted for 3.80% of the total milk production, i.e., 1.3 percentage points more than in 2016. This increase in the market share of organic cow's milk production may be due to numerous factors related to economic, environmental, social, organizational or technological concerns, which are explored further in the study. Currently, there are six EU and one former EU MSs producing organic cow's milk with the combined share of 85.5% of total EU production. These countries are not only countries specializing in cow's milk production, such as Germany (32.5 million tons in 2021), France (24.8 million tons), Italy (13.2 million tons) and the UK (15.7 million tons), but also countries with average milk production, namely Denmark (5.6 million tons), Austria (3.8 million tons) and Sweden (2.8 million tons) [21].

The total milk production and average milk yield per cow have increased in recent years, both in Poland and in the EU, whereas the number of cows has decreased [25]. In 2021, Poland's production of cow's milk was 14.9 million tons, the third biggest producer in the EU27, but the production of organic milk was 33.4 thousand tons, just 0.22% of its total milk production (Table A1 in Appendix A). Indeed, Poland, Croatia and Ireland were at the bottom of the 2021 ranking of EU MSs in terms of their organic share of total cow's

milk production. The largest share of organic milk, as a proportion of the total production, was in Austria (17.3%), Sweden (17.3%) and Denmark (13.2%). Together with the other main producers of cow's milk (Germany, France, UK, the Netherlands, Italy), Poland has been systematically increasing its total milk production in recent years (Table A1 in Appendix A). Even in EU countries where total milk production is low, such as in Lithuania and Latvia, or at an average level, such as in Finland or Romania, the production volume of organic milk in 2021 was higher than in Poland and, in most cases, it has increased in recent years (Table A1 in Appendix A).

Milk processing in Poland is a developed and efficient industry. In 2021, 143 Polish companies, employing at least 10 people, were involved in milk processing. Most of the companies were profitable and the industry maintained financial liquidity [26]. There are also over 800 micro enterprises whose production value is small and accounts for 1.4% of the Poland's annual dairy industry production value of EUR 8.7 billion [21]. For almost 30 years, a process of production and processing rationalization has occurred, driven by the positive effects of concentration, such as greater export opportunities [27]. However, recent research shows the saturation of the Polish dairy sector within the intense consolidation process. Due to structural changes in the milk processing sector, small dairies need to find a market niche if they want to compete with large units [28]. Despite the growing volume of exports of dairy products, which has been particularly dynamic since Poland's accession to the EU [29] (by 150%, to 4.8 thousand tons in the 2021 milk balance sheet), domestic consumption is still the primary market for the milk produced. Domestic dairies ensure food security further, as dairy plants in each of the Polish regions offer a wide range of dairy products [30].

To identify the antecedents and obstacles to increasing organic milk production in Poland, the aim of this study is to explore the low level of organic cow's milk output in Poland compared with sector leaders in the EU.

2. Literature review

The development of responsible consumption and production patterns, (SDG 12), is one of the Sustainable Development Goals (SDGs) of the 2030 Agenda and organic production plays a fundamental role in meeting these objectives [5]. The agri-food sector provides humanity with food security, but also has a negative impact on the environment, often monitored and measured in terms of GHGEs, land use, freshwater use, eutrophication or biodiversity loss [31]. The agri-food sector can have positive effects on the environment through the provision of natural life, the production of oxygen, the maintenance of rural landscapes and the provision of environmental services [32]. Sandström et al. [33] quanti- fied GHGEs from food production, land-use change and trade arrangements for individual food groups, finding that the majority of GHGEs result from land use change and farming (methane emissions from cattle, management of manure, fertilizer use). Dairy products account for 25% of the GHGEs associated with the average EU diet, notably because milk is a dietary staple across the world. Various options are suggested to reduce this negative impact: a reduction in milk consumption and switching to plant-based alternatives, as suggested in the Planetary Health Diet [34,35]. Organic farming shows the potential to bring simultaneous improvements in the global and local environmental performance of dairy farming [36].

Environmentally responsible food production management systems include organic agriculture, which is described as:

"A holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. [. . .]" [37]

In the EU, organic production is strongly supported by politicians who influence the creation of socio-economic policy across the region. Common actions related to tackling

climate change and environmental degradation include fostering the growth of the EU organic agricultural sector. Organic agricultural practices aim to preserve environmental health, biodiversity and biological soil activities, and organic food is based on the natural cycle of the conservation of resources [38]. Organic farmers do not use high solubility fertilizers and pesticides which potentially has a beneficial effect on their health. Every certified organic food producer has to comply with the requirements set by relevant legislation, including Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on the organic production and labelling of organic products. There are strict organic livestock production rules included in Regulation (EU) 2018/848 that have to be met to meet the certification body's and consumers' high production, animal welfare and environmental standards [39]. The totality of these requirements for production affects the fixed and variable costs on the supply side and are reflected in the final price [40]. Premium prices for organic products are rationalized in agri-food markets because of the relatively lower yields and higher production costs, and the presence of certification costs [41]. Higher prices are also a consequence of the widespread perception that organic products are more nutritious and are safer foods compared to the conventional alternatives [42]. Kushwah et al. [43] state that barriers to organic food consumption are common, including high price, limited trust, lack of availability, convenience, knowledge and information, and doubts about labeling and certification. However, these barriers, such as trust and belief in the 'organicness' of the produce, may vary between countries [44], with different levels of organic food production, export activity or size of organic market [45]. The key barriers to organic food market growth in Poland are indicated as being high prices, insufficient consumer knowledge, and low availability in stores [46,47]. The choice of organic food is also influenced by the growing pro-ecological attitudes of buyers, and an altruistic approach to how their purchasing decisions affect the natural environment [48]. The main barriers to organic production highlighted by Polish farmers are the high costs of production, considerable labor input, low yields, uncertain sales, market uncertainty, receiving of inadequate prices for organic products and legal requirements. Further barriers to organic sales for processors, distributors and retailers are legal concerns, an inconsistent supply of organic raw materials and an increased competition in markets [49–51].

Although there has been a common EU legal framework for organic food production in over 20 countries since 2004, there are still significant differences between organic agricultural products' supply and organic food demand across Europe.

