SCIENTIFIC HORIZONS

Journal homepage: https://sciencehorizon.com.ua
Scientific Horizons, 28(6), 9-22

UDC 636.02
DOI: 10.48077/scihor6.2025.09

Improving feed efficiency in Kazakh white-headed cattle: The role of residual feed intake, growth, and dry matter intake

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Article's History:
Received: 12.12.2024
Revised: 21.04.2025
Accepted: 28.05.2025

Abstract. The aim of this study was to investigate the influence of residual feed intake on key technological parameters involved in the rearing of Kazakh white-headed cattle. The experimental research was carried out at four large-scale breeding enterprises raising this breed: the limited liability partnership "Zhana Bereke" (Akmola Region), the limited liability partnership "Galitskoe" (Pavlodar Region), the communal farm "Sabit" (West Kazakhstan Region), and the limited liability partnership "Shalabai" (Abai Region). Data collection and continuous monitoring were implemented using the automated livestock monitoring system known as Vytelle-sense technology. Following a two-week adaptation period, 64 steers of the Kazakh white-headed breed were selected at each enterprise. Over the course of 60 days, measurements were taken for residual feed intake, average daily weight gain, and daily dry matter consumption. Results showed that, across all four enterprises, approximately half of the animals exhibited negative residual feed intake values. The mean average daily weight gain was 0.95 kilograms, while the mean daily intake of dry matter per steer was 11.03 kilograms. A positive correlation was observed between residual feed intake and average daily weight gain, whereas no significant correlation was found with dry matter consumption. Bulls demonstrating negative residual feed intake values along with high feed consumption are recommended for selection in breeding programmes due to the potential for genetically favourable traits. Additionally, the recorded average daily weight gain ranged from 0.1 to 1.81 kilograms, with dry matter intake ranging from 7.82 to 13.91 kilograms per day

Keywords: Kazakh white-headed breed; technological parameters; Vytelle-sense technology; beef cattle breeding; heredity

Suggested Citation:
Matakbayev, D., & Shauyenov, S. (2025). Improving feed efficiency in Kazakh white-headed cattle: The role of residual feed intake, growth, and dry matter intake. *Scientific Horizons*, 28(6), 9-22. doi: 10.48077/scihor6.2025.09.

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INTRODUCTION

The relevance of the study is that the growth of the world population contributes to the need for beef production and the search for improvement of cattle reproduction. Therefore, in countries such as Kazakhstan, the introduction of new cattle breeding technologies to minimise feed costs with excellent technological performance is a priority. According to the data obtained during the study of statistical indicators, G. Kassenbayev *et al.* (2024) noted that the growth of cattle population is 2-4% from year to year. It was also noted that maintenance feed requirements can be up to 75% of the total cost of feeding and care of beef cattle breeds per year. Crop production as an industry for beef cattle feedstock is very dependent on weather conditions, as a result feed price can fluctuate, and this figure can be even higher. At the same time, it is noted that the majority of beef cattle are in small farms that compete with large enterprises. This means that only the introduction of new technologies, which can only be done on large farms, will allow large enterprises to change the situation. In order to realise these trends and to comply with age-old traditions, the Republic of Kazakhstan pays considerable attention to ensuring food security.

S.K. Abugaliyev *et al.* (2019) and A.T. Bissembayev *et al.* (2023) note that beef and its source in Kazakhstan – beef cattle breeding, it is an essential and necessary food product and fulfils a leadership role for obtaining affordable food. I. Baltenweck *et al.* (2020) and R.G. Alders *et al.* (2021) conclude that the use of modern technologies in the field of programming and information has simplified and accelerated the collection of data for genetic evaluation of herds and technological parameters of feeding. Genetic improvement extends to the production of new and improvement of existing breeds, species, lines of beef cattle. After all, the basis of any animal breeding is selection. For this purpose, it is necessary to collect reliable information on productive indicators of animals. Kazakhstan is an ideal platform for utilising the potential to increase meat production because beef cattle breeds have valuable biological and economic features. Studies by L. Cavani *et al.* (2024) showed that feed intake is an inherited trait and can serve to improve the efficiency of cattle breeding by selection of beef animals. Thus, feed conversion ratios and residual feed intake (RFI) is a heritable trait. The costs of feed production and animal feeding are now being realised by consumers as a personal health, environmental and animal welfare issue rather than just an economic issue (Montayeva *et al.*, 2023).

