DOI 10.32900/2312-8402-2025-134-170-180
UDC 636.2.034.084.52

THE EFFECT OF USING GRAIN SILAGE FEED FROM DIFFERENT CROPS ON THE MILK PRODUCTIVITY OF COWS

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The article presents the results of studies of milk productivity indicators of Ukrainian Black-and-White dairy cows when corn silage was replaced in their diets with grain silage from a vetch-oat mixture or winter triticale. Cows in the first (control) group received the basic diet. In the diets of the animals in the second (control) and third (experimental) groups, 50% (by nutritional value) of the corn silage was replaced with grain silage made from green mass of vetch-oat mixture or winter triticale.

It was found that replacing corn silage with grain silage from winter triticale in the feed mixture of the experimental group, with a slight decrease in starch content, contributed to an increase in crude protein content by 93 g or 3.4%, digestible protein by 26 g or 1.2%, non-digestible protein by 68 g or 10.7%, digestible protein by 102 g or 11.6%, sugar by 391 g or 66.8%, and fat by 28 g or 4.5%.

Replacing 50% of corn silage in the feed mixture for cows with winter triticale grain silage contributed to an increase in their average daily milk yield by 2.23 liters or 13.1% ($p \leq 0.05$) and the amount of milk obtained during the experiment (on average per head) by 541 liters. Due to the slightly higher fat and protein content in the milk of the experimental group animals by 0.09% and 0.04% compared to the first control group, feeding grain silage from winter triticale had a positive effect on the amount of milk fat and protein obtained from milk. In particular, the animals in the experimental group had an advantage in this indicator by 25.6 kg and 19.0 kg, or by 15.7% ($p \leq 0.01$) and 14.6% ($p \leq 0.05$).

Feeding grain silage from both vetch-oat mixture and winter triticale contributed to an increase in milk fat content (by 0.09%) and milk protein content by 0.01% and 0.04%. The difference in the mass fractions of dry matter and dry skim milk residue in milk, compared to the animals in the first group, was 0.08% and 0.2% and 0.08% and 0.1% in favor of the animals in the second and third groups.

Keywords: cows, milk productivity, milk quality, grain silage, winter triticale.

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ВПЛИВ ВИКОРИСТАННЯ ЗЕРНОСІНАЖІВ ІЗ РІЗНИХ КУЛЬТУР НА ПОКАЗНИКИ МОЛОЧНОЇ ПРОДУКТИВНОСТІ КОРІВ

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У статті наведено результати досліджень показників молочної продуктивності корів української чорно-рябої молочної породи при заміні у складі їх раціонів кукурудзяного силосу на зерносінажі з вико-вівсяної сумішки або з озимого тритикале. Корови першої (контрольної) групи одержували основний раціон. У раціонах тварин другої (контрольної) та третьої (дослідної) груп 50 % (за поживністю) кукурудзяного силосу заміняли зерносінажем, виготовленим із зеленої маси вико-вівсяної сумішки або із озимого тритикале.

Встановлено, що заміна у складі кормосумішки тварин дослідної групи кукурудзяного силосу на зерносінаж з озимого тритикале, за незначного зменшення вмісту крохмалю, сприяла підвищенню вмісту сирого протеїну на 93 г або 3,4 %, протеїну здатного до розщеплення на 26 г або 1,2 %, протеїну нездатного до розщеплення на 68 г або 10,7 %, перетравного протеїну на 102 г або 11,6 %, цукру на 391 г або 66,8 % та жиру на 28 г або 4,5 %.

Заміна у складі кормових сумішок корів 50 % кукурудзяного силосу на зерносінаж з озимого тритикале сприяла збільшенню їх середньодобових надоїв, на 2,23 л або 13,1 % ($p \leq 0,05$) та кількості молока отриманого за період досліду (в середньому на 1 голову), на 541 л. Завдяки дещо більшому вмісту жиру та білка у молоці тварин дослідної групи на 0,09% і 0,04 % порівняно з першою контрольною, згодовування зерносінажу з озимого тритикале мало позитивний вплив на показник кількості молочного жиру та білка отриманих з молоком. Зокрема, тварини дослідної групи мали перевагу за цим показником на 25,6 кг і 19,0 кг або на 15,7 % ($p \leq 0,01$) і 14,6 % ($p \leq 0,05$).

