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REGULARITIES OF SEASONAL CHANGES IN MILK FAT ACCORDING TO THE REICHERT-MEISL NUMBER

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Abstract. The composition of cow's milk is a variable parameter that depends on a number of factors determined by the genetics of cows, feed, stage of lactation, climatic conditions, etc. In recent years, milk production in Ukraine has undergone significant changes. In order to evaluate the technological properties of milk, milk lipids was examined according to an indicator that characterizes the content of volatile water-soluble fatty acids in it (Reichert-Meisl number). Low-molecular fatty acids make the greatest contribution to the formation of organoleptic and physical properties of butter, and the Reichert-Meisl number is used as one of the criteria for evaluating the natural composition of milk fat. Despite the fairly wide range of fluctuations in the content of low-molecular fatty acids in milk, the Reichart-Meisl number for milk fat is much higher than for vegetable fats, which allows this indicator to be used to detect possible adulteration of dairy products. Differences in the properties of milk fat associated with climate change, conditions of keeping and feeding animals require clarification of the ranges of variability of the Reichert-Meisl number for milk harvested in different regions of Ukraine. As a result of the monitoring of milk raw materials, regularities of seasonal changes in the properties of milk fat according to the Reichert-Meiss number in three natural climatic zones of Ukraine were established. Based on the analysis of the Reichert-Meisl number of harvested milk, ranges of values were established taking into account seasonal features and natural and climatic zones of Ukraine. The ranges of changes in the Reichert-Meisl number of milk fat were established: in winter – 24.3-30.0; in spring – 25.4-30.7; in summer – 23.0-30.2; in autumn – 24.3-29.8. At the same time, the average annual values of this indicator were 27,3, respectively; 28.8; 28.2; 27.0. The average value of the Reichert-Meisl number was determined to be 27.8, with baseline values of 23.0-30.7.

Keywords: cow's milk, milk composition, milk fat, milk lipids, fatty acid composition, Reichert-Meisl number, seasonal changes.

Introduction. Formulation of the problem

Milk fat is a natural component of milk, which is processed into such traditional dairy-fat products as cream, butter, cheese, dry whole milk. The lipid composition of cattle's milk undergoes seasonal changes and largely depends on feed and feeding rations. In recent years, interest in the benefits of milk fat and its individual components for human health has increased. New technologies for processing milk fat open up opportunities to improve its nutritional and functional properties. Both limiting the consumption of certain fatty acids and mandatory consumption of other beneficial fatty acids are recommended. However, the lipid composition of milk is very variable, and the identification of factors affecting changes in milk fat composition is of interest to both producers and consumers. Therefore, identifying patterns of seasonal changes in milk fat according to the content of saturated fatty acids in milk obtained in different natural and climatic zones of Ukraine is relevant in view of significant changes in the structure of the raw material base and the influence of climatic factors on systems of keeping and growing cows.

Analysis of recent research and publications

The composition of cow's milk is a variable parameter that depends on a number of factors determined by the genetics of cows, feed, stage of lactation, climatic conditions, etc. Milk lipids form a fat-in-water emulsion with water [1]. Milk fat consists of 98% triglycerides, while other milk lipids are mono- and diacylglycerol (about 2% of the lipid fraction), cholesterol (less than 0,5%), phospholipids (about 1%), and free fatty acids (about 0,1) [2]. Numerous studies of the composition of milk fat indicate changes in the lipid composition of cow's milk depending on seasonal fluctuations, conditions of feeding and housing of cows [3-7]. The importance of the influence of these factors may differ for different systems of milk production and keeping cows. The ratio of saturated (SFAs) to unsaturated fatty acids (UFAs) is approximately 70%

and 30% respectively. Saturated fatty acids are lowest in summer when cows are grazing and highest in winter due to indoor feeding. The content of unsaturated fatty acids (UFAs) has the opposite relationship, with the highest amount in summer [2]. Recent studies of the effects of prolonged periods of heat have confirmed that an increase in the temperature-humidity index can affect the quantitative of fatty acids composition in lactating high-yielding cows of the Holstein breed [8]. This increase caused a significant increase in the total content of unsaturated fatty acids (UFAs) in milk, as well as monounsaturated (MUFAs) and polyunsaturated fatty acids (PUFAs), which was accompanied by a decrease in the ratio of SFAs/UFAs [8].