Cattle feed consumption must create a sustainable beef production model. As noted by C. Davison *et al.* (2021), even small changes in feeding technology affect feed intake and feed conversion. Three indicators give a complete and correct picture of understanding these processes, these are RFI by individual cattle, average daily live weight gain and dry matter intake (DMI). The use of RFI in beef cattle selection is a more effective method of breeding cattle for feed productivity than selection for feed inputs per unit of live weight gain (Kropyvka *et al.*, 2024). This indicator, actively used in the technology of selection of beef cattle, makes it possible to accurately and purposefully put into practical use the fattening of beef cattle with increasing the productive effect of feed and increasing the profitability of the livestock industry. In fact, in addition to a selection tool, RFI can be a tool to measure the efficiency of animal feeds (Montayev *et al.*, 2023). At the same time, the continued use of RFI for selection will result in progeny consuming the minimum amount of feed at the same level of productivity as progeny consuming more feed but with the same level of productivity.

There are inaccurate and outdated models for predicting feed intake based on eating behaviour, live weight and age, but their use is subjective and inaccurate. Specialised software now collects individual and daily information using cloud-based technologies, digital animal identification, etc. Such opportunities allow collecting quickly and qualitatively all technological information, minimising the human factor with its inherent errors. Objective of the work was to study the effect of process parameters like RFI, ADG, DMI on each other. The tasks to fulfil this goal were collecting and analysing information on RFI indicator, experimentally using Vytelle-sense technology and analysing the data obtained with its help.

LITERATURE REVIEW

Until now, many small and large farms in Kazakhstan use inefficient ways of determining feed efficiency indicators (Kassenbayev *et al.*, 2024). These are such well-known indicators as feed conversion ratio and DMI. These indicators can be used only for short-term analyses of growing technology for a period of not more than two months, while growing technology for a longer period gives a lot of factors that distort these indicators. These factors are feed quality, microclimate and some parasitic diseases which distort the real conversion rate. N. Kazhgaliyev *et al.* (2020) noted that, given the fact that regardless of the conditions of cattle breeding development, the main direction of development is to get the greatest profit from the largest number of the most productive animals, which are bred in specific conditions. At the same time, the official assessment of the breeding value of animals in beef cattle, which is applied at the present stage in the Republic of Kazakhstan, always implies two qualities: breeding and productive, and therefore they cannot be separated. This statement is considered controversial because it was considered as an axiom in the first half of the last century, which does not correspond to modern scientific approaches. This axiom can be destroyed by the genetics of quantitative traits,

or modern socio-economic conditions of the agro-industrial complex of the republic.

Quantitative determinations of breeding qualities of bulls of the Kazakh white-headed breed by assessing the indicators of their productivity were carried out by A. Nugmanova *et al.* (2024). Productivity indicators were evaluated by the dynamics of live weight, daily growth rate, efficiency of feed conversion and morphological quality of meat, as well as in the use of complex indices "A" to assess breeding potential. These indices allowed selection of the best 10% of bulls for further utilisation of their genetic potential, the remaining bulls also performed well and only 10% of bulls were culled. Such studies allow saving forage by not spending it on bulls with poor performance, and manipulating heritability by obtaining progeny from bulls with good performance. L.F. Benfica *et al.* (2020) noted in their works the same idea: RFI is also a breeding quality of the breed, because it is a measure of feed productivity, which is the difference between the feed that was consumed by the animal actually and that which the animal should have consumed according to the norms established on the farm and according to the technological regulations. P. Guarnido-Lopez *et al.* (2021) note that RFI is a complex and versatile indicator under the control of many biological processes, including nutritional selection, feed conversion, metabolism at the cellular level, and catabolism. B.N. Baban *et al.* (2020) noted in their studies that the organism of an animal with this low index spends less energy on heat production and protein metabolism. This index is heritable and does not depend on growth rate and body weight. Therefore, J.R. Johnson *et al.* (2019), A. Foroutan *et al.* (2021) consider subjectivity to use only this index for selection without ADG and DMI, this immediately improves the profitability of beef producers by as much as 33%. An inverse proportional consistency with the DMI indicator is observed.

