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Purchase of raw milk in Poland under coronavirus epidemic conditions – a proposal for organisational improvements

Skup mleka surowego w Polsce w warunkach epidemii koronawirusa – propozycja usprawnień organizacyjnych

Abstract. Purchase of milk in the conditions of the worldwide coronavirus pandemic 2019-nCoV, causing COVID-19 disease, since the first months of 2020, has resulted in numerous changes in the organization of the processes of raw materials acquisition and distribution, their processing and sale, as well as information flows accompanying these processes. One of the areas which is to some extent subject to specific changes is the organisation of passenger and freight transport, including transport to processing plants for raw milk obtained from farmers. The solution proposed in the article was created on the basis of interviews conducted in the spring of 2020 with 25 farmers – milk producers. The solution assumes maximum limitation of direct contacts between carriers and farmers during collection of raw milk from farms, as well as improvement of the system of transferring information about the quality of raw material obtained from farms and receivables for the producer.

Key words: transport, purchase of milk, coronavirus, tankers

Synopsis. Skup mleka w warunkach panującej od pierwszych miesięcy 2020 roku pandemii koronawirusa 2019-nCoV wywołującego chorobę COVID-19 spowodował liczne zmiany m.in. w organizacji procesów pozyskiwania i dystrybucji surowców, ich przetwarzania i sprzedaży, a także przepływów informacyjnych, towarzyszących tym procesom. Jednym z obszarów, który w pewnym stopniu podlega określonym przekształceniom, jest organizacja transportu osobowego i towarowego, w tym przewóz do zakładów przetwórczych mleka surowego pozyskiwanego od farmerów. Proponowane w artykule rozwiązanie powstało na podstawie przeprowadzonych wiosną 2020 roku wywiadów z 25 rolnikami – producentami mleka. Rozwiązanie zakłada maksymalne ograniczenie bezpośrednich kontaktów przewoźników i rolników podczas odbioru surowego mleka z gospodarstw, a także usprawnienie systemu przekazu informacji o jakości pozyskiwanego z gospodarstw surowca i należności dla producenta.

Słowa kluczowe: transport, skup mleka, koronawirus, cysterny

Introduction

In Poland, milk is one of the most important agricultural products – it has the highest share in commercial agricultural production [Wiza 2020]. The basic raw material for the dairy industry is cow's milk, obtained from producers – dairy cattle breeders – in the form of the so-called raw milk. The ingredients of raw milk in liquid form are water (about 88%) and dry matter (about 12%), consisting of about 250 ingredients, including protein, fat, mineral salts and lactose. Race, health, nutritional, individual and physiological factors influence the fact that the chemical composition of milk is not constant and its fluctuations – if they are within the accepted limits – are acceptable and do not prove e.g. abnormalities in the milk glands of animals [Czerniewicz 2010a].

In terms of quality, milk constituting a raw material for the dairy processing industry should have a specific chemical, microbiological (in terms of the number and type of microflora), cytological (the number of somatic cells coming from the udder), as well as technological suitability and required level of chemical and mechanical impurities. Moreover, as a raw material for industry, milk should be characterized by such elements as:

- freedom from pathogens,
- no harmful, poisonous or foreign substances,
- a small number of bacteria,
- no symptoms of enzymatic activity,
- low somatic cell content,
- having nutritional and functional properties,
- delicate, mildly sweet and slightly salty taste,
- fresh and natural scent.

In order to obtain the desired characteristics, which constitute the highest quality raw milk, it should be obtained and stored under hygienic conditions protecting it from infection and development of acidifying and harmful microorganisms; it should come from healthy animals; it should have an acceptable chemical composition [Czerniewicz 2010a]. It should be treated with due diligence by the farmer-producer himself, as well as during the whole process of transport and transfer from one tank to another in accordance with specific legal requirements, accepted procedures and generally applied principles of good practice. Moreover, seasonal changes in the physicochemical composition of milk, which are additionally influenced by the location of milk production (e.g. in lowland or mountainous regions), should be taken into account.