The lipid composition of milk affects the formation of organoleptic and physical characteristics of the obtained dairy products [9-13]. In particular, due to low melting temperatures and high content of low-molecular fatty acids, the specific taste, aroma and consistency of the cream butter are determined. On the other hand, an increase in the content of low-molecular-weight volatile fatty acids during oxidation can cause a deterioration in the taste of milk fat.

Methods for determining the adulteration of milk fat are based on the determination of the characteristic properties of milk lipids [14-18]. It is known that despite the rather wide range of fluctuations in the content of individual fatty acids in milk, the content of volatile water-soluble fatty acids can be a fairly stable characteristic of milk fat, which is expressed by the Reichert-Meisl number [19].

In addition, the value of the Reichert-Meiss number of milk fat is significantly higher than that of most vegetable fats and oils, which makes it possible to use this indicator for the quantitative determination of the content of milk fat in products with a combined fat phase (spreads, products and mixtures containing milk fat) and to identify possible falsification of cream butter due to the addition of vegetable oils.

The method of determining the Reichert-Meiss number is based on the determination of the content of low-molecular water-soluble volatile fatty acids in milk fat. The index of the Reichart-Meisl number was used as the basis of the methodology for determining the content of non-dairy fats in products with combined fat (Certificate of metrological attestation No. 081/12-0086-03 dated 05.05.2003). The methodology was developed in 2003 on the basis of the basic values of the Reichert-Meiss numbers of milk fat, characteristic of raw milk, taking into account the regional and seasonal characteristics of the composition of the harvested milk (Patent 67470 Ukraine "Method of quantitative determination of the content of non-dairy fats in oils with a combined fat phase", Patent 93825 C2 Ukraine "Method of detection of milk fat substitutes in cow's milk and dairy products" [20].

This technique is adapted for use in laboratories of milk processing enterprises and is intended for operational production control of raw milk, drinking milk, butter, spreads, and cheese products. This method uses ranges of values of the Reichert-Meiss number from 25,4 to 30,7 units, which correspond to the indicators of natural milk fat, and deviations beyond these ranges indicate the presence of non-dairy fats in the fat phase. To date, the active development of the industry of milk fat substitutes allows the production of compositions involving vegetable and animal fats, the use of which makes it difficult to assess the naturalness of the fat phase of the product. Therefore, the ranges of values of the Reichert-Meisl number for domestic raw materials according to this method have been established and require updating and adjusting the limits of this indicator, which correspond to the naturalness of milk fat.

The purpose of the research was to determine the basic values of the Reichert-Meisl number depending on regional and seasonal changes in milk raw materials. In addition, adjusting the ranges of the content of low-molecular water-soluble volatile fatty acids according to the Reichert-Meissl number in raw milk will allow to improve the methodology for determining the content of non-dairy fats in the fat phase of dairy products.

Materials and methods.

The Reichert-Meissl number (RMN) was determined according to the routine method in the amount of 0,1 N of alkali, which was used to neutralize volatile water-soluble fatty acids, isolated from 5 g of fat after its saponification, followed by its splitting with sulfuric acid and distillation of volatile acids with water vapor [21]. The Reichert-Meissl number characterizes the content of low-molecular-weight water-soluble volatile fatty acids in fat.

For monitor the physico-chemical research of harvested milk, 3 climatic zones of Ukraine were covered: Polissia (Zhytomyr, Rivne, Ivano-Frankivsk regions), Forest-Steppe (Kyiv, Vinnytsia, Poltava, Cherkasy, Sumy regions), Steppe (Mykolaiv, Odesa, Kharkiv regions). Milk was sampled for milk fat studies from 18 farms during the year.

