

Стаття присвячена комплексному дослідженню впливу раціонів годівлі та породи корів на технологічні властивості молока та якісні характеристики сиру типу голандського. Незважаючи на велику кількість інформації щодо взаємозв'язку між годівлею тварин та технологічними параметрами виробництва сирів, можлива взаємодія між особливими властивостями породи тварин, змінами в раціонах годівлі та позитивним впливом на якість продукції потребує глибокого вивчення. Тому актуальним є дослідження впливу породи тварин та оптимізації раціонів їх годівлі на комплекс технологічних показників та показники якості сирів типу голандського. Сир голандський виробляли в серії експериментів із молока корів різних порід, отриманого при різних раціонах годівлі.

Проведено порівняння хімічного складу молока трьох груп корів – української бурої молочної, лебединської та симентальської порід за різних раціонів годівлі. Отримані результати свідчать, що використання люцернового сінажу сприяє підвищенню у молоці масової частки сухого знежиреного молочного залишку, покращенню його сиропридатності у порівнянні з молоком, отриманим у силосно-сінний період.

Опрацьовано технологічні режими виробництва твердого голландського сиру з молока трьох порід корів при різних раціонах годівлі. Показано, що за умови застосування у раціоні годівлі тварин люцернового сінажу тривалість основних технологічних операцій скорочується. Це сприяє зменшенню відходу сухих речовин (у т. ч. жиру) до сироватки, а також збільшує вихід готового продукту. Зразки твердого голландського сиру, отримані з молока усіх трьох груп тварин у сінажно-сінний період, характеризувалися вищим вмістом незамінних амінокислот, а також вільних амінокислот, розчинного та небілкового азоту. Це обумовило у них вищий ступінь зрілості та вищу балоу оцінку за органолептичними показниками (на 7–9 балів) у порівнянні зі зразками сиру, виробленого із молока, отриманого у силосно-сінний період. Найвищу балоу оцінку за органолептичними показниками (99 балів) отримали зразки сиру голландського, вироблені із молока тварин української бурої молочної породи, отриманого у сінажно-сінний період.

Встановлено, що порода тварини значною мірою впливає на сиропридатність молока та на вихід готового продукту. Найбільш значимий вплив оптимізованого раціону годівлі було отримано на органолептичні та сенсорні показники сиру голландського. Підтвердженням цього є показники протеолітичної активності. Збільшився приріст азоту розчинних фракцій, прискорився процес визрівання про що свідчить накопичення низькомолекулярних азотистих фракцій. Найбільшу сумарну кількість вільних амінокислот містили сири, отримані з молока корів за умов годівлі покращеним раціоном з використанням люцернового сінажу.

Розроблені раціони годівлі, вдосконалені технологічні параметри виробництва голандського сиру, як методи управління собівартістю та якістю продукції можуть бути рекомендовані для масового і крафтового виробництва сирів

Ключові слова: сир голандський, амінокислотний склад, сиропридатність, сінаж з люцерни, оптимізація раціону

DETERMINING THE INFLUENCE OF THE COMPOSITION OF MILK FROM COWS OF DIFFERENT BREEDS ON QUALITY INDICATORS FOR THE DUTCH-TYPE CHEESE

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1. Introduction

Production of hard cheese and its consumption have played a significant role in the historical development of mankind. Cheese deserves to be one of the favorite delicious and healthy food products, its important economic and rep-

resentative role is recognized in many countries. For example, there are such well-known cheese countries as Switzerland, France, Italy, where each region has its own tradition of cheese making. The individual properties of cheese are comprised of several components, the most important of which is the high-quality raw milk [1], affected by the breed of cows,

keeping and feeding animals [2], as well as the technological parameters for processing raw milk, production, maturing and storage of the product.

An increasing number of small dairy businesses, set up recently, try to provide the market of dairy products with tastes of a “home-made” product. However, they do so mainly by the elevated fat content, which does not exactly meet the requirements of nutrition science to the diet of a modern person who should receive balanced, in terms of composition, and safe dairy products. At the same time, there is an untapped reserve to create unique cheeses in terms of their organoleptic indicators, useful in their composition, and with a nutritional biological value. Such a reserve is the breeds of dairy animals and their balanced feed, grown under certain climatic conditions [3, 4].

Dairy industry deals with the issue on improving the quality of products that is closely linked to the quality of the processed milk. Therefore, they pay special attention to the preservation of those genotypes of cattle that ensure the desired quality of milk [5].

Current innovative technological approaches to dairy products quality management imply obtaining raw materials with a balanced composition and an elevated biological value. It should be noted that by using modern technologies for keeping, optimizing the feeding, and utilizing breeding factors in dairy cattle breeding, it is possible to receive raw milk whose application would reduce the cost of cheese making, which is an important factor in the cost of the product. In addition, when using high quality raw materials, it becomes possible to obtain a product not only with exclusive organoleptic properties, but also with useful, health-improving characteristics. It is known that amino acids, which form as a result of protein decomposition, are used for the biosynthesis of cells, which is very important for the human body [6]. However, it is not known whether a change in cow feeding rations affects the amino acid composition of cheese.

Small businesses at present pay much attention to the production of various dairy products, but the products obtained are not fully examined; they take into consideration only the organoleptic indicators and indices for compliance and safety of dairy products. The do not take into consideration the impact of a product on human health, they do not explore nutrition and biological value, unique, authentic properties of these products, raw materials from which they are made. Therefore, it is a relevant task to undertake a comprehensive study into raw milk, the technological parameters of production, and quality indicators for a Dutch-type cheese, depending on the breed of cattle and the optimized feeding rations. Investigating these factors would make it possible for cheese manufacturers to improve the process of production and to receive a product with predictable quality indicators.

2. Literature review and problem statement

There is a recent tendency in production management to handle production costs so that the maximum profit is earned. The original raw material in cheese production is milk, which is not suitable to long-term storage. However, cheeses, which are made from it, can, depending on the type and conditions of storage, remain at a cheese storing facility from 4–5 days to 5–10 years. Thus, production of cheese is also one of the ways to prolong the shelf life of food products [7].