The development of the COVID-19 pandemic poses a real threat to farmers and milk processors. First of all, the spread of the virus has significantly reduced the demand for dairy products. The decrease in consumption was mainly due to the closing of the HoReCa market. The reduction in demand resulted in a drastic drop in prices, difficulties in exporting products, a sharp increase in packaging prices and an increase in freight prices. The supply of high-quality raw milk to processing plants has become a significant problem due to the risk of virus transmission with the transport of milk.

Aim and methods

The aim of the study was to develop a solution ensuring safe supplies of raw milk from the producer to the enterprise. The research used data from the Central Statistical Office and information from the literature on the subject on the latest technological solutions. The study was based on interviews conducted with a group of 25 milk producers from: Kościerzyn Wielki (commune Łobżenica, Piła county, Wielkopolskie Voivodeship), Woźnawieś (Rajgród commune, Grajewski county, Podlaskie Voivodeship) and the Augustów district, Podlaskie Voivodeship). The surveyed farmers delivered milk to: District Dairy Cooperative in Łobżenica and MLEKPOL Dairy Cooperative in Grajewo. The study presents the situation on the milk market in 2020, types of cisterns for transporting milk and devices used in the control and measurement system for milk collection.

Production and purchase of milk during the pandemic in Poland

The COVID-19 pandemic has heavily impacted many agricultural sectors around the world [Barichello 2020, Marton 2020, Zhang et al. 2020]. Among the sectors that have suffered the most is the dairy industry because dairy products are highly perishable and depend on integrated and time-sensitive supply chains [Drury 2020, Marshall 2020].

According to the data of the Polish Federation of Cattle Breeders and Milk Producers [Polska Federacja Hodowców Bydła i Producentów Mleka 2020], in December 2019, the number of dairy cows in our country was 2,164,459, while in June 2019 it reached 2,221,000, a decrease of 2.3% (Figure 1). Overall, between 2010 and 2019, the share of dairy cows in the total cow population decreased from 96 to 90%. Last December, a decrease in the number of dairy cows was recorded in 13 provinces, the largest of which were in Podkarpackie (by 13.7%), Małopolskie (by 9.6%), Lubuskie (by 9.2%), Opolskie (by 7.7%), Zachodniopomorskie (by 6.7%), and Kujawsko-Pomorskie (by 6.3%). An increase in the number of dairy cows was recorded only in 3 provinces: Śląskie (by 3.9%), Łódzkie (by 3.2%) and Wielkopolskie (by 0.3%).

Purchase of milk in June 2020 in Poland amounted to a total of 1,035.7 million l, which was 3.6% lower than in May this year and 4.4% higher than in June 2019. In the first half of 2020, the total of 6 156.2 million l of milk were purchased from producers, which is 2.6% more than in the comparable period of 2019. At the same time, from January to June 2020, the largest amount of milk was lost from the following provinces: Warmińsko-Mazurskie (292.9 million l), Kujawsko-Pomorskie (238.9 million l), Wielkopolskie (187.1 million l). From other provinces, milk was mainly delivered to Podlaskie Voivodeship (888.5 million l). For comparison, in May 2020, 13 192.0 thousand tons of milk was delivered to dairies in the 27 countries of the EU, i.e. 0.5% more than the year before and 3.3% more than in April this year. It should be noted that the five largest milk producers in the EU-27 (Germany, France, the Netherlands, Italy and Poland) purchased a total of 8,473.0 thousand t of cow's milk in the analysed month, i.e. by 0.1% less than in 2019 (this volume constitutes 64.2% of all milk purchased in the EU [Polska Federacja Hodowców Bydła i Producentów Mleka 2020].