Згодовування зерносінажів як з вико-вівсяної сумішки, так і з озимого тритикале, сприяло підвищенню жирномолочності (на 0,09 %) і вмісту білка в молоці на 0,01 % і 0,04 %. Розбіжність за масовими частками сухої речовини і сухого знежиреного молочного залишку в молоці, порівняно з тваринами першої групи, становила 0,08 % і 0,2 % та 0,08 % і 0,1 % на користь тварин другої та третьої груп.

Ключові слова: *корови, молочна продуктивність, якість молока, зерносінаж, озиме тритикале.*

Introduction. Corn is considered a traditional crop for use in intensive feed production technology. However, in recent years, global warming has led to extremely unstable yields of both corn and other traditional crops, which has a negative impact on silage production (Pomitun et al., 2018; Thornton et al., 2009). These changes indicate that in order to adapt the feed production industry to climate change, it is advisable to implement a set of measures, one of which is to increase the acreage of perennial, winter,

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or more drought-resistant crops. Therefore, in order to increase production volumes and reduce the cost of livestock products, it is necessary to use the most productive and adaptive crops and feed harvesting technologies for each natural and climatic zone, capable of providing 20-30% more nutrients compared to traditional feed crops (Shchipak, 2019) .

Studies have shown that small-grain cereal crops are preferable for use as raw materials for canned feed due to their greater drought resistance, resulting from their shorter growing cycle (Edward J. DePeters et al, 1990; Salgado et al, 2013; Celis-Alvarez et al, 2016; Aída Gómez-Miranda et al, 2020; Vianey Colín-Navarro et al, 2021).

The LFI NAAS has identified priority feed crops and their mixtures, based on which a low-cost feed base can be created for the sustainable feeding of cows in the forest-steppe zone of Ukraine, the use of which can ensure an increase in livestock production with the rational use of land resources and savings in energy and funds (Gnoevyi, 2006; Gnoevyi et al, 2007).

One such crop is winter triticale, a hybrid of winter wheat and rye, which successfully combines the high productivity of wheat with the ecological plasticity of rye to abiotic factors. Rye is capable of providing stable yields even in dry years and makes it possible to obtain high-quality raw materials for grain silage, which is almost equal in terms of the content of certain nutrients and even exceeds traditional grain fodder crops and their mixtures in some respects (Baron et al, 2015; Harper et al, 2017).

It is characterized by high grain and green mass yield potential, increased adaptability to growing conditions, in particular winter hardiness, drought resistance, and undemanding soil requirements. In addition, the crop is resistant to fungal diseases, contains more protein and lysine in the grain, and is rich in nutrients in the green mass. These characteristics significantly expand the geography of cultivation, making it possible to actively introduce triticale in regions unsuitable for other grain crops, which makes it possible to consider it as a promising crop for use in feeding cattle (Habtamu et al., 2018; Randhawa et al., 2019).

However, the impact and feasibility of introducing such grain silage into the diet of cows as an unused reserve for creating a stable feed base for feeding high-yield dairy cattle has not yet been definitively determined, which explains the relevance of our research.

Materials and methods. The study was conducted at the State Enterprise "Gontarivka" of the National Academy of Agrarian Sciences of Ukraine in the Chuhuiv district of the Kharkiv region. Laboratory tests of feed included in the diets of the test animals were performed in the department for the assessment and monitoring of the quality of livestock products and feed, in accordance with the requirements of DSTU and generally accepted methods in animal husbandry (Vlizlo, et al., 2012). The energy value of the feed was calculated in accordance with the current standards and methods of DSTU ISO 8066:2015 (2015).

