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THE ANNALS OF "VALAHIA" UNIVERSITY OF TARGOVISTE

TRENDS AND INNOVATIVE SOLUTIONS IN SMART GROWTH PRODUCTION OF MILK AND DAIRY PRODUCTS

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Abstract

SMART solutions, offered by innovations in precision agriculture, provide livestock farms with the key to an infrastructure modernization based on technological advances, with a direct result on sustainable economic growth. The Romanian farmer and the one from the Member States of the European Union face a series of trends and challenges that would determine the need to develop new management strategies, in line with the global and European requirements on sustainability and sustainability, production efficiency and animal welfare. Nowadays, digitalization is a primary factor in increasing quality and efficiency on farms, and in dairy farms and exploitation of cows is given by high-quality solutions and correct managerial decisions on feed recipes (producers want to know exactly what they feed the animals), protection from diseases, how they are cared for, the climate in the shelter (the influence of their internal and external environmental factors), watering and milking systems, as well as the collection and storage of manure. In other news, the resilience of the food system to shocks is also given by the implementation of circular economy principles.

Keywords: SMART Livestock Farming, SMART Dairy Farms, SMART Management Reproduction, Production, Innovation

1. INTRODUCTION

Due to the constraints imposed by globalization, population growth (the planet reached and surpassed on November 15, 2022, 8 billion inhabitants) and rising global temperatures, the security of food and feed supply chains is constantly under pressure.
While these challenges continue to persist and increase in severity, it is vital that our efforts to address them focus on what can be controlled.
Feeding the global population in a sustainable way is a major concern, even if ensuring the food security of its own citizens is the obligation of each individual state.
A holistic and integrated planning of the issue of food insurance based on scientific evidence is strictly necessary to provide a safety net for the growing population and to prevent food insecurity and reduce hunger. Thus, food security and the possibility for the population to have access to basic food products that benefit from the appropriate quality, is of interest to all the countries of the world, with a greater risk being recorded in underdeveloped or developing countries.
With the launching, by the European Commission, in December 2019 of the set of initiatives and policies called the European Green Deal [1] for the European Union's path towards a sustainable economy, European farmers and production systems face a number of challenges posed by the three pillars of sustainability.
The demand for food products has increased globally, and milk and dairy production, which falls into the category of basic foods that are part of the minimum monthly consumption basket for a person, does not deny this trend.
Thus, European milk and dairy production systems are affected by the decisions taken at the level of the European Union, to which we must add the fact that the regions within the union are characterized by diversity and complexity.
The European Union was, in 2022, the largest producer of cow's milk globally, with a total volume of 143.9 million tons out of the total of 155 million tons (which represents 96%). Each Member State of the European Union achieves a higher or lower production of cow's milk, where approximately 64.2% of the total gross volume is made in Germany (20.9%), France, Poland, the Netherlands, Italy and Ireland, as evidenced by Figure 6. and Table 1 [3]. Unfortunately, Romania ranks last in the European Union in the production of cow's milk per cow with 3 362 kg, compared to Denmark, which accounts for 10 097 kg.
From the analysis of the last 6 years (2017-2022) of the dynamics of cattle herds in the European Union (Figure 1) we can say that they have decreased with the increase in the production of cow's head milk.
The increase in efficiency and yield in dairy farms, which are also influenced by their size and the number of heads, cannot take place without the development of innovations in agriculture and the sector of rearing and exploitation of livestock for milk production.
The use of SMART management on the breeding of bovine animals exploited for milk production is strictly necessary under the current conditions imposed by the European Union in order to demonstrate the sector's commitment to responsible food production in sustainable agriculture and to prevent disparities arising due to technical factors and variations in yield.

2. MATERIALS AND METHODS

The growing demand for nutritious and affordable food, against the background of limited natural capital, is subjecting agricultural sites around the world to continuous stress. In order to correctly present the information related to the subject, the methodology used consisted in the comparative analysis of the materials made available by national and international organizations, active at national, regional, European and global level in the production and processing of the market.
Thus, the comparative analysis used combines several datasets from the European Commission, the National Institute of Statistics, the Ministry of Agriculture and Rural Development of Romania, EUROSTAT, FAOSTAT, Statista.
The dynamics of milk herds and production at a global, European and Romanian level and the evolution of milk and dairy prices were taken into account, highlighting innovative trends and solutions in the intelligent growth of milk and dairy products production by implementing a SMART management in dairy farms.