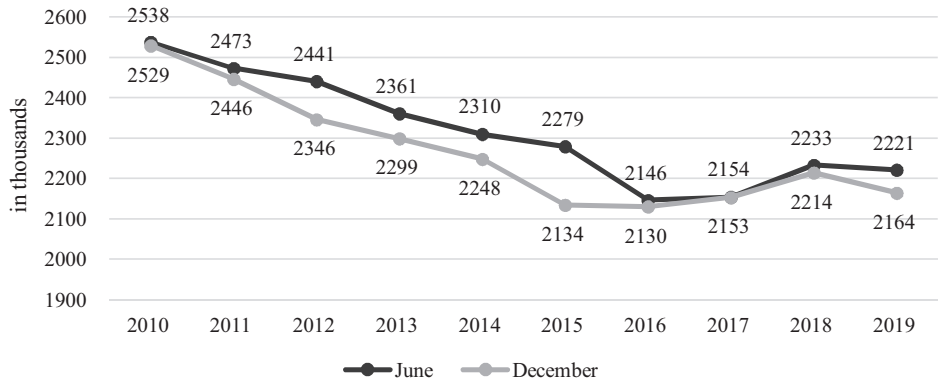

Figure 1. The number of dairy cows in Poland in 2010–2019
Rysunek 1. Pogłowie krów mlecznych w Polsce w latach 2010–2019
Source: own study based on data GUS.

According to the analysts of the Polish Federation of Cattle Breeders and Milk Producers, the upward trend in the price of purchased milk, which persisted in the second half of 2019, unfortunately did not persist in the first half of 2020, in which the downward trend has practically continued since February. According to the data of the Central Statistical Office, in June 2020 the average price of purchased milk amounted to 130.61 PLN/hl and was 0.2% lower than in May of the same year and 1.1% lower than in June 2019. Moreover, there are quite significant differences in the in the first half of 2020 of last year's upward trend in the price of purchased milk, which became a downward trend, did not automatically affect the deterioration of production indicators for dairy products, which could be influenced by imports of milk from abroad. As indicated in the July edition of the Milk Market report [Polska Federacja Hodowców Bydła i Producentów Mleka 2020], between January and May 2020, 1,447.1 million l of drinking milk was produced (6.1% more than in the same period of 2019). During the five months of this year, 142.5 thousand tons of ripened rennet cheese was produced (0.8% more than in 2019). According to CSO data, the total production of butter from January to the end of May 2020 reached 107.5 thousand t, which is 8.5% more than in 2019. In the first 5 months of 2020, the production of skimmed milk powder was reduced by 2.1% (compared to 2019) to 75.7 thousand t. The production of whole milk powder was also reduced by 8.2% (compared to 2019), which amounted to 14.5 thousand t.

As indicated by the Polish Federation of Cattle Breeders and Milk Producers, in the short term perspective for 2020 for agricultural markets in the EU, prepared by the European Commission, it is predicted that the volume of milk collection will be reduced while its export will increase. However, the observed growing retail demand for milk and its products will not be able to compensate significantly for the losses incurred by the whole catering industry as a result of restrictions introduced by the governments of the countries covered by the coronavirus pandemic. A certain factor mitigating the effects of the pandemic may be the increasing opening of the HoReCa sector (hotels, restaurants, catering), especially in the holiday season of 2020, however, the reduced purchasing power of con-

sumers and the sustained increase in prices may prevent a rapid return to the 2019 level. For Polish farmers, who own more than 80% of milk production in our country, the most important achievement during the pandemic was to maintain continuity of work, even though there were cases of unexpected termination of contracts for delivery of thousands of litres of raw milk per day by existing customers, which forced its producers to look for new contractors [Lewandowski 2020].

Transport of milk – from the producer to the processor

The milk transport process begins immediately after milking [Rozporządzenie (WE) nr 853/2004]. This means that it is necessary to observe all requirements and recommendations related to maintaining, among others, its hygienic, microbiological and cytological purity, as well as its nutritional value, until the delivery of raw milk to the processing plant (which should process raw milk within a day of its receipt). One of the elements is to maintain the appropriate temperature of the milk, which should not exceed +8°C if it is collected from the farm during the day, and +6°C if it is not collected daily. In case of high microbiological quality of raw milk, it is possible to keep the freshness longer – e.g. at +4 °C even up to 48 h [Czerniewicz 2010a]. Maintaining sufficiently low temperatures of the transported raw milk must be maintained at all times, as the temperature of the raw milk must not be higher than +10°C after its arrival at the final recipient. By observing these temperature values, it is possible to maintain milk quality even if the time of transport and marketing of milk by its producers and recipients is extended. The above mentioned thermal limitations in milk storage and transport may be omitted, however, in cases when milk from its milking is processed within 2 hours, as well as when, for technological reasons, higher temperature of the raw material is necessary in connection with the production of specific dairy products, however, on condition of receiving permission for it from the competent supervision authority [Kowalik 2011].