Results of the research and their discussion

Changes in the climate and feed base definitely affect the composition and properties of milk produced in Ukraine. Changes in the composition of milk fat, in turn, can affect the formation of quality characteristics of fat products.

The territory of Ukraine has three distinct natural and climatic zones: Polissia, Forest-Steppe and Steppe.

The Polissia zone makes up about 25% of the land fund of Ukraine. The climate of Polissia is characterized by moderately cold winter, relatively wet summer, gloomy and rainy autumn, spring is always colder than autumn. The amount of precipitation is the highest among all zones of Ukraine. The Polissia zone includes the following regions: Volhynia, Zhytomyr, Ivano-Frankivsk, Lviv, Rivne, Chernihiv, Zakarpattia. The

total amount of milk produced in these regions was 2518,7 thousand tons, which was about 32,4% of the amount of milk produced by all types of farms in 2022.

The Forest-Steppe zone occupies approximately 34% of the territory of Ukraine. This zone is characterized by more favorable climatic conditions: significantly higher average annual air temperatures, warmer summers, less precipitation, warm autumn, mild winter. The following regions are located in the Forest-Steppe zone: Vinnytsia, Kyiv, Poltava, Sumy, Ternopil, Kharkiv, Khmelnytskyi, Cherkasy, Chernivtsi. The total amount of milk produced in these regions was 3956,7 thousand tons, which was about 51% of the amount of milk produced in 2022.

The Steppe zone covers an area of approximately 40% of the territory of Ukraine. The climate of the Steppe is characterized by a hot and dry long summer, a winter with unstable snow cover, a short, intense spring, often with dry spells. The amount of precipitation is not sufficient. The following regions are located in the Steppe zone: Dnipropetrovsk, Donetsk, Zaporizhia, Kirovohrad, Luhansk, Mykolaiv, Kherson, Odesa. The total amount of milk produced in these regions was 1292,3 thousand tons, which was about 16,6% of the milk produced by all types of farms in 2022.

Milk production has undergone significant changes over the past 20 years. In particular, the total production of milk decreased and the structure of production by farm category changed.

During the year, milk from 18 different farms was examined for the content of low-molecular water-soluble volatile fatty acids according to the Reichert-Meissl number and the ranges of changes in the value of this indicator were determined depending on the climatic zone and season.

Table 1 shows the ranges values of the Reichert-Meissl number (min-max) that characterize seasonal and regional changes in milk fat. It was noted that significant fluctuations of this indicator are observed within each zone, region and season.

In all zones, the maximum limits of the Reichert-Meissl number (RMN) of milk fat are typical for the spring season. The decrease in RMN indicators occurred in autumn and winter, the lowest values were noted for the regions of the Polissia and Forest-Steppe zones. At the same time, it should be noted about significant deviations in the case when the minimum value of RMN was observed in the summer in Ivano-Frankivsk region.

On the basis of the established regional indicators of Reichert-Meissle number, the average values of this indicator were determined for the zones – Polissia, Forest-Steppe and Steppe and the range of their fluctuations.

The data shown in Fig. 1 characterize seasonal changes in the average values of RMN across regions in the Polissia zone. Milk fat in this region is characterized by the highest values of RMN in the spring (annual average of 29,0 units). In the section of the regions of this zone, the smallest seasonal fluctuations of the average values of RMN were in the spring and winter periods of 0,3 units and 0,5 units respectively. In summer and autumn, the range of fluctuations was the largest.

The average values of RMN in the Polissia zone during the year ranged from 26,4 to 29,0 units.