RFI is very useful for controlling feed digestibility and converting it into live weight (Pogranichniy *et al.*, 2023). Thus, G.F. Moraes *et al.* (2019) and P. Martin *et al.* (2024) experimented with cattle with different productivity. Data were obtained that cows with high productivity and lower RFI gave similar reproductive performance to cows with low productivity and higher RFI. It was concluded that selection for heifer and heifer efficiency gave poor results for lactation performance and questionable results for reproductive soundness. Thus, the use of RFI alone to evaluate cows for calf and milk production is questionable, although it was noted that selection for a favourable RFI increases gestation. However, in the study of F.M. Rouquette *et al.* (2023), low RFI coincided with a decrease in subcutaneous fat. This is what the producer needs (within reasonable limits of course): to get more meat and less fat. Low RFI results in low blood cortisol, which means that animals with low RFI are less stressed and therefore have stronger immunity and are easier to vaccinate.

The reverse research experience is also possible, in which phenotype and genotype data or genetic markers, as in the work of I. Beishova *et al.* (2024), can be used to predict and improve the productivity of meat of the Kazakh white-headed breed of cattle. The efficiency of meat production in this case is carried out by supplementing the base of genetic knowledge of this particular breed using selection by diplotypes for which identified those that had a phenotypic effect of rapid and stable live weight gain. There are information technologies for measuring RFI mentioned in the studies of V.K. Sharma *et al.* (2021), C. Yang *et al.* (2022): Vytelle-sense – feed logging system provides an opportunity to engage in efficient selection of beef cattle. In fact, it is a simple mathematical and genetic correlation between feed intake and production performance based on heritability. Vytelle-sense technology can continuously record weight and feed intake and accurately identify cattle with high or low RFI values in minimal time and faster than traditional RFI testing. This technology provides the ability to accurately present weight gain charts in a short period of time. The system, by collecting information quickly, allows the farmer to get several more tests per year. The database currently contains data on 140,000 animals of 24 breeds and over 32,000 RFI phenotypes. The review concludes that RFI is recommended for beef cattle producers with small operation requirements as a beef cattle sampling tool to reduce feed requirements and identify those herds with high feed conversion efficiency, but does not consider development, carcass quality, reproductive and lactation performance.

MATERIALS AND METHODS

The study was conducted on the basis of four farms: Zhana Bereke Limited Liability Partnership (LLP) (Akmola Region), Galitskoe LLP (Pavlodar Region), Sabit communal farm (West Kazakhstan Region) and Shalabai LLP (Abai Region). Zhana Bereke LLP (Akmola Region) is a closed-cycle agricultural company (i.e., the company has agricultural fields, a feed mill, meat cattle breeding and a meat processing complex). Galitskoe LLP (Pavlodar Region) is a large agricultural enterprise engaged in crop production, dairy and beef cattle breeding, horse breeding, and fodder production. Thus, beef cattle breeding is provided with fodder of own production. Communal farm "Sabit" (West Kazakhstan region) is a communal farm, the main activity of which is breeding of pedigree cattle of Kazakh white-headed breed. LLP "Shalabai" (Abai region) is an enterprise engaged in breeding of sheep, horses, and cattle of meat breeds, as well as crop production and fodder production.

The survey was conducted with the help of Vytelle-sense technology. This is a system that allows the weight of cattle to be measured without stressful factors such as being put on special scales or being held for measurement. The system also allows the

measurement of feed intake. When the animal drinks water through the In-pen Weighing System (IPW) drinker, the system collects information on the live weight of the animal, and the collected information is collected in the Vytelle-sense Systems software analytical system. At the same time, indicators such as RFI, DMI, and ADG are measured simultaneously and accurately. Before the beginning of the experiment, the experimental animals were given 14 days to adapt to the new feeding conditions. According to the manufacturer (Canada), the equipment can be used for up to 60 days. The largest bulls were selected from four farms, as it was planned to use them for breeding. Bulls at weaning age were selected. Housing conditions: cold loose housing, access to feed and water 24 hours a day. The trial lasted 60 days during November 2023 – March 2024 on the farms in question.

Bulls were marked by RFI data, also data collected included Wt1 – weighing on the first day of the experiment and Wt60 – weighing on the last day of the experiment.; ADG: average daily gain; DMI: average daily DMI during the test. The experiment was also conducted, and groups of steers were formed at the enterprises Zhana Bereke LLP (Akmola Region) (29 bulls), Galitskoe LLP (Pavlodar Region) (29 bulls), Sabit communal farm (West Kazakhstan Region) (38 bulls) one group each, at the enterprise Shalabai LLP (Abai Region) two experimental groups (20 and 30 bulls). For the purity of the experiment, all animals on all four farms received the same diet for the main parameters (Table 1).