The smooth functioning of the milk supply chain, from collection, processing and distribution to the final retail consumer, is very much dependent on efficient transport. That is why it is so important to properly organize the transport process of milk, including the access to the farmer – the producer of the raw material, collection and transport to the processing plant and delivery of the obtained milk, as well as subsequent loading and unloading of finished products or semi-finished products for wholesale and retail recipients. Organization of the transport process must assume its proper functioning taking into account the use of the farmer's own vehicles – milk producer, processing plant or hired carriers (e.g. within the framework of outsourcing), having appropriate means of transport and properly trained personnel.

The transport between the milk producer and the processing plant takes place in two ways: direct or indirect deliveries, using an additional element of the supply chain, i.e. the collection point. The latter form may facilitate a more flexible management of the purchased raw material and a better adjustment of deliveries to the premises of the final recipient of raw milk, however, it brings with it the danger of mixing in stationary tanks or mobile tanks of milk with non-identical quality parameters, coming from different producers. A separate issue is the necessity of additional protection of raw material (espe-

cially when pumping and overflowing several times) against its aeration, temperature changes, increase in the amount of microorganisms and other negative elements, which decrease the quality of milk [Litwińczuk 2004].

The technological quality of the raw milk is also adversely affected by mechanical stimuli such as shocks (strokes) or vibrations (vertical and horizontal) at low and high frequencies during transport and pumping. Vibration in car transport, depending on the type of factors causing it, is in the range of 0.5–10 g (usually 0.5–1.5 g. occasionally 2–3 g), and 1–25 Hz. It was found that only the transport on a good quality asphalt pavement, in case of acceleration of 2 m/s, speed of about 60 km/h and over 60% filling of the tanker tank does not cause significant changes in the quality of transported milk [Czerniewicz 2010b].

High susceptibility of milk to mechanical influences damage to the structure of its components (mainly fat), which results in destabilization of the emulsion, manifested by the formation of butter grains. Passing vibrations through raw milk causes, first of all, mechanical deformation of fat globules, which leads to damage to their phospholipid-protein envelopes. All this favors the escape of liquid fat, which is the binder of the fat globules. As a result, shocks and vibrations of raw milk intensify the hydrolysis of milk fat. The destructive influence of mechanical influences on milk components, especially on fat globules, is intensified when the raw material is aerated. Mechanical interactions during transport of raw milk, resulting in the above mentioned transformations of its components, bring about an increase in acidity, a decrease in thermal and ethanol stability, as well as a significant conflict between rennet clotting time [Czerniewicz 2010b].

Milk transport equipment – specialised equipment

Modern means of milk transport are characterized by increasingly specialized systems of collection and analysis of milk collected directly from producers. The technical devices currently offered on the domestic market can be of great help in organizing milk collection from producers during the coronavirus pandemic. The most important are cisterns and The most important ones include tankers and control and measurement systems.

Tankers

On the Polish market, manufacturers offer tanks which can be mounted - depending on the customer's wish - on chassis of various brands, including DAF, MAN, MAZ, Mercedes-Benz, Mitsubishi, Renault, Scania or Volvo. These tanks are equipped with a raw milk collection system and their capacity may vary from e.g. 3000 to 17,000 litters. The tank is made of stainless steel and the number of internal chambers and their capacity is agreed with the customer before placing an order. The external surface of the tanker is made with the use of the technique of smearing or grinding – depending on the customer's preferences. Tank sections are also available: elliptical, circular or trunk sections. The use of an elliptical section guarantees lowering of the vehicle's centre of mass, which improves its traction. Moreover, the elliptical cross-section improves durability and reliability of the body structure. The use of polyurethane foam also provides 25% more effective thermal insulation of the tanker than many fillers used before. This solution protects

the transported milk against temperature changes of up to 1°C even after several hours of standstill with a difference in ambient temperature and tank content of up to 30°C. Equipment manufacturers can issue an ATP certificate[1]. Mounted on a road chassis, the tanker is also equipped with an installation enabling washing in the system CIP[2].