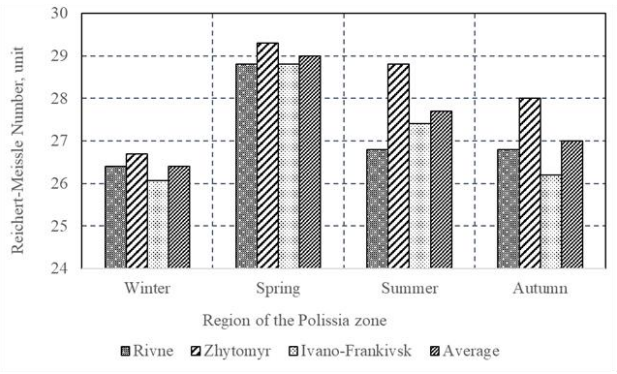

Fig. 1. Changes in the average values of the Reichert-Meissle number depending on the season in the Polissia zone

Table 1 – Ranges of values of the Reichert-Meissle number throughout the year

Region	Ranges of values (min-max)			
	Winter	Spring	Summer	Autumn
Polissia zone				
Rivne	26,0-26,9	27,2-29,5	26,2-27,9	26,2-27,2
Zhytomyr	26,2-27,8	28,05-29,8	27,0-29,2	26,8-28,3
Ivano-Frankivsk	25,0-27,8	26,4-30,7	23,0-28,9	25,0-28,3
Forest-Steppe zone				
Vinnytsia	24,4-28,0	25,4-29,4	24,4-29,2	24,7-28,9
Kyiv	26,5-28,5	28,7-30,6	26,0-28,4	24,3-29,3
Poltava	27,4-30,0	27,7-30,6	28,0-29,3	26,4-29,8
Cherkasy	24,3-27,9	26,5-29,4	24,5-27,4	24,5-27,0
Sumy	25,3-27,8	26,0-29,5	24,4-29,2	25,2-27,9
Steppe zone				
Odesa	25,0-27,3	26,3-28,4	27,8-30,2	25,8-28,1
Kherson	25,2-28,2	27,9-29,7	27,5-29,7	26,3-29,8
Mykolaiv	24,6-28,4	25,5-29,7	25,4-29,5	24,9-29,2

In fig. 2 shows data characterizing seasonal changes in the average values of RMN in Vinnytsia, Kyiv, Poltava, Cherkasy, and Sumy regions. A wide range of regional changes in the Reichert-Meissl number was noted for the Forest-Steppe zone. However, in all regions, this indicator had maximum values in spring and summer. It is characteristic that, compared to other regions, the RMN of milk fat in the Poltava region was the highest in winter (29,4 units) and was distinguished by high values in other seasons of the year.

The average values of the RMN in the Forest-Steppe zone during the year were within 27,4-29,1 units. It is obvious that in comparison with Polissya, the range of seasonal fluctuations of the RMN of milk fat in the Forest-Steppe zone was somewhat wider. At the same time, the maximum value of the RMN was also higher (29,1 units). Perhaps such differences are due to the peculiarities of the feed base of the studied farms, since this factor was not taken into account in our work.

The Forest-Steppe zone is characterized by developed dairy farming, which ensures the production of more than 50% of dairy raw materials in Ukraine.

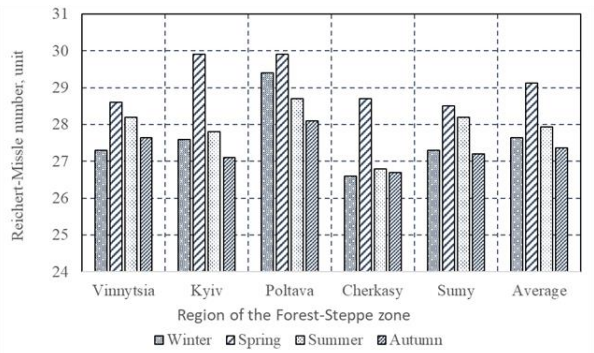

Fig. 2. Change in average values of Reichert-Meissl number depending on the season in the Forest-Steppe zone

Fig. 3 shows data characterizing changes in average values of RMN in Odessa, Kherson and Mykolaiv regions. The obtained research results showed that the Reichert-Meissl number of milk fat in Kherson region, regardless of the season, had the highest average values – 27,5-28,9 units. The maximum values of Reichert-Meissl were recorded in the spring and summer periods of the year for each region and for the Steppe zone as a whole (28,2-28,9 units). In the winter and autumn periods, average values of this indicator were noted at the level of 27,0-27,1 units with minimal fluctuations across regions.