***Table 1**. Basic requirements for diets in experimental animals of farms of Zhana Bereke LLP (Akmola Region), Galitskoe LLP (Pavlodar Region), Sabit communal farm (West Kazakhstan Region) and Shalabai LLP (Abai Region)*

Indicators	Hay	Straw (barley)	Silage (corn)	Barley grain
Humidity, %	17	12.2	67	11.2
Dry matter, %	83	87.8	33	88.8
Crude protein, g	6.5	3.77	8.33	14.7
Exchange energy, MJ	1.91	1.48	2.32	2.92
Starch, %	1	1.3	22.54	52.99
Sugar, %	4	3.52	1.9	2.65
Crude fat, %	2.88	1.75	3.16	2.4
Ca, %	0.36	0.38	0.28	0.09
R, %	0.21	0.11	0.26	0.45
Mg, %	0.15	0.13	0.18	0.13
K, %	1.29	1.5	1.23	0.58
Na, %	0.23	0.11	0.04	0.02

***Source:** created by the authors*

All procedures performed in studies involving animals were in accordance with the European convention for the protection of vertebrate animals used for experimental and other scientific purposes (1986).

RESULTS AND DISCUSSION

The study was conducted in parallel on four farms (Tables 2-6) and similar data were obtained. The results from these farms revealed similar patterns in RFI, ADG, and DMI, providing a comprehensive overview of feed efficiency and growth performance in the steers. The data from Table 2 reveals significant variability in RFI across the experimental steers, ranging from negative to positive values. Better feed efficiency is indicated by negative RFI values, which imply that certain steers grow at comparable or superior rates while consuming less feed than anticipated. This demonstrates how breeding programmes can increase feed efficiency by selecting for low RFI. Nonetheless, the existence of both negative and positive RFI values in the same group indicates significant genetic variation and implies that a variety of factors affect feed efficiency.

***Table 2**. Results of the experiment on individual steers of Zhana Bereke LLP (Akmola region)*

Experimental animal number	RFI	Wt1	Wt60	ADG	DMI
KZC160257597	-1.9	358.92	374.42	0.31	10
KZC160257685	-1.63	292.89	321.39	0.57	7.82
KZC160257623	-1.5	279.3	315.8	0.73	8.4
KZC160257193	-1.26	251.66	287.66	0.72	10
KZC160257481	-1.07	339.79	368.79	0.58	10.2
KZC160257172	-0.98	299.5	339	0.79	10.2
KZC160257187	-1.2	275.79	319.29	0.87	10.05
KZC160257465	-0.78	339.1	357.1	0.36	10.3
KZC160257500	-0.61	382.97	417.97	0.7	11.11

Table 2. Continued

Experimental animal number	RFI	Wt1	Wt60	ADG	DMI
KZC160257504	-0.37	259.26	283.76	0.49	10.27
KZC160257195	-0.36	283.56	314.06	0.61	12
KZC160257579	-0.23	350.4	403.4	1.06	12
KZC160257634	-0.2	330.34	364.34	0.68	9.8
KZC160257562	-0.08	365.13	407.13	0.84	11.04
KZC160257642	-0.17	365.05	397.05	0.64	14
KZC160257615	0.22	370.66	406.16	0.71	10
KZC160257620	0.38	304.61	359.61	1.1	11.37
KZC160257572	0.38	263.38	278.38	0.3	10.94
KZC160257683	0.38	295.61	353.11	1.15	12.35
KZC160233434	0.39	310.15	310.65	0.01	10.69
KZC160233356	0.4	389.96	413.46	0.47	9
KZC160233369	0.41	310.67	313.67	0.06	8.8
KZC160233374	0.42	324.76	334.76	0.2	14.58
KZC160233416	0.45	344.88	396.38	1.03	13.84
KZC160233414	0.47	313.95	367.45	1.07	11.69
KZC160233349	0.5	298.02	325.02	0.54	13.11
KZC160233344	0.51	369.18	396.18	0.54	16.95
KZC160233367	0.6	222.12	257.62	0.71	10.72
KZC160233397	0.9	339.93	374.43	0.69	12.75