Figure 2. Tank (capacity 26,000 l), with a wheeled section on a self-supporting semi-trailer
Rysunek 2. Zbiornik (pojemność 26 000 l), z częścią kołową na naczepie samonośnej
Source: [WSK „PZL – KROSNO" S.A.]

Figure 3. Tank with elliptical section on Mercedes-Benz chassis
Rysunek 3. Zbiornik o przekroju eliptycznym na podwoziu Mercedes-Benz
Source: [WSK „PZL – KROSNO" S.A.]

[1] ATP (Aqreement Transport Perisahble) International agreement drawn up in Geneva on 1.09.1970 sets out the rules for the international transport of certain perishable food products using special means of transport and for checking the compliance of these means of transport with the applicable standards.
[2] CIP System (Cleaning in Place), i.e. on-site cleaning, refers to cleaning in a circular or continuous process of production installations and pipes – without the need to dismantle them beforehand.

Figure 4. Tank with elliptical section on Scania chassis
Rysunek 4. Zbiornik o przekroju eliptycznym na podwoziu Scania
Source: [WSK „PZL – KROSNO" S.A.]

Figure 5. Tank with elliptical section on DAF chassis
Rysunek 5. Zbiornik o przekroju eliptycznym na podwoziu DAF
Source: [WSK „PZL – KROSNO" S.A.]

Figure 6. Tank with chest section on MAN chassis
Rysunek 6.
Source: [WSK „PZL – KROSNO" S.A.]

Figure 7. Three-axle tanker – trailer with elliptical section
Rysunek 7. Cysterna trzyosiowa – przyczepa o przekroju eliptycznym
Source: [WSK „PZL – KROSNO" S.A.]

Figure 8. Two-axle tanker – trailer with a wheeled section
Rysunek 8. Cysterna dwuosiowa – przyczepa z częścią kołową
Source: [WSK „PZL – KROSNO" S.A.]

Control and measuring system for milk collection

Side cabinet made of stainless steel (heated), mounted on shock absorbers at the tanker, closed with a split door, contains a direct milk collection system with control and measuring equipment of the selected company. The devices of this system can be made in different variants, individually tailored to the customer's wishes. The control and measurement system consists of the following elements:

- hydraulically driven impeller pump with a capacity of e.g. up to 30,000 l/h. It is also possible to install a high-performance vacuum-pumping system – up to 60,000 l/h,
- air separator (e.g. 70 l capacity) providing accurate measurement, equipped with washing valve, venting valve and venting line, which thanks to its design guarantees reliability in all operating conditions, as well as ease of cleaning its individual elements and maintaining high hygiene of the separator,
- magnetic-inductive flow meter,

– mechanical filter,
– check valve,
– valve system – central drain collector,
– control panel – control box,
– the computer control unit,
– temperature sensor,
– liquid sensor,
– thermal printer,
– sample taker (with manual or automatic carousel bottle substitution mechanism).

Figure 9. Cases with installations for milk collection and analysis on elliptical tankers on three-axle self-supporting trailers
Rysunek 9. Przypadki z instalacjami do zbierania i analizy mleka na eliptycznych cysternach na trzyosiowych przyczepach samonośnych
Source: [WSK „PZL – KROSNO" S.A.]

Milk collection system

There are examples of functions:
– milk collection,
– measuring the quantity of milk collected,
– displaying data on milk parameters,
– measurement of the temperature of the raw material to be taken,
– automatic pump blocking in case of exceeding the present milk parameters,
– switch the milk pump on and off with the remote control,
– data recording in the control unit memory,
– programming of milk collection routes,
– printing receipts and other statements,
– automatic sampling of representative suppliers with automatic bottle change,
– storage of samples in a warehouse with an active cooling system,
– automatic representative tanker sample collection,
– data transmission from the road tanker to the processing plant computer using a cache module (USB stick, memory card), WIFI, cable,
– automatic bottle identification with barcode reader,
– identification of suppliers by means of GPS.