To conduct a scientific and economic experiment using the pair-analogue method, three groups of highly productive cows of the Ukrainian black-and-white dairy breed of the second and third lactations were formed, with 10 heads in each group, with an average daily milk yield of 21 liters, fat content of 3.80%, and protein content of 2.65%. The cows in the first (control) group received the basic diet. In the diets of the animals in the second (control) group, 50% (by nutritional value) of the corn silage was replaced with grain silage made from green mass of a vetch-oat mixture. In the diets of the animals in the third (experimental) group, 100% of the above-mentioned grain silage was replaced with grain silage made from winter triticale. The diets were adjusted after each control milking of the animals.

Table 1.

Research design

Groups		
I (control) (n = 10)	**II (control) (n = 10)**	**III (experimental) (n = 10)**
Basic ration (BR)	BR (50% of corn silage (in terms of nutritional value) replaced with grain silage from a vetch-oat mixture)	BR (50% of corn silage (in terms of nutritional value) replaced with winter triticale grain silage)

The animals were kept tethered, fed twice a day, and had free access to water. Analogues were selected according to age, sex, breed, physiological condition, and individual daily milk yield. The dynamics of changes in milk productivity of cows were determined on days 30, 60, 90, 125, 155, 180, 211, and 244 of the experiment, both individually for each animal and on average for the group (Ibatullin et al., 2017). The diets were adjusted after each control milking of the animals. The diets were balanced in accordance with detailed feeding standards (Bogdanov et al., 2012), (Kandyba et al., 2012).

Milk productivity was recorded based on the results of individual monthly control milkings of cows, with subsequent calculation of the average for each month for the group. The average milk samples were tested monthly for mass fractions (%): fat, protein, lactose, dry matter, dry non-fat residue, and the freezing point and energy content of milk were determined in accordance with DSTU 8396:2015 "Cow's milk"[ii].

Biometric processing of the obtained digital material was carried out using the method of variational statistics, taking into account Student's criterion according to the methodology of M. O. Plohinskiy (Ibatullin et al., 2017). To assess the reliability of the results obtained—the arithmetic means (M), the arithmetic mean error (± m), and the reliability of the difference between the arithmetic means under study (P)—the standard computer mathematical and statistical program Microsoft Excel was used. Changes between groups were considered significant at $p \leq 0.05$.

Research results. As part of the research conducted, as a basis for achieving the main objective of the work, the chemical composition, nutritional value, content, and ratio of organic acids in grain silage and silage fed to animals were determined, the data for which are presented in Table 2.

Analysis of the results obtained shows no differences in the quality indicators of triticale grain silage compared to vetch-oat mixture grain silage, in particular, lactic acid prevailed in both, accounting for 2/3 of the total amount of acids. At the same time, grain silage from winter triticale had a slightly lower total acidity index. It should be noted that corn silage had almost twice the titratable acidity and contained twice as much acetic acid compared to both grain silages. Butyric acid was absent (Table 2).

An analysis of the chemical composition of winter triticale grain silage compared to vetch-oat mixture grain silage and corn silage shows that its use makes it possible to obtain high-quality preserved feed containing 34.1 g of crude protein, surpassing corn silage in this indicator by 11.5 g or 50.9%, while slightly lagging behind grain silage from

[ii] DSTU ISO 8066:2015. (2015) Kormy dlia silskohospodarskykh tvaryn. Metody vyznachennia enerhoiemnosti i pozhyvnosti: Vydannia ofitsiine [Chynnyi vid 2017-01-01]. [Feed for farm animals. Methods for determination of energy content and nutritional value: Official edition]. Kyiv.

a vetch-oat mixture by 2.0 g or 5.5%. It should be noted that in terms of indigestible protein content, grain silage from winter triticale had an advantage over grain silage from a vetch-oat mixture and corn silage, by 36.8% and 120.4%, respectively. It should be noted that the preparation of grain silage from winter triticale made it possible to obtain feed with a higher content of fat compared to grain silage from a vetch-oat mixture and corn silage, fat by 14.7% and 38.3% and sugar by 15.6% and 873.8% (Table 2).