In 2021, Switzerland had the highest per capita consumption of organic food in the world (425 EUR), followed by Denmark (384 EUR), Luxembourg (313 EUR), Austria (268 EUR) and Sweden (266 EUR) [7]. Organic food purchases were quite low in terms of per person spending in Poland (8 EUR), Bulgaria (5 EUR), Czechia (22 EUR in 2020), Croatia (24 EUR), Ireland (47 EUR in 2020) and Estonia (70 EUR), and remained far below the EU average at 104 EUR per capita in 2021 (66 EUR for Europe) [7]. However, these latter countries also have the smallest organic share of total cow's milk production among all the EU MSs (see Table A1 in Appendix A). The growing demand for organic food imposes a pressure on the national organic food sector [52] and gives a boost to the development of organic agriculture, initiating the process of dairy farms converting to organic farming [25]. With organic milk production in particular, high demand uncertainty, economic shocks, environmental changes and the perishable nature of the product are particularly challenging [53]. The basis of the development of organic dairy farming is the effective functioning of the milk collection system. The small dairy farms, which are widely scattered, dominate in Poland, and this creates major logistical challenges regarding milk collection, taking into account the physiochemical properties of raw milk and economic viability of dairies (recipients) [54]. The connection between the links of the milk chain will impact the agility and development of the organic milk production sector. Thus, the following research questions (RQs) arise:

RQ1. Of the EU countries with a high proportion of organic milk production, how have they specialized to deliver this objective? Three countries are considered: Austria, Sweden and Denmark.

RQ2. How does the current structure of the Polish organic milk production sector impact on the ability of the sector to be agile in meeting market needs?

3. Materials and Methods

In order to frame the research, an exploratory, purposive, snowball review of the academic literature, and recognized bodies' reports, was employed (reports drawn up by the Research Institute of Organic Agriculture FiBL, Frick, IFOAM-Organics International, E.I.T. Food, Agricultural and Food Quality Inspection, Poland (IJHARS)). The databases used to consider the current information on organic milk production in Poland and Europe were Science Direct, Google Scholar and Google. The ultimate source of the data analyzed was the unpublished data collected by IJHARS from individual farms, covering the years 2010, 2016 and 2020. These data made it possible to carry out a robust analysis of the organic milk production in Poland, including the population of farms that continued or ceased organic production over the investigation period. We also used publicly available secondary data from Eurostat and CLAL, IJHARS reports on organic farming in Poland and the statistical yearbook "The World of Organic Agriculture. Statistics and Emerging Trends" published by the Research Institute of Organic Agriculture FiBL, Frick, and IFOAM- Organics International. The last available data regarding milk production are from 2021. The data for years 2004–2021 were analyzed, although the beginning of the period during which the research was conducted varied, depending on the availability of data. Descriptive statistics and frequency distributions were used for data analysis. The calculations were performed using Excel. The article includes a comparative analysis in time and space, at national and international level.

4. Results

4.1. Review of situation in Austria, Sweden and Denmark

Austria, Switzerland and Scandinavian countries (Sweden and Denmark in particular) have had the highest percentage of dairy cows in organic herds over the last two decades [19,55]. Austria has also been a leader regarding the proportion of dairy farms certified to produce organic milk. Furthermore, the percentage of organic dairy farms in Austria has been on the rise since 2005 [19]. Given that Austria is one of the three countries in the world with the highest share of organic agricultural land in terms of total farmland (26.5% in 2021) compared to the global average (1.6%), European average (3.6%) and the EU average (9.6%), it can be assumed that there are favorable conditions there for developing the organic dairying sector. Indeed, almost 60% of countries worldwide, for which data are available, have less than 1% of their agricultural land under organic management [7]. Sweden and Denmark are among the top ten EU countries with the highest organic share of total agricultural land, so the situation is similar to Austria. In 2021, this was 20.2% of total land for Sweden and 11.4% for Denmark, comparing with Hungary (5.9%), Poland (3.5%) and Ireland (1.9%) [7], the countries with the lowest organic share of total cow's milk production in the EU (Table A1 in Appendix A). Furthermore, Austria was ranked sixth among the EU countries in terms of the area of permanent grassland under organic management [7]. Organic milk production, especially in mountainous regions, is strongly linked to permanent pasture that primarily delivers grass-based forage feeding for rumi- nants. By contrast, in a conventional lowland dairy system, grain feeding levels, breed selection to increase cow milk yield and the use of fossil-fuel-based fertilizers to increase forage yields are important [56]. The milk yields achieved by organic herds are lower, by 15–28%, than the yields per typical conventional cow [22], impacting the efficiency of dairy farms. In organic farming, animals should be

fed with the farm's own feed; the use of external feeds is therefore limited. As a result, the number of animals within the herd is related to the area of pasture [57].

In 2021, the organic food market share of the domestic food market was estimated at 13.0% in Denmark (1st position in Europe), 11.6% in Austria (2nd), 11.0% in Luxem- bourg (3rd), 10.9% in Switzerland (4th) and 8.9% in Sweden (5th). Furthermore, Austrian consumers seem to have become more conscious about health and provenance over the pandemic that, inter alia, has resulted in a further increase in the sales of organic food and drink. In 2020, organic retail sales in Austria increased by 18% and another 6% in 2021 [58]. In Denmark, organic milk has a strong market share (average in different prod- ucts 27%), similarly in Austria (14%) and in Sweden (8%). General retailers have been strongly involved in the growth of the organic market in Denmark, Austria, Switzerland, Sweden and the UK, while specialized retailers have had a significant role in organic market development in France and Italy [7,59].

Austria is an example of a country where the significant role of small-sized shops, which are specialized in organic foodstuffs, has been gradually decreasing [60,61]. In Austria, Switzerland and Germany there has also been a close cooperation between food retail chains and organic associations e.g., Bio Austria, Bio Suisse [20]. Austria has created beneficial conditions and opportunities for organic food market development by (i) the relatively early introduction of national law on organic farming, (ii) the systematic undertaking of promotional activities to raise awareness of organic food benefits, and (iii) the transfer of advice, expertise and training in the food supply chain [59]. Some research results show that most German respondents picked Austria and Switzerland as the most trustworthy producers of organic food among ten European countries [62]. In the same study, Spain and Poland were perceived as the least trustworthy among the listed European countries, due to, inter alia, perceived lower quality and scandals associated with high pesticide usage, which contributed to a poor ecological image. However, due to the cognitive problems arising during the surveys, e.g., illusory correlation, the results of consumer studies need to be interpreted cautiously [63]; on the basis of the available evidence, it can be questioned whether Poland can move from its current milk market structure to one of organic specialization.