Authors of study [8] outlined recommendations for making decisions related to milk production, especially in coun-

tries that are characterized by seasonal delivery of fresh milk. They studied coagulation factors depending on seasonality and a lactation period. However, it should be noted that there are no substantiated studies that would have established a link between a breed and cow feeding, optimization of the technological parameters and unique organoleptic properties, nutritional and biological value of cheeses.

The quality of milk produced by cattle depends on the breed, feeding, lactation period, and health. However, the composition of milk required in the production of cheeses differs from that intended for making fermented milk drinks. That can employ different cattle and different breeds, as well as include a variety of products according to the standard desired dairy products [9]. Thus, milk that is high in protein can be successfully used in the production of cheeses, but cause losses in the production of drinking milk [10]. These papers examined the factors influencing the quality of milk for different types of products, but there is no research into the technological parameters for production, and control over them, taking into consideration milk quality indicators.

The purpose of study [11] was to investigate a change in the composition of milk and technological characteristics that are regularly acquired under field conditions in the Italian dairy industry. The compositional signs were the percentages of fat, protein, and casein, the content of urea and the number of somatic cells; as well as technological characteristics for the duration of raw material coagulation. Data on herd milk were analyzed using a model that included the fixed effect of the region and a seasonal analysis of milk. The authors noted the good quality of milk on average, they observed moderate and high correlation between the composition and technological features. The features differed significantly in terms of regions, which could reflect differences in the management and strategies of the herd. The results of this study showed that the constant monitoring of technological features in the dairy industry is needed to improve product quality at the level of a herd, and this might constitute a technique to select milk according to its processing characteristics. However, the authors did not investigate the effect of cattle breed on the technological parameters and quality indicators of the finished product.

Raw milk from individual cows and different breeds demonstrates different coagulation capabilities. This change is largely influenced by the genetic variants of milk protein. Paper [12] investigated differences in the coagulating properties of milk obtained from three breeds/types of cattle found in Sri Lanka. The authors assessed different properties of milk coagulant, specifically product yield, cheese hardness, syneresis, and rheological properties. They defined the biochemical composition (lactose, protein, fat, non-fat dry milk residue) of milk samples. The results show that there is a significant correlation between a milk coagulating capability and the genetic variants of milk protein. However, there are no data on the impact of the cattle breed on the product's organoleptic properties.

The dependence between milk quality and the cheese produced from it was studied in work [13]; the authors cross-bred the Holstein cows and bulls from the Nordic and Alpine European breeds and investigated whether breeding activities affected milk quality, traditional properties of milk coagulation, as well as modeled the hardness of cheese obtained from selected samples of milk. The results showed that different breeds of parents were characterized by specific technological abilities, but they were not strictly related to other characteristics of milk quality. In addition, favorable characteristics (in terms of quality and technological properties of milk) can be

retained in the third generation without a negative impact on milk productivity. Thus, conclusions from paper [13] indicate that in order to ensure the optimization of crossbreeding of agricultural producers one can select different types of producers (depending on the proposed use of milk). The paper does not report any research into the influence of feeding together with breeding factors.

Paper [14] explored the influence of minerals on stability of a casein micelle in individual cow's milk during complete lactation. The authors analyzed the content of ions of calcium, magnesium, phosphorus, sodium, potassium, and citrate, as well as the following physical properties of milk; pH, rennet coagulation time, and clot stability. During lactation, the authors determined such average values as: the concentration of free Ca^{2+} – 1.88 mm, pH – 6.63, and coagulation time – 13.6 min. Equilibrium relationship between pH and the concentration of free Ca^{2+} was studied by adjusting the pH of milk from 5.9 to 7.1, using acid and alkali. There was a good inverse linear relationship between pH and $\log(\text{free Ca}^{2+})$ for individual samples of milk. However, this is a separate quality index of raw milk suitable for cheese making. There is no study into the impact of this indicator on the characteristics of the finished product.

The milk processing characteristics, examined in study [15], such as duration of milk coagulation, clot density at minutes 30 and 60 after the addition of a rennet enzyme, the size of a casein micelle, and pH of milk, were estimated by predicting the average infrared spectroscopy of equation. The study showed that at least 80 % of the genetic variations in cattle in lactation profiles were associated with a change in the period of lactation. As a result of this work, the authors revealed the existence of genetic variability, which can be used to process milk. This study makes it possible to compare the effect of genetic factors on technological parameters of production, but it does not take into consideration the impact of cattle feeding and does not give any idea about nutritional and biological value of cheese.

The research reported in paper [16] established that milk from the Ukrainian brown dairy cow breed is characterized by high biological value. This is evidenced by better-than-average values for the required total amount of amino acids per 1 g of milk, by 4.69 mg. In addition, when making cheese the consumption of milk to produce 1 kg of cheese from the Lebedinskaya cow breed was 8.9 kg, and from the Ukrainian black-spotted milk breed – 9.13 kg. The amino acid composition of milk proteins from the Ukrainian brown dairy cow breed has a better ratio of amino acids to form the desired organoleptic qualities of milk and dairy products made from it [17]. However, it was not defined the way these parameters affect the technology of hard cheese production and, consequently, the desired reduction in production costs, while unequivocally improving the quality of the finished product.

The gene pool of cattle by the Lebedinskaya cow breed demonstrated the following chemical composition of milk: fat content – 3.82–3.87 %, protein content – 3.33–3.35 %, lactose content – 4.68–4.73 %, dry substances content – 12.61–12.72 % [18]. By conducting a more detailed study into the influence of milk quality on the technological process of production, as well as qualitative characteristics of cheese, it is possible to scientifically substantiate the economic expediency of breeding this particular breed of cows.

The suitability of milk for cheese making, as well as cheese quality, depending on the gene pool of cattle was

investigated in [19]; the authors specifically examined the suitability of milk for cheese making from the Sumy-type cows of the Ukrainian black and spotted dairy breed. They noted that the main condition for the implementation of biological capabilities of dairy cows in terms of productivity is the breed and optimization of feeding rations [20].

Numerous studies have proved that the full and balanced feeding of cows ensures that milk composition is predetermined genetically. Disruption of feeding, changing the composition or structure of ration, the lack of nutrients, lead to a decrease in milk yield and changes the composition of milk [21].

