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FATTY ACID COMPOSITION AND BIOLOGICAL VALUE OF MILK OF HOLSTEIN COWS AT DIFFERENT LACTATION SEASONS

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Abstract-- The research was to obtain information and assess the impact of region and seasonal changes on the physical-chemical indicators of milk, as well as to predict the impact of these changes on the composition and quality of products derived from such milk. To assess the differences in milk taken from different regions, as well as to identify the impact of the season on its quality, physical-chemical indicators, including the content of fatty acids in the milk of Holstein cows of the Republic of Kazakhstan were studied. To assess the health status of lactating animals, the content of somatic cells in milk was additionally assessed. The results of studies found that the season and the region significantly influenced the physical-chemical indicators of milk and the content of fatty acids in lipids.

Key words: fatty acids, cow's milk, season, Holstein breed.

1. Introduction

Nutrition plays an important role in human health, with considerable interest in the composition of animal products, including dairy products [1].

Today dairy cattle breeding is one of the most profitable branches of animal husbandry [2-5].

Cow's milk is the main ingredient of our diet. For centuries, it was introduced as the first baby food as an alternative to breast milk and was seen as essential for growth and development. Now milk is processed on an industrial scale to avoid the risk of infection by pathogenic bacteria with unpasteurized milk [6].

Milk fat is one of the most valuable dietary fats for humans [7-10]. The content of milk fat depends on the type of feeding, as well as on the age and breed of cows and is a valuable source of saturated, mono-and polyunsaturated fatty acids. Separation of fats to adjust the level of fat in milk, and homogenization to prevent the formation of fat deposits are the main processes of fat change in commercial milk production [11].

Fatty acid composition of milk fat has a significant impact on its nutritional and biological value, technological properties of milk [12]. The most valuable are the fatty acids of the family ώ-3 and ώ-6, which are unique in their effectiveness, preventive and therapeutic properties, especially for the prevention of cardiovascular diseases [13-16].

Other fatty acids have been shown to have beneficial effects on human health, such as mono-and polyunsaturated fatty acids and some trans-fatty acids, such as conjugated linoleic acid [17,18].

The increase in productivity of cows is determined by heredity, breed affiliation, conditions of keeping, milking and a number of other factors that have a major impact on the formation of milk productivity, but there are also technological factors that cannot be excluded. These factors include the season of calving cows. Given this factor, it is possible to control the level of profitability of milk production at the complex [19-22].

2. Materials and methods

The composition and technological properties of milk in the comparative aspect were studied on Holstein cows. Basic farms for research were JSC "Astana - Onim" of Akmola region (I), LLP "Rza-ASYL tulik" of Kyzylorda region (II) and LLP "SP Pervomaysky" of Atyrau region (III) of the Republic of Kazakhstan. The experimental material consisted of 240 separate milk samples examined during the year (from June 2017 to May 2018). The maintenance of cows on the dairy product farm is loose. Milk samples are selected to give an overall picture of the milk composition taking into account regional and seasonal conditions.

Physical-chemical indicators of milk were studied in the laboratory of LLP "Kazakh Research Institute of Livestock and Fodder Production" on a high-performance, fully automatic milk analyzer MilkoScan FT+, Fossomatic FT+.

Sample preparation and determination of fatty acid composition were carried out in accordance with GOST 32915-2014 "Milk and dairy products. Determination of fatty acid composition of the fat phase by gas chromatography". Gas chromatograph Shimadzut GC-2010 Pluscwith flame-ionization detector and capillary column AgilentJ&WColumnsGP-Sii 88 forFAME of 100 m × 0.25 mm ×0.2 μl were used to study the fatty acid composition. Gas supply of the detector is carried out from the gas flow regulator by the following gases: nitrogen, hydrogen and air; the maximum temperature of the detector is 2600C; temperature indicators: 1000C – 5 min, up to 2100C – 8 min. At a speed of 40C/min, up to 2400C – 25 min at a speed of 100C/min; the volume of the injected sample – 1 μl. The flow dividing samples 1/40.

3. The results of the study and their discussion.

The composition of milk varies significantly depending on the region, the stage of lactation, the type of feed, the time of year and other factors. However, some relations between its components are constant and can be used as indicators of artificial changes in the composition of milk.

Dairy productivity of cows for 305 days of lactation is presented in Table 1.

Under similar conditions of feeding and keeping animals compared breeds milk productivity and milk composition were different.

The main indicators that determine the nutritional value of milk is the content of fat and protein, the quantitative indicators of which are directed breeding work.