4.2. Review of situation in Poland

Polish milk production concentrates on cow's milk and the cumulative share of sheep's and goats' milk has been very low for years (0.1% in 2021) [21]. In the years 2004–2021, the total production of cow's milk grew by 25.9% to 14.88 million tons, mainly due to yield improvement (by 69% to 7312 kg/head). The number of dairy cows decreased by 25.5% to 2.04 million heads within that time period [21]. Organic cow's milk production dropped significantly over the period 2012–2015 and then remained generally at the level recorded in 2005 (25–26 thousand tons). However, a slow increase in production to 33,419 tons has been observed over the last two years. The number of organic dairy cows in Poland almost halved (to 12.1 thousand heads) over the period 2010–2021 (Figure 1).

Although the milk processing base in Poland expanded significantly to 943 organizations in 2021 (by 43.8% since 2009), most of these entities are micro-enterprises (employing up to 9 people) (Figure 2). Their market share increased from 63% in 2010 to 80% in 2021. The dynamic increase (9 fold) in the number of organic dairies since 2009 has translated into a gain in market share (from 0.61% (n = 4) to 3.71% (n = 35)). There are European countries where at least one in three milk processors produces organic dairy products (Czech Republic, Denmark, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Finland, Sweden and the UK). Thus, it can be asserted that there are a limited number of organic milk processors in Poland, translating into the slow development of the organic dairy sector (Table A2 in Appendix A).

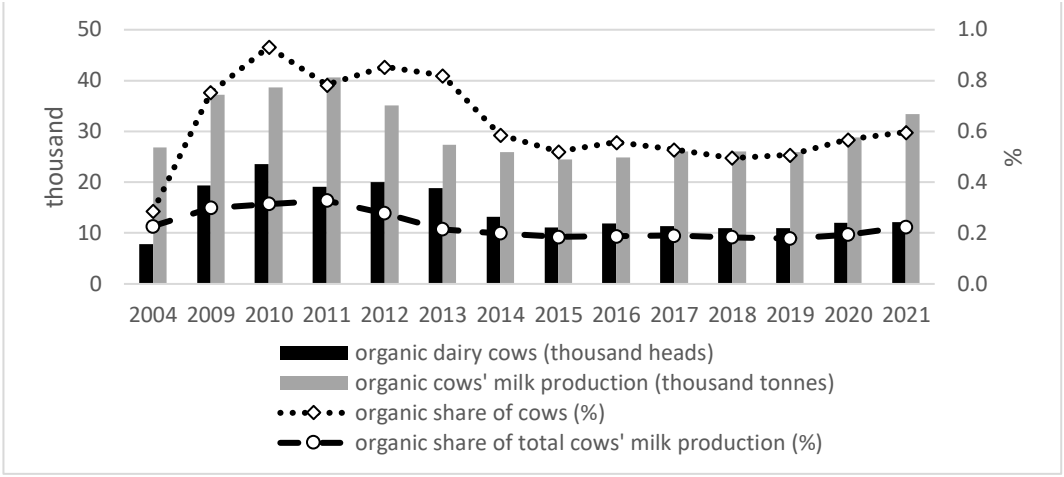

Figure 1. Organic cows' milk production in Poland (Source: own work based on Eurostat and IJHARS data).

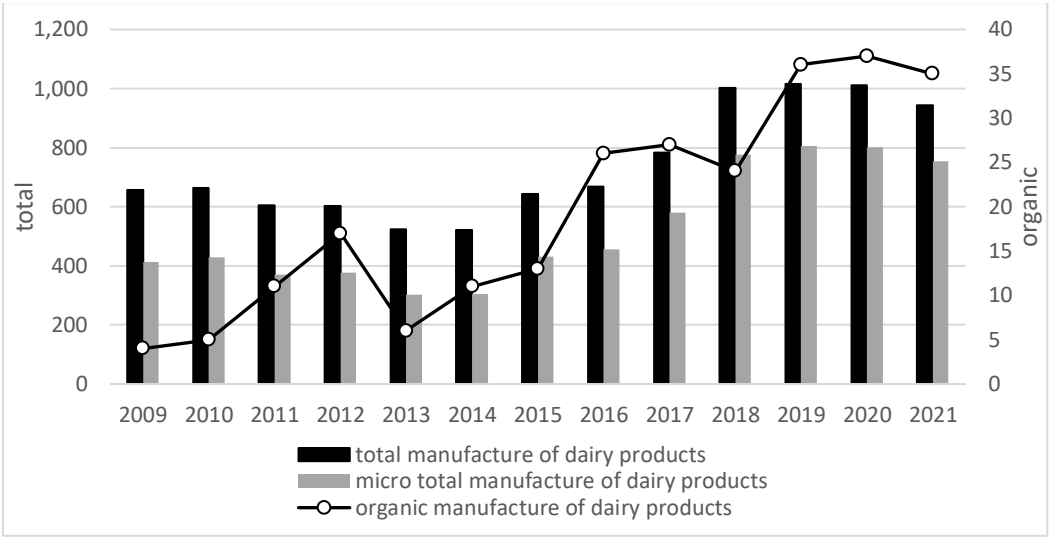

Figure 2. Number of manufacturers of dairy products in Poland (Source: own work based on Eurostat data).

From 2010 to 2020 in Poland, the number of certified farms with dairy cows and the number of farms producing and selling organic milk decreased fourfold, whereas the number of farms with pastures and meadows certified as organic decreased fivefold (Table 1). Only some of the certified organic dairy farms actually sell their milk into the organic market, and not all of them have meadows and pastures certified as organic. The average herd size grew from 5.9 to 13 head per farm from 2010 to 2020 (Table 1). This was mainly due to the decrease in the number of farms with organic cows (by 76.8%) rather than the decrease in the number of certified dairy cows (by 49.2%). The volume of milk produced and sold by an average farm increased by 228% to 58 thousand liters, due to the decline in the number of farms selling milk (by 74.8%) rather than the decline in the volume of organic raw milk sold (by 17.4% to 28.5 million liters). The area of organic meadows and pastures used by farms keeping dairy cows decreased by over 65% to just 11.9 thousand hectares. However, taking into account the rate of the decrease in the number of dairy farms with certified meadows and pastures (79.6%), the average area of organic meadows and pastures per farm increased from 10.4 to 17.7 hectares.

Table 1. Characteristics of organic cow milk farms in Poland (Source: own work based on unpublished IJHARS data).