In addition, feed and breeding factors can change not only the total content of protein and fat in milk, but the fractional composition of these milk components [22]. Despite the practical significance of such results, there is no clear-cut developed relationship between the cattle breed, optimization of rations, technological parameters and exclusive quality characteristics of milk for cheese making.

Thus, it is important to improve the technology for obtaining raw milk with predictable quality indicators, in order to make cheeses with improved technological characteristics, organoleptic indicators, and high biological value. It is advisable to investigate a possibility of using haylage of the alfalfa type to improve rations of cattle feeding.

The indicators of milk quality affect the amount of the product obtained, its structural and taste characteristics. Properties of milk for cheese making have long been discussed by many scientists, but there is constant selection work, with changes in the conditions for keeping cows and the automation of process for preparing balanced rations of cattle feeding. Thus, it is necessary to constantly examine the impact of the process of milk production on the technological parameters of cheese production and quality of finished products, in order to control and predict results. We need to assess quality, including a biological value, of hard cheeses made from different kinds of milk in line with a conventional technology. The implementation of results from such studies would make it possible to provide recommendations for the production of hard cheeses of improved quality from milk by different breeds of cows.

3. The aim and objectives of the study

The aim of this work is to determine the impact of components of milk from cows of different breeds on the technological process of production and quality indicators for the Dutch-type cheese.

To accomplish the aim, the following tasks have been set:

- to compare the chemical composition of milk from three groups of cows – the Ukrainian brown dairy cow breed, the Lebedinskaya cow breed, and the Simmental cow breed, which were fed different feeding rations, based on the following indicators: (mass fraction: dry substances, fat, protein, casein, whey protein, lactose, ash, calcium). To establish the effect of alfalfa haylage on the quality of milk for making the Dutch-type cheese;

- to explore technological (suitability of milk for cheese making), physical-chemical (acidity, density) properties, to work out technological modes for making hard Dutch-type cheese from milk by different breeds of cows at different rations of cattle feeding;

- to define the chemical composition, quality indicators for the hard Dutch-type cheese produced from milk by various breeds of cows at different rations of cattle feeding;

- to characterize the amino-acid composition of proteins in the hard Dutch-type cheese produced from milk by various breeds of cows at different rations of cattle feeding;
- to perform an organoleptic assessment – comparison of the Dutch-type cheese made from milk by various breeds of cows at different rations of feeding.

4. Materials and methods to study the composition of the Dutch-type cheese made from milk by cows of different breeds

4.1. Examined materials and instruments used in the experiment

Our research was performed in line with a program of scientific work at Sumy National Agricultural University (NAU) on the topic “Substantiation of methodology for improvement and preservation of population of the brown cattle under conditions of the North-Eastern region of Ukraine”. The scientific and economic research was carried out at the training-experimental farm “Vivarium” at Sumy NAU.

The cattle were fed a conventional ration based on silage (ration 1) and the improved ration – based on alfalfa haylage (ration 2).

In our research, we used whole cow’s milk of the highest grade according to DSTU 3662:2015 “Raw cow’s milk. Specifications”, received from cows from the training-experimental farm “Vivarium” at Sumy NAU. The raw material had the following characteristics: density – not less than 1.027 kg/m³, mass fraction of solids – not less than 11.8 %, acidity – from 16–18 °T, a group of purity – not less than I (KMAFAM) – not higher than 300 thousand CFU/cm³, the number of somatic cells – to 400 thousand/cm³.

Fermentation was carried out using the culture *FD DVS CH-N 19* supplied by *Chr. Hansen* (Denmark), which contains the mesophilic cultures *Lactococcus lactis ssp. lactis*, *Lactococcus lactis ssp. cremoris*, *Lactococcus lactis ssp. diacetylactis*, *Leuconostoc mesenteroides ssp. cremoris*.

The rennet coagulation employed the milk-seeding enzyme *CHY-MAX Extra 600 IMCU* supplied by *Chr. Hansen* (Denmark) and calcium chloride according to GOST 450-77 “Technical calcium chloride. Specifications” supplied by Browin (Poland).

The level of moisture in a cheese grain and pH were regulated by drinking water according to DSanPiN 2.2.4-171-2010 “Hygienic requirements to drinking water intended for human consumption”.

4.2. Procedures for determining the indicators for samples’ properties

We determined in the course of research:

- titrated acidity of milk and cheese whey – by a titrimetric method according to GOST 3624-92;
- active acidity – by a potentiometric method according to DSTU 8550:2015, temperature – DSTU 6066:2008;
- density – by an aerometric method according to DSTU 6082:2008;
- heat resistance – using alcohol sampling according to DSTU 5073:2008;
- purity – in line with DSTU 6083:2008;
- the mass fraction of dry substances – by an arbitration method in line with GOST 3626-73;
- the mass fraction of proteins – by the Kjeldahl method in line with DSTU ISO 8968-1:2005 (IDF 20–1:2001);

– the mass fraction of fat – by a gravimetric method in line with DSTU ISO 1211–2002;

– microbiological indicators – in accordance with DSTU 7357, DSTU 7089, DSTU ISO 4833, DSTU IDF 100V;

– fermentation or rennet-fermentation sample is defined in accordance with DSTU 7357-2013;

– the number of somatic cells – in accordance with DSTU 7672, or DSTU ISO 13366-1, or DSTU ISO 13366-2;

– the mass fraction of casein – DSTU ISO 8968:2005-2 (Milk. Determining the content of nitrogen. Part 2. Method for using a block for combustion); DSTU ISO 17997-1 (Milk. Determining the content of casein nitrogen. Part 1. Indirect method (control method), and DSTU ISO 5545/IDF 90:2015 Casein, rennet, and caseinates. Determining a mass fraction of ash. Control method);

– the content of fractions of nitrogen in the Dutch-type cheese – DSTU ISO 8968:2005-4 (Milk. Determining the content of nitrogen. Part 2. Method for determining non-protein nitrogen);

– the mass fraction of lactose – ISO 22662:2007 (IDF 198:2007) Milk and milk products – Determining lactose content by high-performance liquid chromatography (Reference method);

– the mass fraction of calcium – DSTU ISO 12081:2004 Milk. Determining the content of calcium by a titrimetric method;

– quantitative composition of amino acids in mature Dutch-type cheese – DSTU ISO 13903:2009 Animal feed. Method for determining the content of amino acids;

– the mass fraction of dry substances in mature cheese – DSTU ISO 5534:2005 Cheese and cream cheese. Determining the total dry substances content (control method);

– the mass fraction of fat in mature cheese – DSTU ISO 1735:2005 CHEESE AND CREAM CHEESE Gravimetric method for determining the fat content (control method);

– the mass fraction of protein in mature cheese – by the Kjeldahl method in line with DSTU ISO 8968–1:2005 (IDF 20–1:2001).