3. RESULTS AND DISCUSSIONS

In order to limit the problems of global hunger and the agricultural system sustainability to be supported and anchored to the reality determined by local geographical, economic and social factors, it is necessary and useful to implement a SMART management in both vegetable and animal farms.
In the case of milk production, in order to highlight the productive potential of dairy cows, the farmer needs to have the necessary knowledge about fertility and the improvement of reproductive outcomes.
The largest percentage of the total overall quantity of milk is bovine milk.
Even if in developing countries the herd of cows with milk is higher compared to that in developed countries, milk production and the lactation period are lower against the background of low genetic potential and poor performance, as well as the influence of external environmental factors (humidity and temperature), poor quality of food and increased incidence of diseases.
Also, in order to increase efficiency, the farmer must be visionary, open to innovation and last but not least realistically plan the stages from idea to implementation of a solution, in order to increase performance. All this involves financial strength and a realistic analysis of the factors of impact on performance.

3.1. Global milk production

Cow's milk yield is influenced by the number of heads, but a first-hand factor is genetic performance that determines productivity.
A comparative analysis of the number of heads was carried out globally starting with 2017 (984.53 million heads), from which it was found that although in the period 2018-2020 there was an upward trend, as shown by the figure below, only in 2021 there was an increase in the herd above the value of 2017 (+11.64 million heads).

The number of cattle heads continued the upward trend that numbered 1,000.69 million heads in April 2022, according to data published by Statista.com [4].

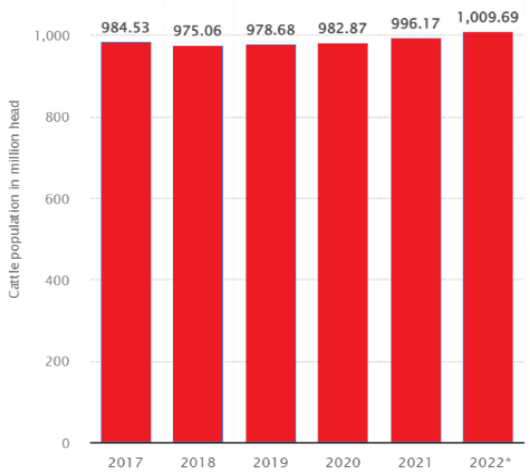


Figure 1. Global growth of cattle from 2017 to 2022 (in million heads) *valid data from April 2022. Source: Statista.com

In terms of comparative analysis of global milk production and data published by the Food and Agriculture Organization of the United Nations [2] it increased by approximately 1% in 2022 compared to the previous year, from an estimated quantity of 927.8 million tons to 937.3 million tons. This increase was due to the volume recorded in Asia, the largest milk-producing region, North America and Central America and the Caribbean. For the other regions, Europe, South America, Africa and Oceania milk production has been forecast to decrease moderately, as evidenced by the figure below.

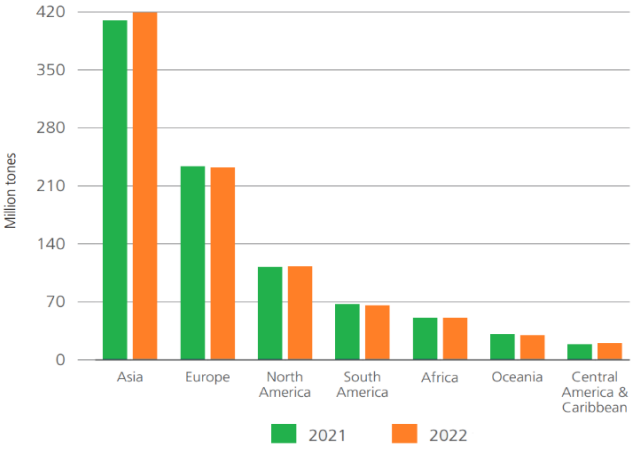


Figure 2. World milk yield by region. Note: estimated 2021, 2022 forecasted. Source: FAO

For 2022, the top 10 largest producers of cow's milk (in million tons) in the world were: EU-27 = 143.9, followed at a distance by the USA with 102.97, India (97), China (39.2), Russia (32.15), Brazil (23.66), New Zealand (21.1), the United Kingdom (15.16), Mexico (12.98) and Argentina (11.9) [5].
In the second half of 2022, prices took a downward turn, with the FAO's dairy prices registering an average of 131 in February 2023.3 points, which represents a decrease of

3.6 points (2.7%) compared to January of the same year and 10.2 points (7.2%) compared to February 2022.
In order to visualize the evolution of the dynamics of dairy prices, we present the figure below [6].