Number of certified organic cow milk farms			
	with cows	producing and selling organic milk	with organic meadows and pastures
2010	3935	1946	3308
2016	1443	834	1323
2020	913	490	675
Average size of an organic cow milk farm			
	herd size (heads of cows)	volume of milk sales (thousand liters)	area of meadows and pastures (hectares)
2010	5,9	17,7	10,4
2016	8,1	28,6	11,5
2020	13,0	58,1	17,7
Unsold production in certified organic dairy farms			
	number of cows from which no milk has been sold (thousand heads)	milk produced but not sold (million liters)	marketability of production (%)
2010	11,4	32,5	51,4
2016	5,3	19,7	54,8
2020	4,3	16,0	64,0

Using unpublished IJHARS data, it can be demonstrated that the average organic milk yield of cows was 2863 L/head in 2010, 3710 in 2016 and 3739 in 2020, respectively, 61%, 62% and 58% of the average national milk yield of cows [26]. Thus, low milk yield may constitute a barrier to the further development of the organic dairy industry in Poland. Considering the average organic milk yield of dairy cows from farms selling milk and the number of cows on certified farms that did not sell milk, it was possible to additionally sell over 16 million liters of organic milk in 2020, which accounted for as much as 56% of actual sales (94% in 2010 and 83% in 2016). A positive trend is the increase in the marketability of organic milk production to 64% in 2020 (Table 1), but it is still much lower than for the entire dairy sector in Poland (over 87%) [26]. A high supply of organic milk depends, namely, on a large number of dairy cows and a high share of farms selling milk to dairies among those producing this raw material.

Small average herd size remains a significant issue in Poland. In 2010, almost 84% of organic farms kept up to 9 dairy cows and this share decreased to 64% in 2020. The number of farms across all herd sizes reduced, but the pace of this decline decreased in line with the increase in the scale of production. These trends can also be found in farms which are not selling milk as organic, i.e., without a certificate (Table 2).

The number of large and very large dairy farms increased by 35% and 37% respectively, which increased the share of these farms nationwide from 1.8% to 10% (Table 2). It is to be regarded positively for economic reasons (regarding economies of scale, customer or supplier relationships, the negotiation position of farmers and so on). We can also positively assess the fact that among farms with medium and large herd size the share of farms selling milk as organic increased over the period 2010-2020 (Table 2).

Table 2. Structure of organic milk farms by the size (number of cows) in Poland (Source: own work based on unpublished IJHARS data).

Herd size		Number of farms by the size with/without a certificate on milk														
		2010					2016					2020				
		Total	With a certificate		Without a certificate		Total	With a certificate		Without a certificate		Total	With a certificate		Without a certificate	
1-2	Very small	**1949**	832	42.7%	1117	57.3%	540	310	57.4%	230	42.6%	223	91	40.8%	132	59.2%
3-9	Small	1351	751	55.6%	600	44.4%	**561**	330	58.8%	231	41.2%	**360**	173	48.1%	187	51.9%
10-19	Medium-small	418	270	64.6%	148	35.4%	216	136	63.0%	80	37.0%	178	128	71.9%	50	28.1%
20-29	Medium-large	114	57	50.0%	57	50.0%	67	31	46.3%	36	53.7%	72	49	68.1%	23	31.9%
30-39	Large	**43**	17	39.5%	26	60.5%	**24**	13	54.2%	11	45.8%	**34**	23	67.6%	11	32.4%
>=40	Very large	60	19	31.7%	41	68.3%	35	14	40.0%	21	60.0%	46	26	56.5%	20	43.5%
Total		3935	1946	49.5%	1989	50.5%	1443	834	57.8%	609	42.2%	913	490	53.7%	423	46.3%

Furthermore, over 60% of the 1,443 farms that kept organic dairy cows in 2016 withdrew from the production of organic milk by 2020 (n=872). There were only 272 farms operating in 2016 (18.8%) that increased the number of organic cows in 2020. Just 128 farms maintained their levels of breeding throughout 2016-2020. As many as 171 farms reduced the number of organic cows in their herd from 2016. Most of the farms that increased the number of organic cows over the period 2016-2020 were farms with up to 19 head of cattle (Figure 3). The number of cows increased most in farms with very small herd size. Concurrently the largest number of farms (n=217) increasing herd size were those with a small area of organic meadows and pastures (up to 20 ha). In the studied group of 272 farms, 2/3 of them produced and sold organic milk (Figure 3). Just 37.5% of the 272 farms increased the area of their organic meadows and pastures along with increasing herd size. As many as 133 farms, despite the increase in herd size, decreased the area of certified meadows and pastures. The question arises as to promotion of naturalness going forward in organic agriculture which is associated, inter alia, with access to pasture [19]. Additionally, among 171 farms that limited their number of dairy cows, 80 reduced the area of certified meadows and pastures at the same time.

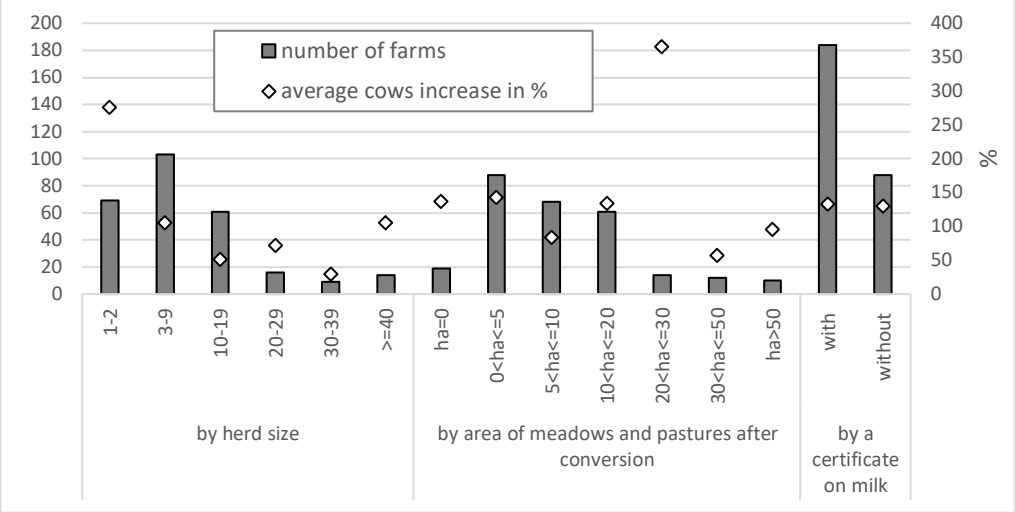

Figure 3. Structure of organic farms keeping certified milk cows in 2016, which increased the breeding of cows (Source: own work based on unpublished IJHARS data).

The majority of organic farms keeping certified cows in 2016 which decided to stop breeding cows (82.7% of 872) were very small and small farms (up to 9 cows). Over 80% of them did not hold certified meadows and pastures or cultivated less than 10 ha. Almost 55% of them produced and sold organic milk (Figure 4).