Figure 10. Open cabinet with installation for milk collection and analysis at a tanker with circular cross-section on a self-supporting semi-trailer
Rysunek 10. Otwarta szafa z instalacją do odbioru i analizy mleka w cysternie o przekroju kołowym na naczepie samonośnej
Source: [WSK „PZL – KROSNO" S.A.]

Figure 11. Cabinet interior with installation for milk collection and analysis at the tanker
Rysunek 11. Wnętrze szafy z instalacją do odbioru i analizy mleka przy cysternie
Source: [WSK „PZL – KROSNO" S.A.]

Figure 12. Installation for milk analysis on a tanker mounted on a Volvo chassis
Rysunek 12. Instalacja do analizy mleka na cysternie zamontowanej na podwoziu Volvo
Source: [WSK „PZL – KROSNO" S.A.]

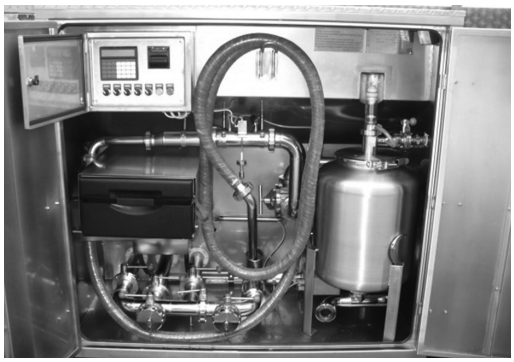

Figure 13. Installation for milk collection and analysis at the tanker
Rysunek 13. Instalacja do zbierania i analizy mleka przy cysternie
Source: [WSK „PZL – KROSNO" S.A.]

Conditions of milk collection and transport during the pandemic in Poland

The production of raw milk is combined with its frequent distribution to the processing plant. Therefore, there are understandable concerns about maintaining the continuity of this transfer between the milk producer and the recipient, resulting both from the maintenance of the health condition of people employed directly at milking, as well as personnel handling the direct collection of milk from the farmer, and the transport of raw material to the processor.

In March and April 2020, the Polish Chamber of Milk [Polska Izba Mleka 2020] developed and presented a document entitled "Procedure for handling coronavirus SARS-CoV-2 in dairy farms". At the same time, individual dairy cooperatives provided their suppliers with additional recommendations, especially concerning the handling of the risk of coronavirus infection of one of the farm inhabitants and keeping an appropriate distance from the staff collecting milk (e.g. tanker drivers), or avoiding contact with it at all [Tobojka 2020]. One of the national leaders in the production of ripened cheese, the Polish Spomlek Dairy Cooperative (having plants in Radzyń Podlaski, Parczew, Młynary and Chojnice), introduced during the pandemic, among others, the necessity to use gloves, masks and disinfectants by the drivers collecting milk from producers, while the hand disinfection takes place both before entering the area and after leaving the farm. The milk producers who cooperate with this company have also been supplied with disinfectant fluids, supporting activities aimed at minimizing the risk of infection. A special Crisis Team established at the beginning of the year in SM Spomlek has also developed a set of detailed recommendations for practical implementation by its suppliers – raw milk producers. Similar organizational and informational activities have also been undertaken by other producer companies in the dairy industry in relations with farmers supplying them with milk, and e.g. one of the largest dairy groups in Central and Eastern Europe, the Mlekovita Group (having 20 production plants and cooperating with 15,000 domestic milk suppliers) from Wysokie Mazowieckie (Podlaskie Voivodeship) asks for making

soap, disinfectant, paper towels and a container for waste disposal available to drivers collecting milk, among others. Moreover, it is pointed out that the access to the farm of people necessary to run it is limited[3].