Table 2.

Chemical composition of grain silage and silage (based on natural moisture content)

Indicators, unit of measurement	Grain silage from a vetch-oat mixture	Grain silage from winter triticale	Corn silage
Dry matter, %	37,50	37,13	30,69
Crude ash, %	2,76	3,31	1,54
Crude fat, %	1,29	1,48	1,07
Crude protein, %	3,61	3,41	2,26
Cleavable protein, g	2,74	2,22	1,72
Non-cleavable protein, g	0,87	1,19	0,54
Digestible protein, %	2,38	2,32	1,26
Crude fibre, %	9,43	9,07	6,76
NDF, % DM	22,1	23,6	22,85
ADF, % DM	16,1	14,8	9,31
Starch, %	1,11	1,80	2,21
Sugar, %	3,2	3,7	0,38
Ca, %	0,200	0,237	0,151
P, %	0,118	0,111	0,061
Energy available for exchange, MJ	3,66	3,62	3,17
pH	4,26	4,43	3,67
Total acidity, %	16,4	14,76	29,42
Lactic acid, %	0,91	0,88	1,30
Acetic acid free, %	0,36	0,41	0,88
Acetic acid bound, %	0,1	0,05	0,02
Butter acid free, %	0	0	0
Butter acid bound, %	0	0	0
Total acids, %	1,37	1,34	2,20
Acid balance:			
lactic	66,42	65,67	59,09
acetic	33,58	34,33	40,91
butter	0	0	0

The above differences in chemical composition resulted in an increase in the nutritional value of grain silage prepared from green winter triticale mass compared to corn silage by 0.45 MJ or 14.2%.

Data on the nutrient content and structure of diets at the beginning of the experiment are presented in Table 3.

Analysis of the data in Table 3 shows that the diets of the control and experimental

groups in terms of the content of essential nutrients at the beginning of the experiment almost completely satisfied their daily requirements, since their intake from feed corresponded to the recommended norms. The exception was the total protein content and its components in the diet of the animals in the first group. However, this difference was insignificant, amounting to 3%.

Table 3.

Composition and nutritional value of animal diets (at the start of the experiment)

Nutrient content and diet composition	Groups		
	I group	II group	III group
Alfalfa hay, kg	3	3	3
Alfalfa haylage, kg	3	3	3
Corn silage, kg	28	14	14
Grain silage from a vetch-oat mixture, kg	-	12	-
Grain silage from winter triticale, kg	-	-	12
Concentrated forage, kg	7	7	7
The ration contains:			
dry matter, kg	19,25	19,45	19,41
energy available for exchange, MJ	204,9	204,5	204,0
crude protein, %	2757	2874	2850
cleavable protein, g	2123	2211	2149
non-cleavable protein, g	634	663	702
digestible protein, %	1735	1844	1837
crude fibre, g	3402	3587	3544
NDF, % DM	22,4	22,2	22,6
ADF, % DM	13,3	14,9	14,6
starch, g	3157	2891	3064
sugar, %	585	916	976
crude fat, g	620	625	648
Ca, g	116,3	133,2	123,6
P, g	75,2	80,8	80,0

The use of winter triticale grain silage in animal diets had no significant effect on changes in the energy concentration in the dry matter of the diets of different groups of animals. It was found that replacing corn silage with winter triticale grain silage in the feed mixture of the experimental group, with a slight decrease in starch content, contributed to an increase in crude protein content by 93 g or 3.4%, digestible protein by 26 g or 1.2%, non-digestible protein by 68 g or 10.7%, digestible protein by 102 g or 11.6%, sugar by 391 g or 66.8% and fat by 28 g or 4.5%. It should also be noted that the use of winter triticale grain silage in cow diets instead of grain silage from a vetch-oat mixture with a slight decrease in crude protein content, allows for an increase in the content of indigestible protein by 39 g or 5.9%, as well as an increase in the content of starch by 173 g or 6.0%, sugar by 60 g or 6.6%, and crude fat by 23 g or 3.7%.