We used the following equipment:

- the analytical balance “OHAUS”;
- the high efficiency liquid chromatograph “Shimadzu LC 20A (lactose);
- the gas chromatograph “Kupol 55”; (FA composition);
- the digester and distiller “Fisher Bioblock Scientific (Kjeldahl);
- the amino acid analyzer “Biotronik LC 2000”.

5. Results of studying the indicators and properties of milk and the Dutch-type cheese

5.1. The scheme and results of research into feeding of cows under conditions of the experiment

Among the main components of cattle feeding are hay, corn silage, and alfalfa haylage in various combinations. Using these components in optimal quantities to feed cows ensures the optimal digestive processes and the composition of milk. To conduct the study, we formed 3 groups of cows (5 animals per each), which were kept under the same conditions and fed the same (*scheme*). The first group included cows by the Ukrainian brown dairy breed (UBD), the second – cows by the Lebedinskaya breed (LEB), the third group (control) – cows by the Simmental breed (SIM).

The scheme of cow feeding under conditions of the experiment:

1. Preliminary period – ration of the silage-hay type;
2. Experimental period I (25 days) – ration of the silage-hay type;
3. Transitional period (15 days) – ration for the transition period;
4. Experimental period II (25 days) – ration of the haylage-hay type.

Under conditions of the experiment, the rations for cows were calculated for the average cow productivity of about 16 kg of milk per day. The procedure implied cow feeding in the three groups first with a silage-hay ration. Following a fifteen-day transition period, silage in the ration was gradually changed for alfalfa haylage. In addition, the rations included high-quality hay that was specifically prepared for the experiment under conditions of an environmentally safe zone – Mikhaylivska Virgin Land, located in the Lebedinsky region of Sumy oblast. The composition and nutritive value of cow rations at different types of feeding are given in Table 1.

Table 1

Composition and nutritive value of cow rations at different types of feeding

Composition and nutritive value	Types of rations		
	Silage-hay	Haylage-hay	Feed norm
Ration composition, kg			
Hay	8	8	–
Corn silage	22	–	–
Alfalfa haylage	–	13	–
Wheat middlings	1.5	2	–
Barley middlings	1.5	2	–
Sunflower cake	1.5	–	–
Salt	0.09	0.09	–
Ration includes			
	fact		norm
Exchange energy, MJ	148	148	148
Dry matter, kg	16.1	16.4	15.8
Raw protein, g	2,033	2,151	1,940
Digestible protein, g	1,304	1,307	1,260
Raw fat, g	579	376	405
Raw fiber, g	3,888	3,983	4,110
Starch, g	2,201	2,220	1,705
Sugars, g	525	574	1,135
Table salt, g	0.09	0.09	89
Calcium, g	89	151	89
Phosphorus, g	45	44	63
Magnesium, g	38.1	31.9	25
Potassium, g	209.8	285.1	96
Sulphur, g	34.3	35.6	31
Iron, mg	3,647	3,598	1,010
Copper, mg	113	142	115
Zink, mg	463	392	755
Manganese, mg	521	697	755
Cobalt, mg	521	697	8.8
Iodine, mg	9.1	8.3	10.1
Carotene, mg	594	675	565
Vitamin D, MO thousand	3.53	4.58	12.6
Vitamin E, mg	932	684	505

In terms of the content of energy and main nutrition factors (Table 1), the rations were almost identical, and corresponded in general to the norms of feeding [21, 22].

We used sunflower cake as protein feed for the silage-hay type of feeding. For the haylage-hay ration, the main source of protein (44 % of daily norm) was alfalfa.

In the course of experiment, we measured cattle feed intake and milk productivity.

We determined the technological indicators for milk in the laboratory at the Department of Milk Technology at Sumy NAU.

5. 2. Determining the composition and technological properties of milk derived from cows by different breeds

The results of determining quality indicators for milk derived from cows by different breeds from the North-East region depending on the feeding rations are given in Table 2.

Comparison of indicators for milk derived from cows by brown breeds that were fed rations 1 and 2 indicates significant differences in the chemical composition. The most valuable component in milk is dry substances because they include all components that define its general nutritional and technological properties of [22]. We established in cows' milk that were fed ration 2 a higher content of dry substances: group 1 – by 0.24 %, group 2 – by 0.17 %, group 3 – by 0.34 %.

When fed ration 2, the mass fraction of fat in the milk from all three groups of cows increased by 0.6–0.9 %, the mass fraction of total protein increased by 0.5–0.6 %, we observed an increase in the mass share of casein by 0.3–0.8 %. An increase in the mass fraction of ash by 0.2–0.5 % testifies to an increase in the content of mineral substances in milk [23].

When making cheese, not only the mass fraction of total protein is important, but its main component – casein [24–26]. Analyzing the composition of protein (Table 3), it should be noted that the content of casein in milk, obtained when cows were fed ration 2, in two groups of cattle by brown breeds is 2.68 and 2.83 %, respectively, which is 0.05 and 0.08 % higher than when they were fed ration 1. In cows from the third group, the content of casein is 0.03 % higher when fed ration 2 compared with that for ration 1.

The protein of milk from two examined groups of cows by brown breeds that were fed ration 2 contains more whey proteins (on average, 0.53 % and 0.61 %, respectively); in cows from the third group, this indicator was 0.62 %, indicating the positive effect of the ration based on alfalfa haylage on this type of proteins.