Particular attention is also paid to the need to report on the current health situation of persons employed and living on the farm, as well as to the obligatory notification of the processing plant collecting milk about every case of coronavirus infection. In case of quarantine and epidemiological supervision of the farm, this information will enable people directly collecting and transporting milk to be particularly careful at all times of milk collection from the producer. Appropriate procedures to prevent the spread of coronavirus have also been implemented on the premises of dairy cooperatives and their production plants, where, among other things, the access of outsiders has been limited as much as possible, and drivers importing milk from farmers have their body temperature measured each time [Polska Izba Mleka 2020].

The proposed solution

The coronavirus pandemic 2019-nCoV, which caused COVID-19 disease, has continued uninterruptedly since the beginning of 2020 in Poland and many other countries in Europe and the world and has caused a number of changes covering almost all areas of life, including the economy and agri-food industry. Forced by, among other things, sanitary and epidemiological reasons, transformations in the organization of the process of collecting raw milk from producers induce the search for new solutions, eliminating to the maximum extent possible spread of coronavirus among the participants of the "milk supply chain". Due to the expected longer (than 1 year) duration of the pandemic, efforts should be made to improve the process of collecting and transporting raw milk from the farmer-producer to the processing plant.

One of the proposals may be to introduce stable or movable raw milk tanks, in places easily accessible to drivers picking up from the farm – without the need to enter the farm (if possible without disturbing traffic). Milk collection would take place without the necessity of any contact between the driver and the milk producer, and information about the collection of a certain amount of raw material, its quality parameters (analysed from the samples taken just before pumping the milk to the tanker), date and time of refuelling and data identifying the producer and the direct recipient (driver) would be transferred on-line to the processing plant. If there would be no need for additional tests of delivered milk at the recipient's place, then on the basis of electronically received data from the driver and available history of cooperation with a particular milk producer (especially in the scope of quality of the raw material received from him), the purchasing company could make a decision on quality qualification of the current delivery and start appropriate financial procedures for payment for the acquired goods (in this case raw milk). The proposed solution should not violate the existing conditions of contracting, but only allow for a completely epidemically safe functioning of milk collection in the conditions of the ongoing coronavirus pandemic.

[3] Data obtained from companies and company information materials.

The assumptions made can be specified in the following groups and points:

1. Prevention of the risk of coronavirus infection:
   - elimination of any contact between the person collecting raw milk and the producer and those living and working on the farm,
   - ensuring maximum epidemic safety of drivers collecting milk from producers' farmers guarantees uninterrupted, planned work of the existing staff, not causing the necessity of emergency start-up of replacements and obtaining additional people "from outside", requiring e.g. professional training on conditions during milk collection and transport to the processing plant.
2. Milk tank(s) to be collected by the driver:
   - if it is technically, organisationally and legally possible, a container/tanks for the raw material to be collected would be placed on the farm (or directly adjacent to it, belonging to the farmer – milk producer),
   - the number of tanks and their capacity would depend on the size of the milk batch to be collected directly by the truck driver (or, if necessary, by several vehicles with trailers during one collection),
   - the milk tank(s) ready for collection would be placed on a solid base or, if this is not possible, on a chassis allowing for slight movement,
   - the collection-ready milk tank(s) would be connected to an existing installation that transports milk from milking to the current milk storage areas. This connection could be permanent (providing better sanitary and quality conditions for the pumped milk) or temporary (installed only for the period of milk transfer from the farm),
   - the responsibility for keeping the collection-ready milk tank(s) clean would rest with the milk producer,
   - installation on the farm (or any other designated place) of a milk tank(s) ready for collection would be carried out under supervision and at the expense of the processing plant or with partial financial participation of the milk producer,
   - the milk tank(s) ready for collection would be owned by the entity collecting the raw material (e.g. a processing plant) and the farmer - producer would use it on a lease basis (free of charge or for a small amount which could be redeemed e.g. for delivering milk of a specific quality),
   - raw milk pumped by its producer to a leased tanker/tanker, at the moment of passing the information to the milk consignee (processing plant, other buying entity) would be the property of the latter and would remain at his disposal until collection,
   - maintaining a certain temperature in the milk tank(s) ready for collection, regardless of the season and weather, would be carried out by means of an installation installed in each of them, powered by energy from photovoltaic batteries (in case of a shortage of energy from the sun, e.g. during the winter period, it would also be drawn from the farm network. The cost of the energy taken – based on the reading of a separate meter – would be divided between the tank owner and the milk producer),
   - the area occupied by the place where the raw milk tank(s) are set up for direct delivery to the driver should make it possible – in case of development of milk production by the farm – to deliver further tanks for direct collection.