Note: *date of experiment: 2024-02-03*
Source: *created by the authors*

An in-depth examination of the data in Table 2 indicates a significant variation in residual feed intake among the 29 steers, ranging from -1.9 to +0.9. Among them, 14 steers demonstrated negative RFI values, signifying enhanced feed efficiency, but the remaining 15 steers exhibited positive RFI values, indicating subpar efficiency. The average daily gain varied from a minimum of 0.01 kg/day (KZC160233434, RFI = 0.39) to a maximum of 1.15 kg/day (KZC160257683, RFI = 0.38), with a mean ADG of roughly 0.65 kg/day across all steers. Significantly, steers KZC160257683 and KZC160257620, both exhibiting an RFI of 0.38, attained ADG values beyond 1.1 kg/day, despite their inferior RFI classification, illustrating that feed efficiency and weight growth are not tightly associated. In steers exhibiting negative RFI (n = 14), the ADG varied from 0.31 kg/day (KZC160257597) to 1.06 kg/day (KZC160257579). The mean ADG in this cohort was almost 0.69 kg/day, which is slightly greater than the average of 0.61 kg/day noted in the positive RFI group. This slight disparity underscores the intricacy of the relationship between RFI and growth performance. For instance, steer KZC160257579 (RFI = -0.23) achieved an ADG of 1.06 kg/day with a dry matter intake of 12 kg/day, while KZC160257193 (RFI = -1.26) exhibited a comparable DMI of 10 kg/day but a reduced ADG of 0.72 kg/day, indicating interindividual heterogeneity in feed conversion efficiency.

The dry matter intake values varied from 7.82 to 16.95 kg per day. The mean DMI for the group was roughly 10.7 kg/day. Notably, steer KZC160233344, with a mild RFI of 0.51, demonstrated the highest DMI at 16.95 kg/day, although achieved only an average ADG of 0.54 kg/day, signifying low efficiency. Conversely, steer KZC160257683 (RFI = 0.38) exhibited a very low DMI of 12.35 kg/day alongside the greatest ADG of 1.15 kg/day, indicating efficient nutrient utilisation despite the elevated RFI. This contrast highlights the complex factors influencing growth performance. The statistical analysis of this sample indicates the absence of a definitive linear correlation between RFI and ADG, as well as between RFI and DMI. The relationship between RFI and ADG is erratic, while DMI values fluctuate independently of RFI levels. Consequently, the data suggest that selecting for feed efficiency based exclusively on RFI may neglect steers exhibiting substantial growth potential and efficient feed utilisation in practical environments. A comprehensive selection method that integrates RFI with ADG and DMI is advised to improve productivity and resource efficiency in Kazakh white-headed cattle breeding operations.

The RFI values for the steers at Galitskoe LLP are shown in Table 3 and range from -2.01 to 0.68. Many of the steers with negative RFI levels were more feed-efficient, using less feed than anticipated while still growing at a similar rate. This implies that these steers could be selected for in breeding programmes that try to increase feed efficiency since they may be genetically inclined to have higher feed conversion.

***Table 3**. Results of the experiment on individual bulls of Galitskoe LLP (Pavlodar region)*

Experimental animal number	RFI	Wt1	Wt60	ADG	DMI
KZS180430872	-1.07	331.47	376.83	0.56	6.98
KZS180430919	-1	340.73	369.89	0.36	6.89
KZS180430433	-2	228.7	299.17	0.87	6.06
KZS180430931	-2.01	358.02	426.88	0.85	8.21
KZS180430972	-1.55	352.78	390.04	0.46	7.92
KZS180430968	-1.38	395.44	414.88	0.24	8.21
KZS180430485	-1	324.96	382.46	0.71	8.11
KZS180430446	-1.37	315.26	341.98	0.33	7.46
KZS180430946	-1.09	409.6	494.66	1.05	9.73
KZS180438080	-1.63	284.5	330.66	0.57	7.49
KZS180438083	-0.99	383.18	423.68	0.5	8.9
KZS180430402	-1.09	283.88	324.38	0.5	7.68
KZS180430195	-0.99	307	346.68	0.49	8.01
KZS180438176	0.68	356.73	388.32	0.39	8.57
KZS180438088	0.55	357.33	380.01	0.28	8.6
KZS180438002	0.52	303.79	340.24	0.45	8.16
KZS180430962	0.38	363.3	388.42	0.31	8.81
KZS180438016	0.38	313.09	364.93	0.64	8.7
KZS180438126	0.37	334.6	353.24	0.23	8.57
KZS180438140	0.37	376.95	419.88	0.53	9.57
KZS180430945	0.21	362.1	420.42	0.72	9.63
KZS180430845	0.16	364.08	425.64	0.76	9.7
KZS180430125	0.08	342.02	388.18	0.57	9.17
KZS180438098	0.2	314.14	334.4	0.25	8.49
KZS180438026	0.21	360.14	403.88	0.54	9.52
KZS180430938	0.36	361.2	413.84	0.65	9.69
KZS180430985	0.37	350.56	377.28	0.33	9.14
KZS180430192	0.61	367.75	417.97	0.62	9.8
KZS180438034	0.77	327.71	372.26	0.55	9.18