In terms of the content of the basic carbohydrate, lactose, we did not find in the milk from cows in all the examined groups that were fed ration 2 any significant differences – this indicator was at 4.77 %, but it was higher than the indicators for the cattle fed ration 1, by 0.01–0.02 %.

Milk is a good source of most minerals. In terms of the content of mineral substances (ash), milk from the cows of brown breeds and from a control group demonstrated no differences, but milk from cows in all the examined groups that were fed ration 2 showed an increase in this indicator, by 0.02, 0.05, and 0.01 %, respectively. An increase in dry matter in the milk of cows from all three groups leads to an increase in density, by 0.2–0.6 ‰.

Technological properties of milk are those properties that milk demonstrates when it is processed. In the practice of cheese making, this is the suitability of milk for cheese making [27]. Cheese making has always been considered the most difficult of all food production. First, this relates to that it is difficult

to make high-quality cheese from milk of any quality, and often impossible, which is why milk in cheese-making must comply with special, enhanced requirements. In order to produce cheese with the required organoleptic, physical-chemical and hygienic indicators, and at the lowest production costs, milk with a specific composition and properties is required [28].

Requirements for milk as a raw material for cheese making are defined by applicable regulations. There are also non-regulated but recommended values for indicators of milk quality for cheese production (mass fraction of protein, casein, calcium, rennet coagulation rate, etc.) [29].

Suitability of milk for cheese making is determined based on the optimal ratio: fat/protein – 1.06–1.24; fat/DFMR – 0.40–0.45, and protein/DFMR – 0.36–0.44. Raw milk for cheese making must meet safety requirements according to DSTU 3662:2015 “Cow’s raw milk. Technical conditions”. In the milk from two groups of cows by brown breeds the ratio of fat/protein is roughly the same and is, respectively, 1.06, while in the control group – 1.22, indicating compliance with the requirements of cheese making.

In the milk from cows that were fed ration 2, values for active acidity were 0.07–0.12 pH units above the active acidity of milk obtained from the same cattle when they were fed ration 1. Moreover, the most significant difference in the increased pH was observed for the Lebedinskaya cow breed (Table 3).

Specifically, by exploring the technological quality of milk, we found that milk from the Simmental breed and brown breed, when compared to the black-and-white breed, contains more casein, at 2.72–2.87. Its consumption to produce 1 kg of cheese amounted to 8.9 kg for both breeds.

An important indicator for cheese making is the indicator that characterizes the capability of milk to coagulate under the action of a milk-seeding enzyme and that shows the number of micro florae, which can generate gas (specifically, the number of BCG): this is a rennet-fermentation test. When cattle are fed ration 2, milk from cows of all three breeds corresponded to class I based on the specified indicator (Table 3), whereas when feeding cows by all breeds with ration 1 milk corresponded to class II based on the rennet-fermentation test, which indicates its lower suitability for cheese making.

In the course of this work, we explored the technological properties of milk selected for making the Dutch-type cheese. The Dutch-type cheese is a typical representative of hard cheeses. It is made from pasteurized milk, normalized for fat with respect to protein. At the training-experimental laboratory at SNAU we made cheese 6 times from milk by each group of cows, respectively, that were fed conventional ration 1 and 2, and investigated the technological properties of milk in the technological process. The cheese was produced in accordance with the technological instructions for making the Dutch-type cheese, round-shaped.

According to the literary data, milk is divided into three types based on the suitability for cheese making [29]. The first type includes milk whose coagulation duration under the action of a milk-seeding enzyme is up to 16 minutes. For the second type of milk, coagulation duration ranges from 16 to 40 minutes. Milk of the third type coagulates after 40 minutes (rennet-sagging milk) or may not coagulate by a milk-seeding enzyme. For cheese making, the best milk is believed to be that of the second

type. Duration of milk coagulation was determined under identical conditions under the action of a milk-seeding enzyme (application rate is 1 g per 100 dm³, coagulation temperature is 32 °C).

The milk obtained from cows of the first group that were fed ration 1 coagulated over 33.5 minutes, the second group – 35.3 minutes, and the third group – 40.0 minutes (Table 4). Therefore, we can assume that the milk obtained from both groups of cattle of brown breeds is suitable for the manufacture of cheese and belongs to the second type in terms of suitability for cheese making while milk from the third group turned out rennet-sagging.

Research into technological properties of milk obtained when cattle were fed ration 2 has shown that the duration of coagulation was, respectively, group 1 – 30.5 minutes; group 2 – 30 minutes, group 3 – 35 minutes. Reduction of milk coagulation when cattle were fed ration 2 testifies to its improved suitability for cheese making. The technological properties of milk were analyzed in the course of the technological process for making the Dutch-type cheese (Table 3).

In the production of cheese, the formation of a casein clot under the action of a milk-seeding enzyme in cows’ milk from group 1, ration 2, occurred in 30.5 min., which is faster, compared to milk from the same group but fed ration 1, by 3.0 min., group 2 – by 4.75 min., group 3 – by 6.5 min.

In this case, duration of the coagulation phase, when casein is combined with calcium, phosphorus, and other components of milk, was longer when making cheese from milk based on ration 1, respectively: – group 1 – by 2.6 minutes., group 2 – by 4.25 min., group 3 – by 3.1 min.

The gel-formation phase, the onset of casein sedimentation in the form of flakes and clot formation [29], was shorter when making cheese from milk by cows from all three groups that were fed ration 2.

It should be noted that density of the rennet clot in all groups meet the requirements of the technological instructions for the production of cheese. However, the density of clot in the milk of cows that were fed ration 2, compared with milk obtained from cattle that were fed ration 1, was higher: in the first group – by 0.1 g/cm³, in the second – by 0.2 g/cm³, in the third – by 0.12 g/cm³.

As for the processing of clot, which includes cutting it, grain formation and agitation, when making cheese from milk by cows that were fed ration 2, clot processing was shortened. It had the following values: group 1 – 38 min., group 2 – 35 min., group 3 – 40 min., which meets the requirements to cheese making in terms of cheese-suitable milk coagulation duration when using a milk-seeding enzyme.