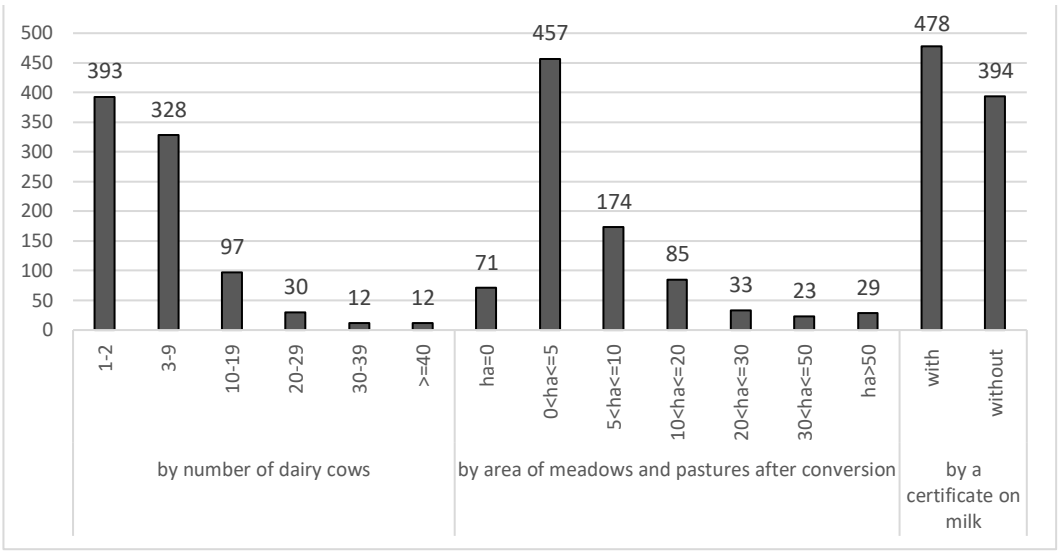

Figure 4. Structure of organic farms keeping certified milk cows in 2016, which stopped the breeding of cows (Source: own work based on unpublished IJHARS data).

According to unpublished IJHARS data, in 2010, 4 dairies processed 664 tons of organic cows' milk. In 2016, there was a dynamic increase in processed milk, as 21 processors processed as much as 149.3 thousand tons of organic raw material. In 2020, 25 entities processed only 19.5 thousand tons of organic cows' milk. Therefore, the situation in the organic dairy market in Poland is volatile. Furthermore, dairies have to obtain raw material from numerous, small and geographically dispersed suppliers of milk (see also 55]. In addition, in 2020 only 2% of the number of organic milk farms operated in producer groups or other associations. Producer groups are considered as a remedy for fragmentation of private agricultural holdings in Poland [64].

In 2020, over 95% of the volume of organic cows' milk processing and cheese production took place in three regions, i.e. Podlaskie, Mazowieckie and Kujawsko-

Pomorskie. These were regions with high total milk production and sales [26]. They were also regions with the highest (first and second psotion amoung 16 regions) or high (sixth position) milk production capacity, taking into account such factors as dairy cow density per 100 ha of agricultural land, total cow's milk purchase, share of purchase in milk production, average milk yield per cow, cow's milk production per 1 ha of ahricultural land, share of cows in farms with more than 50 cows and averafe number of cows per farm [28]. The production efficiency of organic cows' milk processors varied in 2020 (up to 10 tons of dairy products for 11 processors, 14-86 tons for 6 entities, 127-710 tons for 4 entities, 2265-6342 tons for 4 dairies). Four large dairies, including two cooperatives, processed over 90% of organic milk in Poland in 2020. Furthermore, the market share of these entities has increased rapidly since 2016, when they processed just 6.4% of the organic cows' milk. Since 2016, in several regions (Mazowieckie, Pomorskie, Warmińsko-Mazurskie), despite high and growing production and sales of organic milk, the number of organic milk processing entities and the volume of organic dairy products decreased. Organic milk processors in Poland import organic milk [65]. The largest organic dairies are also the largest producers of conventional dairy products in the country. Their power and position in the national milk market results from the long-term concentration processes, although its further continuation seems limited [28]. From 2010 to 2020, only two entities still processed organic cow's milk and increased their volume of production. Only about half of the entities that processed organic milk in 2016, were still operating in 2020, demonstrating the high instability of processing operations.

4.3. Various factors of the development of the dairy organic sector

Previous studies show the influence of various factors on the development of the organic sector in individual countries, including the legal environment, public policies, discourses, and marketing channels, and relations between (organic) actors along the food chain and other "close" stakeholders [66].

4.3.1. Farmgate price

The (premium) prices the dairies are willing to pay for organic milk are of critical importance for the farmers. Insufficient margin at the farm gate, which is not enough to compensate for the costs associated with the conversion period and subsequent maintenance of the organic production system, is a barrier to entering the market. According to FADN data, the average selling price (per liter) for the organic cows' milk in 2020 in Poland on organic farms constituted 94.5% of the price for milk sold by farms specializing in dairy cattle breeding. In years 2010-2019, this ratio ranged from 89% to 98.3% [67]. Thus, the lower price paid for organic milk did not compensate for the lower milk yield of cows in organic production systems. The profitability of organic milk production on farms is also lower due to the lower production value [68].

4.3.2. Farmers' age

In Poland, milk production is often undertaken by older generations, who have inherited the farm from their parents and still run their agricultural holding based on tradition, a sense of duty and an attachment to the land of their forefathers [69]. Poland belongs to the group of EU countries with the lowest ratios of substitution of labor with capital and a relatively small contribution of paid employment in dairy farms [70]. The number of rural inhabitants engaged in agriculture and related services is decreasing [71] and the agricul- tural function decreases in farms with numerous sources of livelihood [72]. The younger generation reject rural careers or prefer crop production, which is less demanding. A lack of knowledge of organic farming principles and a fear of the consequences of not following them are barriers to engagement [73]. Agricultural advisory services or farmer associations can encourage and support farmers undertaking organic production, especially over the two-year period of conversion to an organic farming system. During this time farmers are paid for their milk at the price for

conventional production and milk yield of cows may be lower. Veterinary advisory services, and herd health and production management (HHPM) programs used by animal health management advisors, are also important to ensure compliance with organic production principles [74–76].