Thus, based on the analysis of regional characteristics of milk fat, it was noted that the highest average annual values of RMN are characteristic of Zhytomyr, Poltava and Kherson regions, which amounted to 28,2 units, 29,0 units and 28,2 units, respectively.

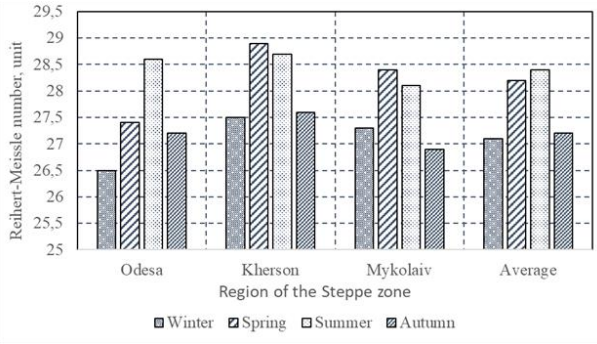

Fig. 3. Change in average values of the Reichert-Meisle number depending on the season in the Steppe zone

The highest average annual values are characteristic of the Forest-Steppe, in particular Kyiv and Poltava regions. The generalized data of RMN indicators for each region are presented in Fig. 4.

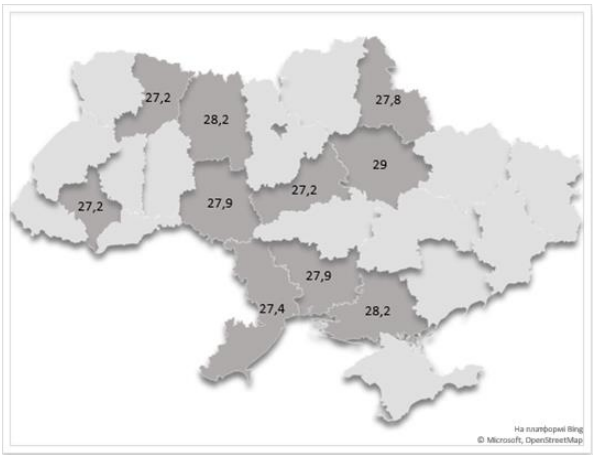

Fig. 4. Change in the Reichert-Meissl number depending on the region of Ukraine

Generalized data on seasonal and regional changes in the composition of milk fat according to the RMN indicator are given in Fig. 5.

It is quite obvious that the regional factor affects the changes in the RMN of milk fat to a lesser extent than the seasonal factor. Thus, in the spring-summer period, the highest average seasonal Reichert-Meissl numbers were recorded for each zone.

The average seasonal values of the Reichert-Meissl number for Ukraine were established: winter – 27,1 units; spring – units 28,8 units; summer – 28,2 units; autumn – 27,2 units. Milk fat from the Forest-Steppe zone was characterized by the highest average annual Reichert-Meissl number – 28,0 units, in the Polissya and Steppe zone – 27,5-27,9 units.

Also, in the Polissya zone, maximum fluctuations in the Reichert-Meissl number were noted in the summer period – by 6,2 units, and minimum – in the winter period – by 2,8 units. In the Forest-Steppe zone,

the Reichert-Meissl number changed in the autumn-winter period – by 5,5-5,7 units, in the summer-spring period – by 4,9-5,2 units. In the Steppe zone, minimum fluctuations of the same type were observed throughout the year – by 3,8-4,9 units.