The use of winter triticale grain silage instead of corn silage in animal diets resulted in a slight decrease in the energy concentration in the dry matter of the diets. On average for the experiment period, it amounted to 10.70 MJ, with fluctuations during the experiment months ranging from 10.86 to 10.51 MJ/kg DM, which was slightly below

normal. However, this difference was insignificant, averaging only 1.3% for the experiment period. As for the crude fibre content in the dry matter of the diets, the use of grain silage from both winter triticale and vetch-oat mixture caused an increase in this indicator from 176.7 g to 182.6 g/kg DM. It should be noted that the values of both indicators in all groups were within the normal range.

Table 4 gives an idea of the relationship between quantitative and qualitative indicators of milk productivity.

Table 4.

Milk production of cows, (M±m)

Indicators	Groups		
	I group	II group	III group
Quantity of animals, heads	10	10	10
Milk yield during the trial period, kg	4140±162,4	4654±175,2*	4681±185,1*
Daily milk yield, kg	17,03±0,668	19,15±0,721*	19,26±0,762*
Milk yield in reference to basic fat content (3.4%), kg	4791±142,9	5518±148,7**	5546±198,4**
Quantity of milk fat, kg	162,9±4,86	187,6±5,06**	188,5±6,75**
protein, kg	130,4±4,90	147,1±5,56*	149,4±5,40*
Protein to fat ratio	0,80:1	0,78:1	0,79:1

Note. $^{\#}p\leq0,1$; $*p\leq0,05$; $**\ p\leq0,01$

Analysis of the data in Table 4 shows that replacing 50% of corn silage in the feed mixture for cows with winter triticale grain silage had a significant positive effect on their average daily milk yield, increasing it by 2.23 l or 13.1% ($p\leq0.05$). This, in turn, contributed to an increase in the quantity of milk obtained during the experiment (on average per head) by 541 l compared to the control group animals. When converting milk yield to base fat content, the animals in the experimental group outperformed the animals in the control group by 755 l or 15.8% ($p\leq0.01$). It should be noted that due to the slightly higher fat and protein content in the milk of the experimental group animals by 0.09% and 0.04% compared to the first control group, feeding grain silage from winter triticale had a positive effect on the quantity of milk fat and protein obtained from milk. In particular, the animals in the experimental group had an advantage in this indicator by 25.6 and 19.0 kg, or 15.7% ($p\leq0.01$) and 14.6% ($p\leq0.05$).

When comparing productivity indicators with animals fed feed mixtures containing 50% corn silage replaced with grain-silage from a special vetch-oat mixture, no significant difference was found. In particular, the difference in their average daily milk yield was only 0.11 l or 0.6%. In terms of the quantity of milk fat and protein, the animals in the experimental group had an advantage of 0.9 kg and 2.3 kg, or 0.5% and 1.6%.

As for the ratio of protein to fat in the milk of cows in all groups, no significant difference was found in this indicator. Thus, on average, there were about 0.78–0.80 parts of protein per part of fat.

As for the quality indicators of milk, the data obtained indicate that there are no significant differences in the chemical composition and physical and chemical properties of milk between animals of different groups. It should be noted that feeding grain silage, both from a vetch-oat mixture and from winter triticale, caused a slight increase in fat content (by 0.09%) and protein content in milk by 0.01% and 0.04%. At the same time, the difference in the mass fractions of dry matter and dry skimmed milk residue in milk,

compared to animals in the first group, was 0.08% and 0.2% and 0.08% and 0.1% in favour of animals in the second and third groups.

It should also be noted that replacing 50% of corn silage with grain silage from a vetch-oat mixture or winter triticale contributed to an increase in the energy value of milk by 41 J and 50 J, or by 1.5% and 1.8%. It should be noted that laboratory assessment of milk quality in cows of all groups showed the same pattern, which allows us to conclude that it complies with the requirements of DSTU 7671:2014 and DSTU 6082:2009, since the freezing point, as a marker criterion of naturalness in case of falsification with water, was practically unchanged and did not exceed the permissible limits, ranging from minus 0.554 to minus 0.558 °C (Table 5).