4.3.3. Forage practices

By law, organic animal production in Poland is generally prohibited if the farmer does not own agricultural land. For this reason, organic dairy farming is mainly concentrated in regions with a large proportion of permanent grassland in the structure of agricultural land. According to EU Regulation 2018/848, at least 60% of the feed must come from the farm itself, and at least 60% of the dry matter in daily rations should consist of roughage, fresh or dried fodder, or silage. However, this percentage may be reduced to 50% for dairy cows for a maximum period of three months in early lactation. It should be emphasized that rearing systems for dairy cows must be based on maximizing the use of grazing pasture. Generally, the total stocking density must not exceed the limit of 170 kg of organic nitrogen per year/hectare of agricultural area. Husbandry practices, including stocking densities and housing conditions, must ensure that the developmental, physiological and ethological needs of the animals are met [77].

The organic conditions of self-sufficiency with regard to forage limit the number of cows that can be kept on one farm, especially in winter, and weather issues such as drought or excessive rainfall can lead to feed shortages. Such extreme weather conditions are predicted to increase as a result of global warming. The purchase of adequate feed can also be problematic, although the availability of organic seeds and feedstuff is improving. Better quality feed positively affects animal health as well as production efficiency. Many studies [78,79] indicate that particular environmental conditions (mainly feed type and quality) on a dairy farm affect the quality of the raw milk obtained and, consequently, that of the final dairy products.

4.3.4. Breeding strategy

The choice of breed is another very important factor. Indigenous breeds (e.g., Polish Red or Polish Black-and-White) with a small proportion of Holstein Friesians, or breeds kept only in certain regions, such as Simmentals, tend to be more successful within a given organic system. Cows from local breeds are valued by farmers for their resistance to disease (including mastitis), ability to adapt to difficult environmental conditions, good health, longevity and ease of acclimation [80,81]. These traits are particularly important in organic production, where antibiotics cannot be used as a disease management measure. The productivity of dairy cows is a crucial factor determining the profitability of farms. There is higher milk yield in an intensive conventional dairy system. Król et al. [82] corroborated the findings of Średnicka-Tober et al. [83] and they found that, when organic and traditional systems of milk production did not fully meet the nutritional needs of cows, this resulted in significantly lower yields (by about 20%) for cows kept on organic and traditional farms (16.1 kg of milk/day and 17.4 kg of milk/day, respectively) versus intensive systems (22.3 kg of milk/day). Moreover, the effects of seasonality on milk production are more marked in traditional system or organic systems [84], as evidenced in not only the yield, but also the chemical composition of milk and its suitability for processing. The decisive factors differentiating milk yield in traditional feeding systems were the seasonal differences in feed quality and supply, which did not allow for the cow's genetic potential to be fully exploited. Kuczyńska et al. [85] found that the highest milk yield on an organic farmwas achieved in summer (24.6 kg/day), when the cows were fed green forage, haylage and concentrate feed.

4.3.5. Milk quality

Organic raw milk is also susceptible to declines in product quality. The productivity of cows, the nutritional value of milk and its suitability for processing are adversely affected by inflammation causing somatic cell counts (SCC) to go above 400,000 per mL of milk. It is an important quality factor that needs to be monitored by producers as milk is tested for SCC on receipt at the processing plant [80]. The quantity and quality of raw milk obtained directly translates to the quantity and quality of the resulting dairy products. In Poland, few farmers independently process and sell dairy products on the local market. On-farm processing entails a number of additional barriers, such as ensuring good manufacturing practice and hygiene standards, in addition to good agricultural practice. Such farms are subject to oversight by not only IJHARS but also by the Veterinary Inspectorate, and some farmers are unwilling to take on the additional costs and obligations necessary to comply with sanitary and hygiene requirements.

Milk processing, especially using traditional methods, is also very labor-intensive and time-consuming. Nowicka et al. [86] point out the food safety risks associated with minimally processed food, which may be contaminated by bacteria, especially if the milk is not heat-treated [87], not pasteurized, or is prepared in inadequate hygienic conditions [88]. The use of non-organic additives which perform mainly technological and organoleptic functions, as well as trace elements and processing aids, is limited in organic dairy pro- duction [39]. Therefore, technological improvement in traits such as consistency, flavor, or aroma is not possible. This necessitates the use of traditional methods of production and extending shelf-life, e.g., the production of ripened cheese or smoked cheese. Unfortunately, artisanal organic dairy products produced on-farm have a shorter shelf-life than their conventional counterparts, which limits their distribution across long distances [73]. However, it should be emphasized that raw milk from organic farms should be considered more valuable than conventional milk, especially in terms of the content of health-promoting substances, such as vitamins, fatty acids, whey proteins and minerals. These components have nutritional value as well as multi-faceted, documented health-promoting properties. This particularly applies to the protein fraction of milk (casein, whey proteins, peptides and amino acids) and the lipid fraction (fatty acids, vitamins A, D, E and K, β–carotene, phospholipids and sphingomyelin). For example, the whey protein β-lactoglobulin plays an important antioxidant role in milk and also exhibits anticarcinogenic activity. Another whey protein, lactoferrin, is increasingly valued due to its antimicrobial (antibacterial, antiviral and antifungal) and anticarcinogenic properties and its stimulation of the immune system. Casein has antitumor properties and is a precursor of bioactive peptides and a carrier of calcium and other microelements [78,79,83]. Many fatty acids also have valuable health-promoting properties. For example, saturated short- and medium-chain fatty acids reduce the risk of obesity and have a beneficial effect on energy balance [89], while unsat- urated fatty acids such as CLA inhibit the development of cancer cells and take part in processes reducing adipose tissue in the body [90]. In this context, given the emergence of new consumer needs, including the need to maintain good health, prevent disease and improve quality of life, organic milk should be an increasingly valued material.

4.3.6. Processing capacity

In areas that are difficult to access, local distribution is rarely sufficient or financially viable, and a lack of buyers limits opportunities to produce and process organic milk. Dairies with limited access to organic milk are also generally unwilling to process such product exclusively. Most facilities in Poland process both organic and non-organic milk simultaneously (unpublished IJHARS data). The undertaking of organic processing can be considered an asset and a strength for such dairies, because the diversification of production not only reduces the economic risk, but also increases the efficiency of using the existing infrastructure and creates opportunities for entering new markets. Łuczka [91] showed that the main incentives for engaging in organic processing include access to

new, mainly urban markets and improved competitiveness. In general, dairies indicate low availability of organic milk, low supplier flexibility and low technological quality of raw material as the main problems in this context [92]. Large dairies more often use modern equipment and technology and have a well-developed logistic network established to make their organic products more accessible.

The principles of organic milk processing require segregation, i.e., organic production must be conducted at a different time or place from conventional production. Dairies usually opt for time separation to avoid the additional costs of purchasing a second, dedicated processing line. Therefore, in order for production to be profitable, it must be based on economies of scale, which are very important in the dairy industry [28]. The efficiency of the inputs used affects the competitiveness of dairies and, more broadly, the improvement in sustainable development in the whole food value chain [93].