The release of dry substances to whey (when processing a clot) from the milk of cows that were fed ration 2, in all three groups, decreased compared with the milk from cows in all groups that were fed ration 1, specifically: group 1 – by 0.7 %; group 2 – by 1.0 %; group 3 – by 0.9 %.

When making cheese, one of the important indicators is the mass of milk used to produce 1 kg of product [30]. If we analyze the norms for the consumption of raw material per 1 kg of cheese, then there is a clear influence of alfalfa haylage on an increase in the dry substances in milk and a decrease in the rated raw material consumption for making 1 kg of cheese, by 1.6 % for group 1, by 2.8 and 2.5 % for groups 2 and 3, respectively (Table 3).

Table 2

Chemical composition and technological quality indicators for milk from cows by different breeds depending on the type of feeding

No.	Indicator title	Value of indicator for cows by breed					
		UBD (group 1)	LEB (group 2)	SIM (group 3)	UBD (group 1)	LEB (group 2)	SIM (group 3)
		silage-hay period (ration 1)			haylage-hay period (ration 2)		
1	Mass share of dry substances, %	12.25	12.57	12.52	12.49	12.74	12.86
2	Mass share of fat, %	3.41	3.56	3.71	3.55	3.65	3.85
3	Mass share of DFMR, %	8.84	9.01	8.81	8.94	9.09	9.01
4	Mass share of protein, %, incl.	3.15	3.39	3.1	3.21	3.44	3.15
	casein	2.63	2.75	2.60	2.68	2.83	2.63
	whey proteins	0.52	0.64	0.50	0.53	0.61	0.62
5	Mass share of lactose, %	4.75	4.76	4.73	4.77	4.77	4.74
6	Mass share of ash, %	0.94	0.86	0.98	0.96	0.91	0.99
7	Mass share of calcium, mg/100 g	137	132	130	141	135	135
8	Acidity °T	18	18	18	18	18	18
9	pH	6.54	6.53	6.51	6.61	6.65	6.60
10	Density, °A	29.1	30.3	30.0	29.7	30.5	30.4
11	Rennet-fermentation test, class	2	2	2	1	1	1

Table 3

Technological properties of milk during cheese production

No.	Indicator title	Indicator value for cows of breed					
		UBD (group 1)	LEB (group 2)	SIM (group 3)	UBD (group 1)	LEB (group 2)	SIM (group 3)
		silage-hay period (ration 1)			haylage-hay period (ration 2)		
1	Coagulation duration with a milk-seeding enzyme, min.	33.5	34.25	40.0	30.5	29.5	33.5
	incl. coagulation phase	28.7	28.25	31.8	26.1	25.0	28.7
2	Gel formation phase, min.	4.8	5.0	5.2	4.4	4.5	4.8
3	Clot processing time, min.	48	46	50	38	35	40
4	Rennet clot density, g/cm ³	3.10	3.05	3.08	3.20	3.25	3.20
5	Release of dry substances to whey, %	47.2	47.0	47.4	46.5	46.0	46.5
6	Mass share of fat in whey, %	0.32	0.31	0.35	0.3	0.29	0.32
7	Norm of milk consumption per 1 kg of mature cheese, kg	9.86	9.9	10.0	9.70	9.62	9.85

5. 3. Determining the chemical composition and biological value of hard Dutch-type cheese

Results of research into chemical composition, acidity, and the indicator of maturity of cheeses obtained, are given in Table 4.

In cheese making, an important factor is the mass fraction of calcium and phosphorus in milk [31]. In milk, casein and calcium salts form a caseinate-calcium-phosphate complex, which is in the form of micelles of different diameter. Under the action of a milk-seeding enzyme, κ -casein of milk loses its stabilizing properties and coagulates, forming a casein clot [32, 33]. The highest calcium content was registered in the cheese made from milk of cows from studied groups that were fed ration 2 compared with ration 1 – by 11.14 and 7.0 mg/100 g, respectively.

In terms of pH, all samples of cheese matched rated values for the Dutch-type cheese [30, 32]; pH was at 5.39–5.42 (Table 5).

Determining a degree of cheese maturity by Shilovich [34] revealed that the greatest degree of maturity characterized the cheese made from milk of cows from all groups that were fed ration 2. Thus, the advantage of cheese from this milk in terms of maturity indicator, compared to the cheese made from milk based on ration 1, amounted for the groups of cows:

4.0 °Sh, 3.0 °Sh and 3.0 °Sh. This means that the cheese made from milk by cows kept on ration 1 underwent less intensive biochemical processes than the cheese made from milk of cows that were fed ration 2. This is due to the positive influence of the balanced feed whose base is alfalfa haylage.

The mass fraction of dry substances, protein, and fat in all investigated samples of cheese matched the rated level for the Dutch-type cheese (Table 4). However, the largest mass share of fat in dry matter was demonstrated by cheese made from the milk of cows in all the studied groups that were fed ration 2. Compared with ration 1, the advantage amounted to 0.3 % for both groups of brown cattle and 0.5 % for the third group.

Maturation of cheese is a very complicated process. It helps form important organoleptic properties of cheese, its taste, odor, dough consistency, and pattern. When cheese matures, the key role belongs to proteins, more specifically, the fractions of casein, as they provide for a possibility to obtain a product and are the main component of cheese, which form the properties inherent in this type of product. Maturation of the Dutch-type cheese involves the microflora of a fermenting agent and the residual microflora [35]. Our cheese was matured at a temperature of 10–12 °C, humidity of 85–90 %, over 60 days.

One of the typical reactions in cheese at maturation is the fermentation of proteins, during which numerous nitrogenous compounds form. The processes of decomposition and the further conversion of products from fermentative hydrolysis are very complicated, because there are many ways to cleave a protein's molecule, which depends on the composition of bacterial enzymes [35]. In addition, the primary products of fermentation do not remain the same, as they are necessary for further reactions and serve as source materials for the synthesis of new compounds [35].

Table 5 gives the content of nitrogen fractions in the Dutch-type cheese whose period of maturation lasted for 60 days; it was determined in line with DSTU ISO 8968:2005-4 (Milk. Determining the content of nitrogen. Part 2. Method for determining the non-protein nitrogen), using the digester and distillator "Fisher Bioblock Scientific".