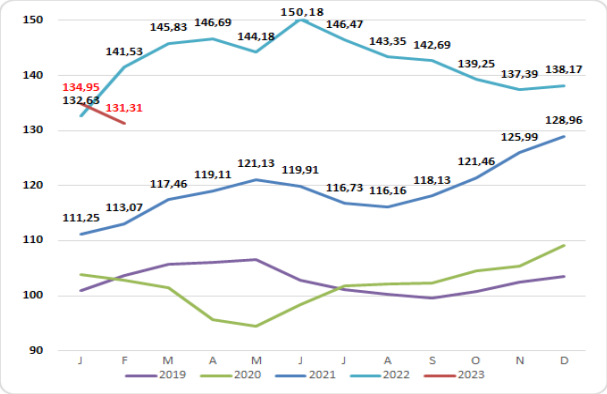


Figure 3. FAO Dairy Price Index** - 2014-2016=100 (world average share of export trade)**
**** is determined by price quotations for butter, cheese, whole milk powder and skimmed-milk powder. Source: FAO**

Thus, after an upward trend of prices recorded in 2021 (from 111.25 points in January to 128.96 points in December) and the first 6 months of 2022 (from 132.63 points in January to 150.18 points in June, with a decrease to 144.18 points in May) it can be seen from the figure above that the trend takes a downward turn (⇨138.17 points in December), which continues into 2023 (131.31 ⇨points in February).
According to the data published by Statista.com [7] the total estimated value of the dairy market in 2021 was about 871 billion US dollars. The same site forecasts an increase of $257 billion over the next five years.
In terms of the volume of the dairy market in 2021 worldwide, Europe is in first place with 53%, where the European Union (EU-27) ranks best, with 38%, plus the other non-EU countries with 15%.

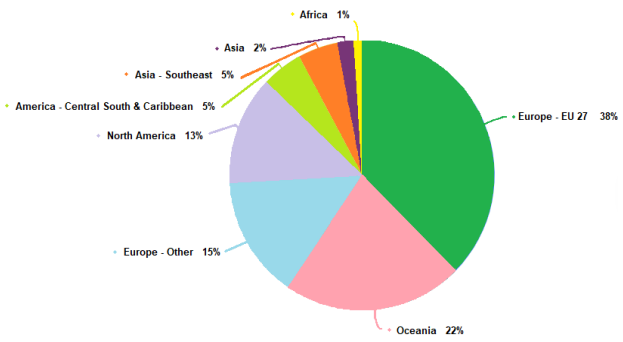


Figure 4. Global situation of the volume of the dairy market in 2021. Source: Statista.com

3.2. EU milk production

As of 31 December 2022, there were approximately 75 million cows in the EU-27, with an average of 7 682 kg of milk produced per cow (up in 2021 from 2020 from 7 300 kg of milk/cow), and milk production and its use on farms was ~ 159.80 million t. [8]
As it is obvious from the picture below, cattle herds decrease from year to year, against the background of improving the genetic potential for breeding and milk production. Electives decreased by 4 154.23 thousand heads in 2022 compared to 2017 (from 79 009.94 thousand heads in 2017 to 74 855.71 thousand heads in 2022).

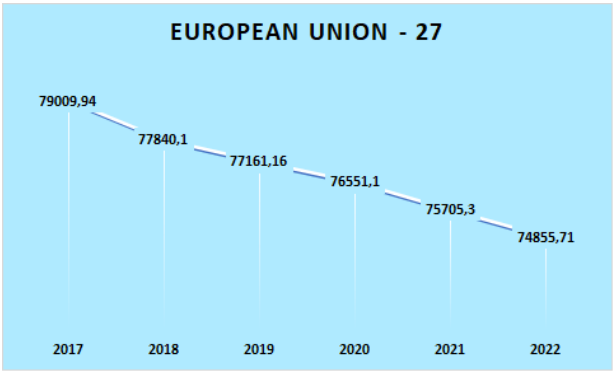


Figure 5. The dynamics of cattle herds in the EU-27 over the last 5 years, thousands of heads. Source: Eurostat

Regarding the dynamics of milk production at European Union level for the period 2017-2021, Germany continues to be in the top 3 places, followed by France and the Netherlands.