5. Discussion

In Austria, Sweden and Denmark, the EU countries with a high proportion of organic milk production, organic food production currently corresponds to a considerable share in the overall domestic food markets. This shift has been driven in part by retail businesses that have influenced organic food market growth in these countries, e.g., by offering organic and conventional food at the same time. Their example may prove a valuable guideline for Poland in terms of how organic dairy sales can be catalyzed. This approach can be supported by the study by Verburg et al. [94], where the development of the organic dairy sector in Denmark and Austria was explored in order to identify potential leverage points that may be applicable to the arrested diffusion of organic farming in the Netherlands and other countries. However, the retail trade situation has been changing dynamically in recent years. Furthermore, in Austria, promotional activities related to organic food have been systematically undertaken and the relevant know-how, expertise and skills training transfer down the food supply chain has been steadily improving. Taking adequate and efficient actions in these two areas could viably improve organic dairy sales in Poland which, as shown by many examples worldwide, is largely driven by consumer demand [95] (RQ1). As a case in point, the success of organic food originating from Austria is in no small part due to its positive consumer perception and good reputation.

Despite naturally favorable conditions, the volume of organic milk production in Poland has been declining in recent years, as shown above, i.e., the number of certified organic farms, the production and sale of organic milk, the number of certified dairy cows and the area of organic meadows and pastures have all decreased since 2010. Only some of the certified organic dairy farms sell their milk as organic or have organic pastures and meadows. A similar situation is observed in other countries with low organic milk production such as Czechia. Not all organic milk produced is sold to dairies as organic, and some organic milk is sold as conventional milk [96]. Nonetheless, certain positive trends are present in Poland in terms of the increasing average size of an organic cow milk farm, improving marketability of organic milk production, the growing number of large farms and their share in the national market. These changes reflect the evolution of the entire milk market in Poland with a clear trajectory towards increasing the scale of production [28,97]. Of the analyzed farms that kept organic dairy cows in 2016, over 60%, mainly small farms, stopped doing so by 2020. This may be attributed to problems with selling organic agricultural raw materials, as reported in other studies pertaining to dairy farms [98]. Notably, it was not due to a surplus of organic milk production and the resulting decrease in the price premium, as was the case in Denmark where farmers discontinued their organic practices [99]. Research (conducted in Poland, Lithuania, Slovenia and the Netherlands) shows that some farmers involved in milk production, particularly older and smaller-scale producers, adopted the strategy of suspending their activity in a difficult market situation [100]. This suggests the reasons for abandoning

organic dairy production are still mainly economic, although problems with certification and control, production techniques and the macro-environment of the farms must also be taken into account [101].

Organic milk processing in Poland is highly concentrated in only a handful of entities, which means many small dairies struggle to gain access to raw milk. Consequently, in several regions of Poland, the number of organic milk processors and the volume of organic milk processed has decreased despite increasing organic milk production. The Polish market continues to struggle with discrepancies between the demand and supply of organic cow milk in terms of location and production volumes. This is a significant problem in many countries with dispersed organic milk production, e.g., Czech Republic, Latvia [102,103]. The quality of organic milk, confirmed by on-site audits and checks on farms and on processing and guaranteed by certificate, the availability of milk and the location of the respective suppliers, are all factors affecting the development of organic cow milk processing [54,79]. However, it is the quantity of produced organic milk in a country that is the key issue.

Infrastructural and institutional factors are among the most important sources of risk in the production of organic milk. Therefore, policy makers in Poland should be cautious when adopting any policy changes and should consider a range of strategic initiatives that will boost farmers' confidence in the long-term prospects of organic milk production [104]. Insufficient availability of raw material is also a significant problem for other organic food processing industries in Poland [105]. One option is to aggregate supply and encourage farmers to join producer groups, which could overcome logistical challenges and enable a much better match between supply from farms and demand for organic milk from processors. This is one of the solutions suggested by the processors themselves [49], supporting organic farmers' efforts to build a network of different participants from the organic food sector. This would facilitate the exchange of knowledge and skills and the carrying out of the formal, market and legal requirements relating to the management of organic production [50]. Such a process seems inevitable in the context of the growing consumer demand for organic milk and dairy products observed in Poland and other European countries. The small-scale organic production in Poland is a weakness because small entities tend to have less access to information, production resources, market outlets, finance and training [106] but, at the same time, it is also a strength, since small entities can be more agile (RQ2). To constitute a viable market alternative, such farms would have to greatly increase in number.

The development of organic farming contributes to a sustainability transition in agriculture, as underlined by the European Commission in EGD [12,94]. Organic farming might be a solution to the low competitiveness of family farms that produce under suboptimal conditions but, also, it may motivate farmers to escape the 'productivist' paradigm of conventional farming competing on global markets [94], which could translate into positive socio-economic and environmental effects at local and national levels. This is in line with the SDG 10 of reducing inequalities and ensuring no one is left behind in sustainable growth. There are a limited number of reliable studies that have evaluated the difference between conventional and organic dairy production regarding GHGEs emissions [107,108] thus this could be examined in future research work.

6. Conclusion

Sustainable practices in organic milk production must be lean and agile enough to enable agricultural holdings to be resilient, and to sustain their operations in a volatile, competitive market driven by the customer-based evaluation of products [109–111]. Building on lessons learned from several recent crises (the pandemic, armed conflicts, natural disasters, etc.), the unpredictable situation in agricultural product markets demonstrates that an agile analysis of opportunities and threats should be systematically undertaken by food business operators and farmers. Providing organic dairy farms with production and market advice and technical support is crucial, as is, to a certain extent,

evidenced by Austria. Both government and non- governmental actors have created good conditions for the development of the organic food sector in Austria. Building on the lessons learned from this country, we believe that strengthening the cooperation of Polish organic dairy farms with processors and organic associations, and collaboration between processors, food retail chains and organic associations, would contribute to a stronger market position of farms and the further development of the organic milk sector in Poland. Furthermore, the specific nature of the raw milk market requires the procurement of organic milk on a lasting basis regarding guarantees of purchase and farmgate prices. In this way, the continuity of organic raw milk supply to processors would be secured and the sector of organic dairy products should grow.