Table 1.Physical-chemical and microbiological indicators of milk by seasons

Indicators	spring	summer	autumn	winter
I – group(n=80)				
Mass fraction of fat, %	3,7	3,73	3,8	3,64
Mass fraction of protein, %	3,18	3,17	3,3	3,22
Acidity, ^{0}T	16,8	18	17	16,9
Mass fraction of dry fat-free substances of milk (skim solids), %	8,56	8,88	8,64	8,48
Group of purity	I	I	I	I
Density, g/cm^3	1027	1028	1027	1027
Somatic cells content,thousand in 1 cm^3	260,11	167,96	282,77	343,92
II – group (n=80)				
Mass fraction of fat, %	3,48	3,67	3,26	3,76
Mass fraction of protein, %	3,05	3,19	3,0	3,13
Acidity, ^{0}T	16,8	17	16	16,8
Mass fraction of dry fat-free substances of milk (skim solids), %	8,68	8,7	8,57	8,66
Group of purity	I	I	I	I
Density of milk, g/cm^3	1028	1028	1027	1029
Somatic cells content,thousand in 1 cm^3	317,43	131,84	229,75	312,83
III – group (n=80)				
Mass fraction of fat, %	3,71	3,77	3,51	3,84

Mass fraction of protein, %	3,16	3,25	3,04	3,35
Acidity, ^{0}T	16,9	17	17	18
Mass fraction of dry fat-free substances of milk (skim solids), %	8,7	8,62	8,8	8,58
Group of purity	I	I	I	I
Density of milk, g/cm^3	1028	1028	1028	1029
Somatic cells content,thousand in 1 cm^3	385,19	647,64	323,08	353,96

Milk of I group cows contained an average of 3.18 % protein and 3.70 % fat. While milk of II and III group cows contained an average of 3.05 %; 3.16% protein and 3.48 %; 3.7% fat, respectively. Small differences between regions and seasons were established by the fat content in the milk of cows of the compared groups in favor of cows of the III group in summer and winter: by the fat content in summer (0.04 % and 0.1 %), and in winter (0.2% and 0.08%), and by the protein content in summer (0.08 %; 0.06%), as well as in winter (0.13%; 0.22%).

In dairy science, the total number of somatic cells, commonly called SCC, in milk is influenced by various factors such as species, breeds, lactation phase, milk yield, differences between individual animals and management methods [23]. Both SCC and composition impact on the quality of milk, but their relationship is not always obvious, except in the case of high SCC corresponding to a high concentration of neutrophils in milk. It is usually difficult to analyze cell composition because SCC is a total number that does not take into account the concentration of any other cell types, which present in secretion [24].

Revealed a higher content of somatic cells in milk of the III group cows in all periods of lactation: 385,19 thousand per cm3; 647,64 thousand per cm3; 323,08 thousand per cm3; 353,96 thousand per cm3.

Counting the number of somatic cells is one of the indicators of udder condition and milk quality. According to European standards for cows allowed the presence of no more than 250 thousand somatic cells in 1 cm3, and in the Technical regulations of the Customs Union 033/2013 "On the safety of milk and dairy products" - 750 thousand in 1 cm3. With the number of somatic cells exceeding this indicator, the quality of milk due to the reduced content of casein, milk sugar, calcium, magnesium and phosphorus in it is insufficient to obtain high-quality dairy products [25].

The analyzed milk samples identified 37 fatty acids, which are grouped, and the main ones are presented in Tables 2 and 3. Other fatty acids are not included in the list, the relative area of peaks, which was more than 0.1 %.

Table 2.Fatty acid composition of milk in spring and summer

Name of fatty acid	Period					
	I – group (n=40)		II – group (n=40)		III – group (n=40)	
	spring (n=20)	summer (n=20)	spring (n=20)	summer (n=20)	spring (n=20)	summer (n=20)
Saturated, total	61,8	64	59,34	58,56	63,42	60,34
among them:						
C4:0	3,29	3,66	3,87	3,53	3,44	3,59
C6:0	1,78	1,88	2,26	1,60	1,77	1,93
C8:0	1,16	1,48	1,56	1,11	1,23	1,31
C10:0	3,05	2,95	3,29	2,27	3,00	2,53
C12:0	3,11	3,11	2,88	2,64	3,77	2,71
C14:0	9,99	11,29	9,68	9,22	11,63	9,70
C16:0	29,29	28,06	23,63	27,26	28,09	25,81
C18:0	9,84	11,32	11,94	10,68	10,27	12,44
C20:0	0,2	0,15	0,15	0,16	0,14	0,21
C22:0	0,09	0,10	0,08	0,09	0,08	0,11

Unsaturated, total	34,07	31,86	35,88	36,69	32,25	35,14
monounsaturated	28,94	27,12	30,97	32,35	28,35	31,79
among them:						
C10:1	0,29	0,34	0,30	0,30	0,33	0,22
C14:1*	1,23	1,18	1,15	1,33	1,02	1,09
C16:1*	2,28	1,99	2,26	2,32	1,96	2,10
C18:1*	25,14	23,61	27,26	28,40	25,04	28,38
polyunsaturated	5,13	4,74	4,91	4,34	3,9	3,35
among them:						
C18:2*	3,84	3,84	4,12	3,58	3,24	2,67
C18:3*	1,29	0,90	0,79	0,76	0,66	0,68
Others	4,13	4,14	4,78	4,75	4,33	4,52
**-The calculation is made by the sum of isomers.*						