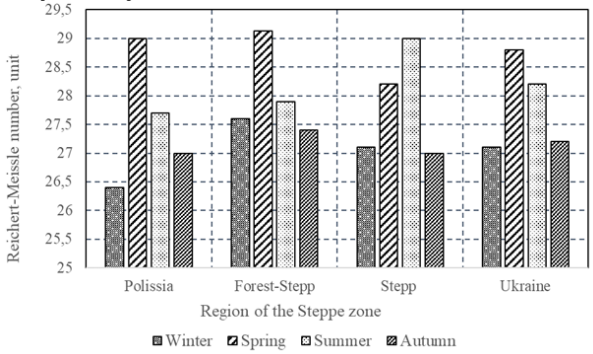

Fig. 5. Change in average values of the Reichert-Meissl number of milk fat in the zones of Ukraine depending on the season

Thus, based on the analysis of the RMN of milk fat, the ranges of seasonal fluctuations of this indicator across Ukraine were established. In particular, seasonal changes in the RMN of milk fat in Ukraine are in winter – 24,3-30,0 units, in spring – 25,4-30,7 units, in summer – 23,0-29,3 units, in autumn – 24,3-29,8 units. The average value of the Reichert-Meissl number in Ukraine is 27,8 units, which is 0,6 less than previously established [20,22].

It is quite obvious that the regional factor affects the changes in the RMN of milk fat to a lesser extent than the seasonal factor.

Approbation of research results. The results of research on the established indicators of the RMN were tested in the conditions of production laboratories of dairy enterprises and the analytical research laboratory of the Institute of Food Resources of the NAAS of Ukraine.

Conclusion

Based on experimental studies of the content of low-molecular water-soluble volatile fatty acids in the composition and properties of milk fat, changes in the composition of milk fat in Ukraine over the past 20 years have been established, which is obviously related to changes in the structure of milk production and climatic conditions. Monitoring of dairy raw materials was carried out and the value of the Reichert-Meissl number was determined depending on the season and natural and climatic conditions of milk production. The data obtained will be used to refine the methodology for determining the content of non-dairy fats in products with a combined fat phase.

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ЗАКОНОМІРНОСТІ СЕЗОННИХ ЗМІН МОЛОЧНОГО ЖИРУ ЗА ЧИСЛОМ РЕЙХЕРТА-МЕЙСЛЯ

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Анотація. Склад коров'ячого молока є змінним параметром, що залежить від низки факторів, обумовлених генетикою корів, кормами, стадією лактації, кліматичними умовами тощо. За останні роки виробництво молока в Україні зазнало істотних змін. З метою оцінки технологічних властивостей молока досліджено склад ліпідів молока за показником, що характеризує вміст у ньому летких водорозчинних жирних кислот (число Рейхерта-Мейсля). Низькомолекулярні жирні кислоти вносять найбільший вклад у формування органолептичних і фізичних властивостей масла, а число Рейхерта-Мейсля використовується як один із критеріїв оцінювання природного складу молочного жиру. Не зважаючи на досить широкий діапазон коливань вмісту низькомолекулярних жирних кислот у молоці, число Рейхарта-Мейсля для молочного жиру значно вище, ніж у рослинних жирів, що дозволяє застосовувати цей показник для виявлення можливої фальсифікації молочних продуктів. Відмінності у властивостях молочного жиру, пов'язані зі зміною клімату, умовами утримання і годівлі тварин потребують уточнення діапазонів варіабельності числа Рейхерта-Мейсля для молока, що заготовляється в різних регіонах України. У результаті моніторингу молочної сировини встановлено закономірності сезонних змін властивостей молочного жиру за числом Рейхерта-Мейсля в трьох природнокліматичних зонах України (Полісся. Лісостеп і Степ). На підставі аналізу числа Рейхерта-Мейсля заготівельного молока встановлено діапазони значень з врахуванням сезонних особливостей та природно-кліматичних зон України. Встановлено діапазони змін числа Рейхерта-Мейсля молочного жиру: зимою – 24,3-30,0; весною – 25,4-30,7; влітку – 23,0-30,2; восени – 24,3-29,8. При цьому середньорічні значення даного показника складали відповідно 27,3; 28,8; 28,2; 27,0. Визначено середнє значення числа Рейхерта-Мейсля – 27,8 при базових значеннях – 23,0-30,7.

Ключові слова: молоко коров'яче, склад молока, молочний жир, жирнокислотний склад, число Рейхерта-Мейсля, сезонні зміни.