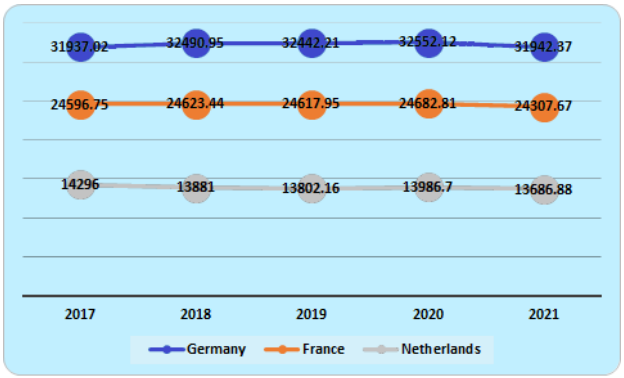


Figure 6. Top three EU-27 countries for the collection of cow's milk, period 2017-2021, thousand tons. Source: Eurostat

With regard to the total quantity of milk, as well as the production and use of milk on the farm at EU-27 level, the situation is presented in Table 1

Table 1

EU-27 Annual Production of Total Milk Compared with Cow's' Milk Collection

1 000 t

GEO	2017		2018		2019		2020		2021	
	Total raw milk, colection	Cows' milk collection	Total raw milk, colection	Cows' milk collection	Total raw milk, colection	Cows' milk collection	Total raw milk, colection	Cows' milk collection	Total raw milk, colection	Cows' milk collection
European Union - 27	: c	40 847.71 ep	153,687 and	142 258.00	: c	: c	155 765 and	: c	: c	: c
Belgium	4 974.07	4 025.42	5 088.13	4 178.89	5 231.65 b	4 288.23	5 365.73	4 431.00	5 251.58	4 380.84
Bulgaria	660.83	578.79	712.50	643.00	717.80	651.51	758.83	680.54	736.70	664.87
Czechia	: c	2 979.34	: c	3 033.02	: c	3 073.49	: c	3 192.02	: c	3 128.74
Denmark	5 525.40	5 506.30	5 615.00	5 615.00	5 619.90	5 615.00	5 671.75	5 666.00	5 648.60	5 644.00
Germany	: c	31 937.02	: c	32 490.95	: c	32 442.21	: c	32 552.12	33 669.15	31 942.37
Estonia	751.65	726.79	779.96	748.07	777.76	763.12	801.57	787.58	821.22	799.24
Ireland	8 307.10	7 480.40	8 647.80	7 812.60	8 957.60	8 225.70	9 316.30	8 541.70	9 552.00	9 021.10
Greece	1 465.28	602.50	1 498.30	620.90	1 472.62	632.97	1 542.79	652.65	1 593.18	665.92
Spain	: c	7 027.67 p	: c	7 117.01 p	: c	7 251.37	: c	7 449.67	: c	7 476.92
France	25 684.85	24 596.75	25 672.53	24 623.44	25 711.67	24 617.95	25 770.48	24 682.81	25 401.89 p	24 307.67 p
Croatia	: c	476.77	: c	453.46	: c	435.61	: c	434.22	: c	428.67
Italy	13 623.01	11 902.24	13 804.97	12 070.75	13 925.59	12 086.47	13 399.80	12 556.46	13 902.71	13 042.03
Cyprus	280.33	216.37	292.09	228.08	305.37	238.76	348.24	275.16	380.27	298.14
Latvia	911.01 p	831.78	832.83 p	780.65 p	871.82	785.19	880.51	790.50	907.82 p	812.65 p
Lithuania	: c	1 403.06	: c	1 366.60	: c	1 358.09	: c	1 359.75	: c	1 348.86
Luxembourg	: c	374.35	: c	394.78	: c	: c	: c	: c	: c	: c
Hungary	: c	1 545.46	: c	1 535.30	: c	1 575.72	: c	1 625.67	: c	1 739.26
Malta	41.03	41.03	40.41	40.41	41.27	41.27	42 11	42.11	39.88	39.54
Netherlands	15 169.00	14 296.00	14 872.00	13 881.00	:	13 802.16	:	13 986.70	15 461.36	13 686.88
Austria	3 381.99	3 190.33	3 379.53	3 182.90	3 267.51	3 139.80	3 289.48	3 137.19	3 285.24	3 153.83
Poland	11 648.93	11 646.05	:	11 952.60	:	12 183.03	: c	12 464.78	: bc	12 521.18
Portugal	: c	1 848.17	: c	1 866.82	: c	1 900.70	: c	1 921.99	: c	1 920.15
Romania	1 249.91	1 027.83	1 385.19	1 120.41	1 320.76	1 125.30	1 350.56	1 132.01	1 341.72	1 128.10
Slovenia	598,40	578.85	591.38	570.64	581.54	563.97	585.26	580.11	591.27	588.77
Slovakia	: c	825.89	: c	817.11	: c	814.30	: c	832.24	: c	824.18
Finland	2 365.90	2 365.90	2 353.69	2 353.69	2 329.66	2 329.66	2 362.13	2 362.13	2 271.90	2 271.90
Sweden	2 830.71	2 816.66	2 773.52	2 760.23	2 716.15	2 704.39	2 785.17	2 772.74	2 794.37	2 782.22