Table 3.Fatty acid composition of milk in autumn and winter

Name of fatty acid	Period					
	I – group (n=40)		II – group (n=40)		III – group (n=40)	
	autumn(n=20)	winter (n=20)	autumn(n=20)	winter (n=20)	autumn (n=20)	winter (n=20)
Saturated, total	58,39	61,16	59,52	62,58	60,12	61,94
among them:						
C4:0	3,27	2,83	3,77	3,10	3,36	2,60
C6:0	1,58	1,78	1,74	2,20	2,44	1,69
C8:0	1,23	1,27	1,16	1,60	1,44	1,59
C10:0	2,08	2,93	2,22	3,10	2,40	2,33
C12:0	2,71	3,31	2,41	3,50	3,23	3,90
C14:0	10,03	11,03	8,74	11,50	10,01	12,50
C16:0	28,27	27,76	28,36	27,10	27,39	26,90
C18:0	9,02	9,94	10,92	10,20	9,63	10,10
C20:0	0,13	0,22	0,12	0,20	0,15	0,25
C22:0	0,07	0,09	0,08	0,08	0,07	0,08
Unsaturated, total	37,5	33,38	36,12	33,23	35,76	33,28
monounsaturated	32,89	29,67	32,1	29,53	32,25	29,08
among them:						
C10:1	0,26	0,30	0,24	0,30	0,29	0,28
C14:1*	1,29	1,12	1,12	0,95	1,40	1,10
C16:1*	2,09	2,08	2,31	1,88	2,16	2,10
C18:1*	29,25	26,17	28,43	26,40	28,40	25,60
polyunsaturated	4,61	3,71	4,02	3,7	3,51	4,2
among them:						
C18:2*	3,60	2,91	3,34	2,60	2,80	3,00

C18:3*	1,01	0,80	0,68	1,10	0,71	1,20
Others	4,11	5,46	4,36	4,19	4,12	4,78
**-The calculation is made by the sum of isomers.*						

The composition of milk fat in all periods was dominated by saturated fatty acids, their number ranged from 58.39 to 64 %, the concentration of unsaturated fatty acids was in the range of 31.86–37.5 %.

Saturated low-molecular volatile fatty acids of the lipid component from C4:0 to C8:0 (oil, caproic, caprylic) are found only in milk fat. They provide the taste and smell of milk and dairy product. Great importance is butyric acid, which is an inhibitor of colonocarcinoma (colon cancer) [26].

Among MUFA C18:1 isomers were the main components. In general, the remaining monounsaturated fatty acids in I– group were 28,94%; 27,12%; 32,89%; 29,67%; in II – group - 30,97%; 32,35%; 32,1%; 29,53%, and in III group - 28,35%; 31,79%; 32,25%; 29,08% of the total amount of milk fat, and they were all significantly higher in milk of cows of II group in the spring and summer, and in the autumn and winter, the amount of monounsaturated fatty acids was higher in cows of I-group.

PUFA was in cows of I group 5,13%; 4,74%; 4,61%; 3,71% in II group 4,91%; 4,34%; 4,02%; 3,7%, and in III group was 3,9%; 3,35%; 3,51%; 4,2% of the total fatty acid composition. In all groups of milk, respectively, and C18:2n-6 was the predominant compound.

The percentage ofώ -3 PUFA was higher in samples of I group (1.29%; 0.9%; 1.01% against 0.79%; 0,76%; 0.68% and 0.66%; 0.68%; 0,71%) in spring, summer and autumn periods than in the II and III groups, but the percentage of ώ -3 PUFA in the winter incows of III group was 1.2 % against 0.8%; 1.1% in the I and II groups, whereas the percentage of ώ -6 PUFA (3,84%; 3.6% vs 3.58%; 3.34% and 2.67%; 2,8%) in summer and autumn periods, in cows of I - group was higher than in the II and III groups, but the percentage ofώ -6 PUFA in spring in cows of II group was 4.12 % against of 3.84% and 3.24%.

In metabolic changes, linoleic acid (ω-6) and α-linolenic acid (ω-3) compete for the same digestive enzymes.

Polyunsaturated fatty acids are essential for the proper development of young organisms, as well as maintaining good health. These acids belong to the family ω-6 and ω-3.

4. Conclusions.

Studies of physical-chemical and microbiological indicators of milk of Holstein cows of different regions of the Republic of Kazakhstan, performed from June 2017 to May 2018, found that the composition of cow's milk is significantly different, there are also differences in the seasons.

The fat content in the milk of III group cows in winter was 3.84%, which is the highest indicator, and the lowest fat content was observed in autumn -3.26 %, in cows of II group. There are also significant differences between groups in the content of somatic cells. The highest content of somatic cells was observed in the summer in the milk of III group cows, which amounted to 647.64 thousand in 1 cm3, the lowest indicator was in cows of II group – 131.84 thousand in 1 cm3 in the same period of the year. When assessing the fatty acid composition, the most striking fluctuations were recorded in the level of MUFA and PUFA. Higher content of unsaturated fatty acids, and hence better digestibility of milk fat in cows of II group in spring and summer (35.88%; 36.69%), and in autumn and winter the maximum content of unsaturated fatty acids in cows of group I: 37.5%; 33.38%.

In order to increase the concentration of the fat phase of milk and increase its biological value, it is necessary to optimize the diets of highly productive cows for all nutrients, while assessing the fat composition of the fodder, including the missing fatty acids.

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