***Note:** experiment date: 2023-11-06/2024-01-26*
***Source:** created by the authors*

Significant variance can be seen in the data when looking at the ADG; the greatest ADG was 1.05 kg/day, while the lowest was 0.24 kg/day. It's interesting to note that although lower RFI values are generally linked to better ADG, the data also reveals that some animals with negative RFI had comparatively slow growth rates, suggesting that feed efficiency and growth performance are not always correlated. This disparity implies that the diversity in ADG may also be influenced by other environmental factors and genetic factors, such as growth potential. The steers' DMI ranged from 6.06 kg/day to 9.73 kg/day, and there was no discernible pattern linking DMI and RFI. The heterogeneity in ADG and the absence of a clear correlation between RFI and DMI imply that feed intake is not the only factor influencing growth outcomes. Other elements, such the feed's nutritional value, metabolic effectiveness, and overall health, probably have a big impact. These results highlight the intricacy of feed growth and efficiency, suggesting that a more comprehensive strategy that takes into account other variables in addition to RFI may be required to maximise breeding tactics.

The RFI values of the steers from the Sabit communal farm are displayed in Table 4 and vary from -2.17 to 1.34. A subset of the steers may be more feed-efficient, using less feed in relation to their performance, based on the negative RFI levels. The large range of RFI levels, however, suggests that the steers' feed efficiency varies significantly, most likely as a result of a combination of environmental and genetic factors. Although the positive RFI values imply that other factors, like feeding practices or metabolic variations, may also be impacting feed intake, this variation offers a chance to investigate genetic selection for feed efficiency.

***Table 4**. Results of the experiment on individual steers of Sabit communal farm (West Kazakhstan region)*

Experimental animal number	RFI	Wt1	Wt60	ADG	DMI
KZL102204595	-2.17	201.53	283.43	1.17	5.15
KZL102204543	-1.52	262.79	357.29	1.35	7.45
KZL102204461	-0.89	199.6	271	1.02	5.98
KZL102204531	-0.87	205.43	262.83	0.82	5.58
KZL102204497	-0.84	266.22	352.32	1.23	7.88
KZL101734419	-0.71	280.17	395.67	1.65	9.39
KZL102204511	-0.71	237.72	260.12	0.32	5.03
KZL101734321	-0.58	223.5	326.4	1.47	7.97
KZL101734393	-0.43	241.36	317.66	1.09	7.44
KZL102204605	-0.36	220.76	255.06	0.49	5.51
KZL102204493	-0.32	220.39	298.09	1.11	7.2
KZL102204503	-0.29	261.05	362.55	1.45	8.92
KZL101734305	-0.27	287.98	383.18	1.36	9.2
KZL101734315	-0.25	251.3	338.1	1.24	8.23
KZL102204373	-0.2	222.91	298.51	1.08	7.3
KZL102204473	-0.12	287.28	348.88	0.88	8.07
KZL102204539	-0.03	186.33	261.93	1.08	6.74
KZL102204377	0	259.25	353.75	1.35	8.92
KZL102204485	0.04	213.02	281.62	0.98	7.07
KZL102204483	0.04	280.62	339.42	0.84	8
KZL102204593	0.05	227.5	306.6	1.13	7.76
KZL102204467	0.11	252.64	349.24	1.38	8.97
KZL101734331	0.18	237.12	298.02	0.87	7.39
KZL101734395	0.21	243.21	330.71	1.25	8.55
KZL102204529	0.21	265.76	329.46	0.91	8.08
KZL102204513	0.21	267.91	347.01	1.13	8.7
KZL102204389	0.34	254.19	359.19	1.5	9.56
KZL101734403	0.46	219.69	321.19	1.45	8.89
KZL102204615	0.47	239.09	316.79	1.11	8.35
KZL101734311	0.48	232.77	312.57	1.14	8.33
KZL102204581	0.65	267.12	368.62	1.45	9.98
KZL101734317	0.7	232.85	311.25	1.12	8.49
KZL102204359	0.8	205.16	253.46	0.69	6.89
KZL102204499	0.84	215.26	307.66	1.32	8.82
KZL102204601	0.92	227.59	294.09	0.95	8.16
KZL101734323	1.25	247.04	300.24	0.76	8.35
KZL102204465	1.29	198.7	298.1	1.42	9.22
KZL102204353	1.34	253.34	335.24	1.17	9.67