Source: EUROSTAT NewCronos - apro_mk_pobta and apro_mk_farm

Note - : not available; **bc** break in time series, confidential; **b** break in time series; **c** confidential; **e** estimated; **p** provisional

If we refer to January 2023, as compared to January 2022 in terms of the price volution of raw milk in the European Union, it recorded a value of +35%, and out of the 27 Member States the data for Luxembourg are confidential and Ireland did not provide the necessary information. Thus, for the rest of the countries the situation is as follows: the largest increase was recorded in Spain by +61% while Lithuania kept its price at the level of January 2022. The only country that has seen a decrease in price is Malta by -2% [9]

In order to visualize the exact evolution of the price of raw milk in the European Union, we present the figure below.

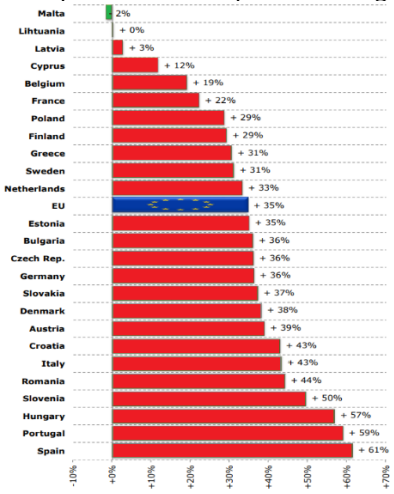


Figure 7. The evolution of the price of raw milk in January 2023 compared to January 2022. Source: Milk Market Observatory

3.3. Milk production in Romania

Although Romania is a predominantly agrarian country, where geographical and climatic conditions offer the possibility of developing animal husbandry, the number of dairy cows shows a downward trend as shown in Figure 8, an exception being 2018 when there was a slight increase of 1 101 heads.

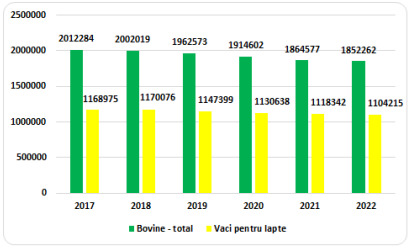


Figure 8. Dynamics of dairy cows in Romania from total cattle at national level. Source: Eurostat



Figure 9. Raw cow's milk produced in Romania and delivered to the dairy factories, in thousands of tons, for the period 2017-2021. Note - Data for 2018-2021 are provisional. Source: Eurostat

Table 2

Comparative evolution of the quantity of cow's milk collected by the processing units in January for the period 2017-2023

2018/2017		2019/2018		2020/2019		2021/2020		2022/2021		2023/2022	
t	%	t	%	t	%	t	%	t	%	t	%
+9 021	+12,4	+4 781	+5,8	-1 174	-1,4	+1 764	+2,1	- 2 303	-2,6	+1 0458	+12,3

Source: INS [11]

The Romanian milk producer is in difficulty due to the lack of development in forms compared to those in Western Europe and against the background of the geo-political situation and their economic and energy crises. Feed shortages also create additional stress for farmers, hence the need to think about an integrated system of plant and animal production.

Currently, Romania has a deficit of about 700 thousand tons of milk, and in stores you can find mostly imported milk. Even though Romania has the highest price increase in the European Union (+64%), farmers receive the lowest price from the EU-27 (5 lei/liter) [10], which is why domestic producers prefer to export the production.