The lowest degree of proteolysis was demonstrated by cheeses made from milk of cows from all the studied groups that were fed ration 1. An analysis of data above allows us to state that an increase in nitrogen of soluble fractions, which reflects the general proteolytic process, is one of the indicators for a maturation process rate [36]. It was more active and uniform in cheeses made from milk of cows that were fed ration 2. In cheeses that were made from milk of cows from all three groups that were fed ration 1 the proteolysis process was less even and intensified over the second period of maturation, indicated by the accumulation of low-molecular nitrogenous fractions. One type of these compounds in cheese is free amino acids.

The highest total amount of free amino acids was registered in cheeses made from milk of cows by both brown breeds when they were fed ration 2. In comparison, the cheeses made from milk of cows by the brown breed and a control group that received feed of ration 1, respectively, the total amount of free amino acids was lower: group 1 – by 3 %, group 2 – by 2.9 %, control group – by 2.8 %.

In order to characterize the biological value of cheeses, we determined the amount of essential amino acids [36]. An analysis of the content of amino acids in cheese made from milk of three examined groups of cows on ration 1 revealed its less value than when fed ration 2. This is evidenced by the mass of essential free amino acids. The quantitative composition of amino acids in mature Dutch-type cheese was determined using the amino acid analyzer "Biotronik LC 2000", in line with DSTU ISO 9001-13903:2009 Animal feed. Method for determining the content of amino acids. Results of research into the quantitative composition of amino acids are given in Table 6.

In terms of the content of essential amino acids based on different types of feeding, cheeses had differences as well. The largest lysine content was registered in cheese made from milk of cows from groups 1 and 2 on ration 2. The cheeses made from milk of cows from groups 1 and 2 on ration 1 contained less of it, by 17 %. In terms of the content of leucine, the cheeses made from milk of cattle on ration 2 outperformed cheeses made from milk of cows ration 1, respectively: group 1 – by 28.3 %; group 2 – by 30.0 %; control group – by 24.8 %, aspartic acid – by 8.7; 9.5 and 8.7 %; proline – by 11.8; 10.4 and 9.7 %; glycine – by 27.3; 25.5 and 26.2 %, phenylalanine – by 15.8, 16.2, and 14.6 %, respectively. The content of isoleucine in cheeses while keeping cattle on ration 1 was less than that on ration 2, accordingly, for groups, by 20.0 %, by 22.5 %, and 21.2 %.

Thus, in terms of the content of essential amino acids based on different types of feeding, cheeses demonstrated an increase, which shows a positive impact on the biological value of cheeses made from cow's milk by the Ukrainian brown breed and the Lebedinskaya breed.

We performed the organoleptic evaluation of cheese after maturing over 60 days based on a point rating by deriving the total estimate for all indicators [36], given in Table 7. The maximum estimate is 100 points.

Table 4

Chemical composition, acidity, and indicators of maturity for the Dutch-type cheese samples

No.	Indicator title	Indicator value for cows of breed					
		UBD (group 1)	LEB (group 2)	SIM (group 3)	UBD (group 1)	LEB (group 2)	SIM (group 3)
		silage-hay period (ration 1)			haylage-hay period (ration 2)		
1	Mass fraction of dry substances, %	58.2	58.4	56.0	57.0	57.2	56.5
2	Mass fraction of fat (absolute), %	29.1	29.2	28.0	28.5	28.6	28.2
3	Mass fraction of protein, %	24.3	24.2	23.4	25.5	25.6	23.8
4	Mass fraction of fat in dry matter, %	49.7	49.8	49.7	50.2	50.2	50.2
5	Calcium content, mg/100 g	1,321	1,320	1,324	1,332	1,334	1,331
6	Maturity degree by Shilovich, °Sh	190	192	190	194	195	193
7	pH	5.55	5.50	5.55	5.39	5.4	5.47

Table 5

Content of nitrogen fractions in samples of the Dutch-type cheese made from milk

No.	Indicator title	Indicator value for cows of breed					
		UBD (group 1)	LEB (group 2)	SIM (group 3)	UBD (group 1)	LEB (group 2)	SIM (group 3)
		silage-hay period (ration 1)			haylage-hay period (ration 2)		
1	Cheese maturation period, days	30	30	30	30	30	30
2	Total soluble nitrogen, %	29.1	29.2	28.0	28.5	28.6	28.2
3	Non-protein soluble nitrogen, %	18.0	17.5	16.2	19	18	17.1
4	Amine nitrogen, %, to total nitrogen	9.4	9.2	8.8	11.3	11.5	9.4
5	Total amount of free amino acids, g/100 g	13.83	13.89	13.59	14.25	14.30	13.98
6	Essential amino acids, g/100 g	10.2	9.99	10.14	11.9	11.71	11.65

Table 6

Quantitative composition of amino acids in mature Dutch-type cheese

No.	Amino acid name	Indicator value for cows of breed					
		UBD (group 1)	LEB (group 2)	SIM (group 3)	UBD (group 1)	LEB (group 2)	SIM (group 3)
		silage-hay period (ration 1)			haylage-hay period (ration 2)		
1	Arginine	0.80	0.82	0.81	0.88	0.87	0.86
2	Valine	1.53	1.50	1.51	1.56	1.55	1.54
3	Histidine	0.8	0.8	0.79	0.82	0.82	0.81
4	Isoleucine	1.16	1.11	1.11	1.45	1.43	1.4
5	Leucine	1.6	1.55	1.69	2.24	2.21	2.22
6	Lysine	1.62	1.59	1.6	1.95	1.92	1.93
7	Methionine	0.58	0.57	0.59	0.61	0.59	0.6
8	Threonine	0.78	0.79	0.77	0.86	0.82	0.83
9	Tryptophan	0.29	0.26	0.25	0.3	0.28	0.27
10	Phenylalanine	1.04	1.0	1.02	1.23	1.22	1.19
	Total	10.2	9.99	10.14	11.9	11.71	11.65

Table 7

Comparative evaluation of the Dutch-type cheese quality made from milk at different ratios of cow feeding