Table 5.

Nutritional value and physical and chemical properties of milk from cows of different groups, (M±m)

Показники	Groups		
	I group	II group	III group
Mass content in milk, %			
fat	3,94±0,100	4,03±0,054	4,03±0,101
protein	3,15±0,042	3,16±0,039	3,19±0,047
lactose	4,90±0,035	4,91±0,036	4,94±0,017
dry matter	12,88±0,0,95	12,96±0,075	13,08±0,101
non-fat dry milk solids	8,95±0,050	8,93±0,037	9,05±0,040*
fat : protein	1,25:1	1,28:1	1,26:1
Freezing point, °C	-0,554±0,002	-0,555±0,003	-0,558±0,002
Energy value of milk, J	2827	2868	2877
Ratio: fat : NfDMS	0,440:1	0,451:1	0,445:1
protein : NfDMS	0,352:1	0,354:1	0,352:1

*Note: *p≤0,05*

Discussion. According to our data, it was established that the preparation of grain silage from the green mass of winter triticale made it possible to obtain high-quality canned feed, which contains 37.3% dry matter and 9.18% crude protein per dry matter. It was also found that replacing corn silage with grain silage from winter triticale in the feed mixture of the experimental group of animals contributed to an increase in crude protein content by 93 g or 3.4%. The data obtained are consistent with those obtained by foreign researchers. In particular, in experiments (Khorasani G. et al., 1997), when winter triticale was used as raw material, grain silage with a dry matter content of 34.4% and crude protein content of 12.3% was obtained. The slightly higher crude protein content is explained by the use of nitrogen fertilisers in the cultivation of raw materials. According to data (Harper M. et al. 2017), replacing 10 kg of corn silage with 10 kg of grain haylage in the diets of dairy cows contributed to an increase in the crude protein and NDF content of the diet.

We also found that replacing 50% of corn silage in cow feed mixtures with winter triticale grain silage had a significant positive effect on their average daily milk yield, increasing it by 2.23 litres or 13.1% ($p \leq 0.05$). Regarding the positive effect of using grain silage in feeding dairy cows, the data obtained in our studies are consistent with the results (Gnoievyi I.V. 2006; Gnoievyi V.I. et al. 2007) in whose experiment, when replacing

25 kg of corn silage in the diets of dairy cows with the same quantity of silage from a 4-component mixture of cereal and leguminous grain crops, it contributed to an increase in the average daily milk yield in cows of the experimental group, compared with the control group, by 2.6 kg or 14.5%. At the same time, the fat content in the milk of the experimental group was 0.05% higher than in the control group, which was a result of better provision of digestible protein to the animals in the experimental group, since its content in the combined silage, calculated on a dry matter basis, was more than twice as high as in corn.

However (Khorasani G.R. et al. 1993) found in their studies that the use of winter triticale grain silage in the diets of dairy cows, with a slight increase in productivity, contributed to an increase in milk fat content from 3.6% to 3.9% and protein from 3.2% to 3.35%.

Thus, given that under current climatic conditions, harvesting grain silage from grain fodder crops allows for an increase in dry matter and crude protein yield compared to corn dry matter and crude protein yield compared to corn, with the aim of ensuring a sustainable supply of feed for the livestock industry, which is facing climate change, as well as increasing feed production per unit of land area while reducing its cost, the feasibility of using grain silage made from green mass of winter triticale in feeding dairy cows has been proven.

Conclusions

1. The research has substantiated the possibility and feasibility of using winter triticale grain silage instead of part of corn silage in dairy cattle feed rations.

2. It has been established that replacing 50% of corn silage in cow feed mixtures with winter triticale grain silage contributes to an increase in average daily milk yield by 2.23 litres or 13.1% ($p \leq 0.05$).

3. Feeding grain silage from both vetch-oat mixture and winter triticale contributes to an increase in milk fat content by 0.09% and protein content in milk by 0.01% and 0.04%.

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