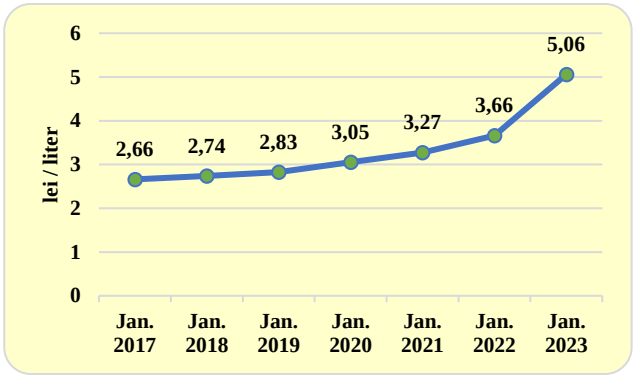


Figure 10. The average price (lei / liter) of fresh cow's milk for January each year (2017-2023) in the agri-food markets Source: INS – TEMPO – Online

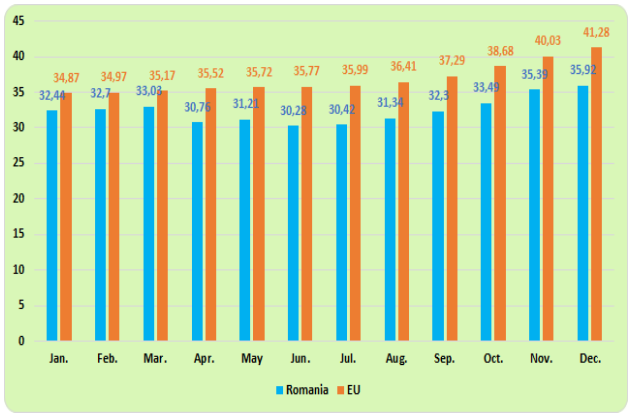


Figure 11. The monthly price in 2021 of the Romanian raw cow's milk compared to the EU prices, in Euro/100 kg Source: Milk Market Observatory - Member States (Reg. (EU) No 2017/1185 Article 12(a) - Annex II.4(a))

In 2021, the evolution of the price of raw cow's milk in Romania recorded an upward trend (from 32.44 to 35.92 Euro/100 kg), respecting the trend at EU level.

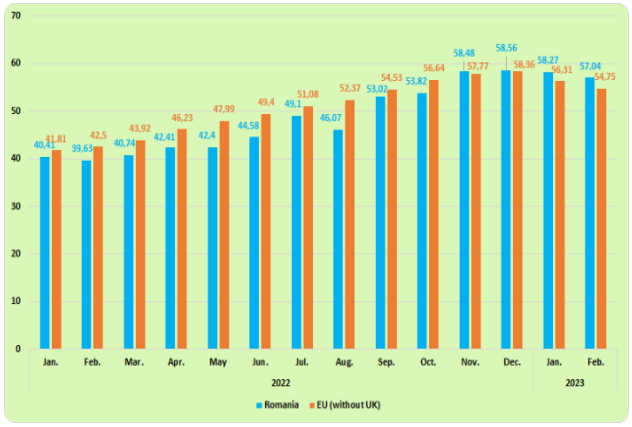


Figure 12. The monthly price in 2022 and January and February 2023 of raw Romanian cow's milk compared to EU prices, in Euro/100 kg. Source: Milk Market Observatory - Member States (Reg. (EU) No 2017/1185 Article 12(a) - Annex II.4(a))

Starting with November 2022 and until February 2023, the price of raw cow's milk per 100 kg was higher in Romania than at EU level, of 58.48 euros compared to 57.77 euros, reaching in February 57.04 euros in Romania and 54.75 euros in the EU.

Based on the data presented in Figures 11 and 12 and for a correct view of the evolution of price comparison between Romania and EU-27, for January 2021-January 2023, we present the Figure below.

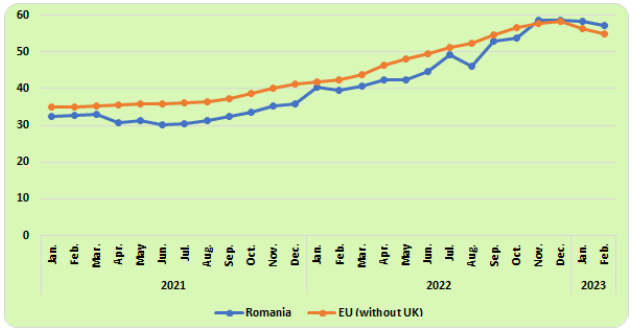


Figure 13. The dynamics of the monthly price of Romanian raw cow's milk compares hem with EU prices (Euro/100 kg)

3.4. Smart dairy production & innovation

Through a SMART management at the level of dairy farm that uses technology, aiming at innovation with a direct result in business development, the specific objectives set by the business plan can be implemented and achieved. Innovative solutions are aimed not only at improving milk production, but also at increasing the efficiency of the process. Through a digitalization strategy, milk producers have the real opportunity to improve profitability and

productivity by using breeding control and appropriate selective growth.