No.	Indicator title	Indicator value for cows of breed						Estimate ND
		UBD (group 1)	LEB (group 2)	SIM (group 3)	UBD (group 1)	LEB (group 2)	SIM (group 3)	
		silage-hay period (ration 1)			haylage-hay period (ration 2)			
1	Physical appearance	8	9	7	10	9	9	10
2	Taste and flavor	35	32	25	45	45	44	45
3	Consistency	18	22	18	24	24	24	25
4	Pattern	5	8	5	10	10	9	10
5	Color	3	4	5	5	5	5	5
6	Packaging and labeling	5	5	5	5	5	5	5
	Total estimate	74	80	65	99	98	96	100

As a result of the conducted cheese tasting, it was established that cheeses made from milk of cows in all groups that were fed ratio 2 differed by a good physical appearance, had a smooth crust, light yellow color, homogeneous throughout the entire mass. The consistency was plastic, a pattern on the cut consisted of cells created by cultures of lactic acid microflora in the process of maturing. Data from Table 7 show that cheeses from milk on ration 2 were awarded the highest score for taste and flavor at the level of 44–45 points. It is likely that the introduction of alfalfa haylage contributed to disclosing the flavoring and aromatic substances in the lipidic fraction of milk and the transition to cheese, which essentially distinguishes it from the cheese made from milk of cows on ration 1 (silage-based).

The study conducted shows that the production of high-quality cheeses with a high biological value and digestibility should utilize milk from cows of the brown breeds. The ration of cows should be supplemented with alfalfa haylage, because it significantly affects the technological properties of milk and improves its suitability for cheese making.

6. Discussion of results of studying the Dutch-type cheese made from milk of cows by different breeds

Determining the influence of a genotype of cows and optimized rations of feeding on the technological features of production and quality of cheese is relevant. The process of making the Dutch-type cheese shortens, the rated consumption of raw materials required to produce 1 kg of finished product decreases, the biological value of hard Dutch-type cheese improves. This is predetermined by the breeding properties of brown breeds of cows, as well as the scientifically-substantiated cattle feeding rations, which confirms data about the need to sort milk based on a region in order to produce dairy products [9].

The same conclusions could be used to save the population of the Lebedinskaya breed and brown breeds of cows, which were historically kept at the territory of Sumy oblast.

The research conducted makes it possible to reduce seasonality factors in the production of milk with predictable quality indicators, by controlling the breed of a herd and by a balanced ration of feeding, which are given in paper [8]. There are certain limitations imposed by such an analysis should be performed depending on factors that are constantly changing, such as geographical and climatic conditions, the development of technology for keeping cattle and for the automation and mechanization of milking, as well as the period of controlled lactation.

Indicators for the suitability of milk for cheese making make it possible to argue on that the milk received from the brown and Lebedinskaya breed cows could be used for cheese production at a shortened technological process. Consequently, one could reduce energy costs of production, as well as bring down the cost of cheese. It is necessary to continue studying the influence of coagulating properties of milk depending on genetic factors, as indicated in papers [13, 14]. However, it is advisable to carry out a comprehensive study considering feeding, analyzing in this case the completed technological process of production and indicators for a resulting product.

Of special interest is an increase in the total amount of free amino acids, as well as essential amino acids, which indicates the useful properties of cheese as a full-fledged nutritional product. Study into dependence of the biological value of cheeses on the breeds of cattle and feeding rations could yield interesting results concerning recommendations for improving nutrition for a certain category of people. Cheese possesses high organoleptic indicators and could be made industrially or to create a craft product.

Control over product quality, as well as giving it certain properties by using raw materials with predictable indicators, is a modern trend when making wholesome dairy products. Thus, there is a need to continue studying the influence of other factors.

7. Conclusions

1. We compared chemical composition of milk from cows in three groups – the Ukrainian brown dairy breed, Lebedinskaya breed, and Simmental breed, which were fed different rations. It was established that the use of alfalfa haylage increases, in milk from all animals, the mass fraction of dry substances, including the content of the dry fat-free milk residue. The maximum content of DFMR (9.09 %) was observed in animals of the Ukrainian dairy breed.

2. In terms of the technological and physical-chemical properties, milk from cattle in all examined groups, fed the ration that included alfalfa haylage, demonstrated a higher suitability for cheese making compared with milk obtained over a silage-hay period, and a shorter phase of gel-formation. We have worked out the technological modes for making the hard Dutch-type cheese from milk by three breeds of cows at different rations of feeding. We determined the duration of main technological operations, such as milk coagulation and gel-formation, which affect density of the clot and duration of its processing. We calculated a fat content and the release of dry substances to whey. It is shown that application of the optimized formulations for feeding cattle shortens basic technological operations, reduces the release

of dry substances (including fat) to whey, and increases the yield of the resulting target product.

3. A comparative analysis of the chemical composition and quality indicators for the mature hard Dutch-type cheese, obtained from cows in different groups that were fed silage and hay rations, reveals that the mass fraction of dry substances, protein, and fat in all examined samples of cheese was at the level rated for this product. The Dutch-type cheese, made from milk by cows from all examined groups that were fed alfalfa haylage, had a higher mass fraction of fat in dry matter (50.2 %). The target product, obtained from milk by all groups of cattle that were fed a silage ration, did not meet the requirements of normative documents for the specified indicator.

4. The hard Dutch-type cheese, made from milk from all three groups of cattle over a haylage-hay period, was characterized by a higher content of essential amino acids, as well as free amino acids, soluble and non-protein nitrogen, which predetermined a higher degree of maturity of cheeses from the second group. The resulting product has better indicators for a biological value, when using standard technological parameters.

5. The samples of the hard Dutch-type cheese, made from milk of cows from all examined three groups that were fed the ration of alfalfa haylage, had a higher point-based estimate for organoleptic indicators. We compared the samples of cheese made from milk obtained over a silage-hay period. The highest point-based estimate for organoleptic indicators (99 points) was received by samples of the Dutch-type cheese made from cow's milk of the Ukrainian brown dairy breed, obtained over a haylage-hay period. This means that the resulting cheese could be considered as a unique authentic product for Sumy region.

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