Processors could conduct campaigns encouraging farmers to convert to organic practices as part of their marketing activities. There have already been examples of such effective efforts undertaken by buyers of organic raw materials in Poland, i.e., Symbio Polska S.A. or the Dairy Cooperative in Pia ¸tnica. The latter, one of the largest dairies in Poland, started by establishing its own production base by training 40 farmers in cooperation with agri-environmental consultants and successfully encouraging them to convert to organic farming. This might be a benchmark example for other food business operators in Poland. The complete implementation of the Pia ¸tnica plan took 4 years. However, the better farmers are informed about organic farming, the greater their willingness to convert [112] and the faster the conversion process.

Effective national governmental and non-governmental programs aimed at boosting the development of organic milk production and consumption in Poland are needed, including the promotion of groups of producers. The current solutions developed by Polish government and non-governmental organizations should be reevaluated, as shown by the recent situation in the organic dairy sector in Poland. The overall pace of development of the sector has continued to be slow despite the milk market potential. Professional training of milk producers might also be conducted by certification bodies and farm advisory systems (private, public or public–private entities). This is an area where public–private partner- ships (PPPs) could allow the optimal use and sharing of resources (financial, human, social and physical), ideas and innovation, as well as better outreach to a wider audience [113].

It is worth noting that conversion to organic farming is one means of reducing cow milk farms' carbon footprint [114], and a strong increase in the commercial production of organic cow's milk in Poland, the main producer of cow's milk in the EU, would be a milestone towards common EU climate action. The growing demand for organic food products, observed in Poland and many other countries, should provide a powerful incentive for change and facilitate continued development of organic milk production [49], while effective coping strategies will drive resilience [115]. Cooperation between organic producers and processors in dairy sector is essential.

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https://ec.europa.eu/eurostat/data/database (accessed on 1 June 2023); https://www.clal.it/ (accessed on 1 March 2023); https://statistics.fibl.org/data.html (accessed on 1 June 2023).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Production of cows' organic milk in the EU MSs over the period 2012-2021 (Source: own work based on Eurostat and CLAL data).

EU Countries	Production of cows' milk (million tons)			Production of organic cows' milk (thousand tons)			The share of organic production in the total production of cows' milk (%)		
	2012	2016	2021	2012	2016	2021	2012	2016	2021
Belgium	3.12	3.93	4.43	:	89.38	131.26**	-	2.27	2.96
Bulgaria	1.09	1.02	0.84	0	6.97	9.28	0.00	0.68	1.10
Czechia	2.81	3.06	3.31	30.68	32.75	32.36	1.09	1.07	0.98
Denmark	5.01	5.44	5.64	479.10	516.13	745.90	9.57	9.50	13.23
Germany	30.67	32.67	32.51	:	794.70	1266.22	-	2.43	3.89
Estonia	0.72	0.78	0.84	12.17	10.54	8.91	1.69	1.35	1.06
Ireland	5.40	6.87	9.04	:	5.97	14.01	-	0.09	0.15
Greece	0.77	0.71	0.71	:	:	27.81	-	-	3.92
Spain	6.50	7.12	7.62	11.33	15.15	53.47	0.17	0.21	0.70
France	24.72	25.14	24.78	460.78	581.28	1281.64	1.86	2.31	5.17
Croatia	0.81	0.67	0.56	1.63	5.02	0.75	0.20	0.75	0.13
Italy	11.50	11.89	13.20	162.50	214.63	498.54	1.41	1.81	3.78
Cyprus	0.15	0.19	0.30	0	0.62	2.79	0.00	0.33	0.93
Latvia	0.87	0.98	0.99	68.98	97.70	84.60	7.92	9.93	8.55
Lithuania	1.77	1.62	1.47	48.31	41.40	82.87	2.72	2.55	5.64
Luxembourg	0.29	0.38	0.44	2.31	2.83	4.77*	0.80	0.75	1.08
Hungary	1.81	1.92	2.08	9.31	:	6.28	0.51	-	0.30
Netherlands	11.88	14.53	14.22	160.51	198.58	296.19	1.35	1.37	2.08
Austria	3.38	3.63	3.83	:	:	661.69	-	-	17.28
Poland	12.67	13.24	14.88	35.15	24.88	33.42	0.28	0.19	0.22
Romania	3.88	3.93	3.64	:	31.55	39.18	-	0.8	1.08
Slovenia	0.62	0.65	0.64	4.59	5.83	:	0.7	0.9	-
Slovakia	0.93	0.91	0.90	17.56	15.35	19.81	1.9	1.7	2.19
Finland	2.30	2.43	2.31	37.57	56.79	80.91	1.6	2.3	3.5
Sweden	2.86	2.86	2.78	:	371.02	482.32	-	13.0	17.3
United Kingdom	13.86	14.94	15.73*	417.80	519.50	573.50*	3.0	3.5	3.65

: not available, * 2019, **2020 data referring to organic milk is not available for Malta, Portugal.

Table A2. Manufacturers of organic dairy products in the EU MSs over the period 2012-2021 (Source: own work based on Eurostat data).

EU Countries	Number of manufacturers of organic dairy products			Share of manufacturers of organic dairy products in the total number of dairies (%)		
	2012	2016	2021	2012	2016	2021
Belgium	79	67	84**	23.0	16.1	15.1**
Bulgaria	7	29	19	2.4	9.3	6.3
Czechia	79	99	136	42.0	57.6	69.7
Denmark	64	70	74*	100.0	100.0	100.0
Estonia	4	6	10	16.7	17.6	30.3
Ireland	:	13	14	-	8.3	9.3
Greece	51	65	121	6.2	7.2	14.2
Spain	131	137	224	9.1	9.1	13.4
France	238	336	:	19.8	27.5	-
Croatia	8	8	13	6.7	7.1	12.5
Italy	482	687	1137	13.9	19.4	35.9*
Cyprus	3	5	5	3.3	5.0	5.1
Latvia	15	24	30**	32.6	37.5	47.6**
Lithuania	7	6	14	15.9	18.8	45.2
Luxembourg	:	4	4	-	50.0	44.4
Hungary	16	11	11	14.8	8.7	8.0
Netherlands	112	144	166	38.1	48.6	45.7
Poland	17	26	35	2.8	3.9	3.7
Portugal	12	16	20	3.1	3.8	4.4
Romania	7	18	26	1.4	3.6	4.8
Slovenia	7	7	11	6.0	3.0	4.2
Slovakia	16	17	17*	8.1	9.8	10.1*
Finland	34	38	31	55.7	56.7	37.8
Sweden	35	69	104	22.2	28.6	37.3
United Kingdom	160	83	316**	27.3	12.4	45.7**

* 2020, ** 2019

: not available, data on the number of manufacturers of organic dairy products is not available for Germany, Malta and Austria.

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