3. Making the organisation of milk collection by producers more flexible:
   - milk collection (in accordance with the conditions in force) can take place at the most convenient time from the point of view of the economy of using the tanker fleet,
   - in case of a vehicle breakdown, milk collection could be carried out without any disruption by another driver, at another time, without breaking the previously applicable schedule for collecting raw milk from the producer,
   - notification (by electronic means) by the farmer of readiness to hand over milk to the driver would make it easier for the consignee (the owner of the tanker fleet) to use the vehicles available at that time that are not working,
   - the information provided in real time by milk producers on their readiness to transfer milk from leased tanks would allow the processing plant to rationally manage their milk for this further storage and collection from farmers,
   - at the moment of transferring by the driver the information about milk collection and its quality and confirmation of the recipient's acceptance of these data, the processing plant or other entity collecting milk would start the procedure of transferring the receivables for purchased milk to the producer's account,
   - in case of necessity to perform additional tests collected from the producer by the milk driver in the processing plant, until they are completed and the raw material is evaluated, the duty transfer procedure would be stopped.

In the course of the conducted research, milk farmers – producers paid attention, above all, to the necessity of legal and financial regulations between a milk producer and its recipient, with regard to the foundation of leased tanks and their operating costs. They positively assessed the possibility of selling milk at the moment of its collection (after a positive assessment of its quality) combined with a quick transfer of receivables for the transferred raw material. About half of the surveyed persons had some controversy about the issue of separating a part of the farm's area, especially since the area is located as close as possible to a public road, which – if the conditions allow it – would make it possible to collect milk from the leased tanks without the need for a tanker truck to enter the private area and the possibility of introducing pathogenic viruses there. Possible "financial losses" resulting from separating part of the farm for these tanks could be compensated by free of charge lease of these devices, self-sufficient (if solar conditions allow it) in terms of energy – despite the necessity of keeping the tanks clean by the lessee. The overwhelming majority of dairy farmers emphasized the benefits of fast transfer of raw material to the leased tanks, which would automatically free up space for a new batch of milk and the preceding cleaning operations of the entire plant.

Another interesting aspect seems to be the possibility, arising as a result of the proposed solution, of temporary storage by producers in leased milk tanks, which would formally become the property of the recipient at the moment of collection by transport (after acceptance of the quality data of the raw material transmitted electronically by the driver), but can be transferred by the recipient not only to his own plants, but – in the case of e.g. unexpected failure or oversupply – directed to another processing plant or sold to another recipient.

Conclusions

The collection of raw milk from producers is a very important part of the supply chain in the milk and dairy products market. The offer of milk tankers available on the market and their equipment allow you to collect milk from producers in a safe way. Due to the coronavirus pandemic, however, organizational changes are necessary.

The paper presents a solution for safe delivery of raw milk to breeding enterprises. This proposal is particularly important during the development of the COVID-19 pandemic. Due to the limited timeframe of the field analyses, the studies conducted so far do not fully exhaust the signs of complementarity. Therefore, the adopted assumptions should be verified also on the basis of opinions of representatives of processing plants of the dairy industry and other institutions dealing with the purchase and marketing of raw milk, as well as unions and associations associating both milk producers and milk processors. This article may, however, constitute a pre-implementation proposal which will inspire other representatives of science and practice to deepen, among others, the subject of computerization and management of milk collection organization in the era of rapid development of digital economy, electronic transmission of information and means of payment, as well as awareness of proper behaviour during the ongoing epidemic. The authors are aware of the need for further research and analysis in this area, all the more so because the deadline for the definitive end of the coronavirus pandemic in the world, especially in Europe and Poland, is impossible in the foreseeable future.

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