The reproductive performance and efficiency of dairy animals are determined by the genotype, genetic characteristics, environmental factors, animal feeding systems, adaptability of dairy cows, and not least by the production system used. Also, the socio-economic conditions in the area where the producers carry out their activity put their mark on the reproductive performance.

From the desire and need to produce quality milk, producers must take into account good agricultural practices in terms of animal welfare and health, nutrition, milking hygiene, the environment and socio-economic management.

Precision farming in general aims to identify when to intervene, the place and resources required. Thus, monitoring and control of parameters in dairy farms can be carried out online, using any Internet connection tools. By using these tools (computer, tablet or smart phone) and analysis programs, data related to microclimate parameters (temperature, humidity, concentration of methane, monoxide and carbon dioxide, etc. will be collected in real time) and installation operating parameters (for ventilation – directing air currents in shelters, illuminating, milking and/or manure disposal).

In the case of bovine animals reared and operated for milk in enclosed houses with insufficient ventilation, high concentrations of ammonia (NH_3), carbon dioxide (CO_2) and hydrogen sulfide (H_2S) may be recorded, the presence of which must be as low as possible.

With the help of automation, which is carried out according to the needs of each farm, it adjusting the parameters of the microclimate automatically or remotely is allowed.

Monitoring can take place both in the dairy houses of cows, and in the feed storage area and in the tanks for storing the collected milk.

In addition to improving milk production, lowering the mortality rate and increasing the efficiency of the process, ensuring an optimal microclimate is so necessary, on farms. Thus, Smart Dairy Farming uses state-of-the-art technologies such as sensors, the Internet of Things (IoT), broadband technologies and analysis tools, which constantly provide an updated overview and reports with values recorded in real time over different time periods (time of day, day, week, month etc.).

An important factor in the growth and development of cows exploited for milk production is their welfare conditions, and by smart monitoring of the conditions offered, in case of exceeding some standard values, alerts can be sent for the timely correction of the identified problems [12].

For example, in the case of increasing / decreasing the temperature and humidity, as well as for the ventilation of the shelter, by using the tool connected to the Internet (computer, tablet or smart phone) they can be turned off or on depending on the message in the alert (alerts received).

Also, in dairy farms, in order to ensure animal health and increase milk production, the watering system is also very important, since a high-performance cow can consume up to 100 l of water in 24 hours.

In order not to be considered biased or that we advertise for a particular company or system, we will not make a presentation of the innovative solutions that exist and are so necessary for a SMART management of breeding in cows exploited for milk production.

4. CONCLUSIONS

European agriculture in general is undergoing a process of modernization, where innovative systems and technologies are gaining at the expense of traditional techniques.

Thus, digitization on the milk production chain is not impossible, but at Romanian's level it will be achieved with difficulty due to the low financial power of farmers.

For this reason, in order to be able to make investments, the ideal would be to choose modular solutions that allow the staggering of the expenses intended for it and the development of the business, always having all the necessary functionalities in the farm.

An advantage of innovative systems and technologies is that the necessary resources can be precisely programmed, which leads to a decrease in production costs, the sector becoming more cost-effective and sustainable at the same time, and monitoring operations and conditions, as well as management in cow farms exploited for milk production, is improving.

Overall, the connection of the branches of the vegetable and animal production sectors in an integrated system offers a better sustainability and provides the farmer with the possibility to control the decisive factors that influence the protection of the environment and, last but not least, the quality of the products made.

Increasing the sustainability of production processes and improving the profitability of farmed cows for milk production, as well as the need to have livestock with high health and welfare standards, there is a need for holistic, intelligent use and integration of multiple data sources, models and analysis, while incorporating vital knowledge and expertise.

At the product level, innovative systems and technologies increase milk production by implementing robots for milking, analysis, processing and milk preservation, and at the process level, the monitoring of feeding, movement and health activities, through the new systems, aim to ensure the well-being and health of cows exploited for milk production.

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