***Note:** experiment date: 2024-01-06/2024-03-16*
***Source:** created by the authors*

An analysis of the experimental data from Sabit communal farm indicates that residual feed intake values for the 38 steers varied from -2.17 to +1.34. Seventeen steers had negative RFI values, signifying exceptional feed efficiency, whereas twenty-one steers displayed positive RFI values, indicative of worse feed conversion efficiency. The steer exhibiting the highest feed efficiency was KZL102204595, characterised by a RFI of -2.17, an average daily gain of 1.17 kg/day, and a remarkably low DMI of 5.15 kg/day. In contrast, the least efficient steer, KZL102204353 (RFI = 1.34), had an ADG of 1.17 kg/day while necessitating 9.67 kg/day of DMI, or 88% more feed than the most efficient animal for the equivalent growth rate. The average ADG for steers exhibiting negative RFI was 1.14 kg/day, whereas those with positive RFI averaged 1.12 kg/day, demonstrating only a negligible disparity in growth rate despite significantly divergent feed efficiency. Steer KZL101734419 (RFI = -0.71) attained the highest average daily gain in the cohort at 1.65 kg/day, accompanied with a dry matter intake (DMI) of 9.39 kg/day, so demonstrating that certain animals exhibit substantial development alongside comparatively modest feed consumption. In contrast, KZL102204511 (RFI = -0.71) had a very low ADG of

0.32 kg/day, despite a comparably low DMI of 5.03 kg/day, underscoring individual diversity in nutrition utilisation.

Regarding DMI, intake varied from 5.03 kg/day (KZL102204511) to 9.98 kg/day (KZL102204581), with a mean of roughly 7.95 kg/day. Of the 10 steers exhibiting the greatest DMI (⩾ 8.89 kg/day), only four presented negative RFI values, indicating that elevated intake alone does not dictate superior feed efficiency. KZL102204503 (RFI = −0.29) exhibited a substantial ADG of 1.45 kg/day and a DMI of 8.92 kg/day, while KZL102204389 (RFI = 0.34) attained a similar ADG of 1.50 kg/day, albeit with a higher RFI and a comparable DMI of 9.56 kg/day. The data indicate an absence of a consistent linear correlation between RFI and ADG. Multiple steers exhibiting elevated positive RFI values (e.g., KZL102204465, RFI = 1.29; ADG = 1.42 kg/day) had comparable weight increase to those with negative RFI values (e.g., KZL102204543, RFI = −1.52; ADG = 1.35 kg/day), underscoring the multifaceted character of growth. Similarly, the association between RFI and DMI is diverse. KZL102204497 (RFI = −0.84) and KZL102204581 (RFI = 0.65) had comparable ADG values (1.23 and 1.45 kg/day, respectively); however, the latter ingested 2.1 kg more dry matter daily, signifying much inferior feed efficiency.

The RFI levels of the steers from Group 1 at Shalabai LLP are reflected in the data in Table 5. The significant variation in feed efficiency among the steers is highlighted by the presence of both negative and positive RFI values in this group. Certain steers with negative RFI values are more effective in turning feed into weight gain, indicating that they are making better use of their feed resources. Conversely, positive RFI readings indicate less efficient feed usage, with steers ingesting more feed than is necessary for their growth. This range in RFI values indicates the presence of genetic variations in feed efficiency, but it also highlights the possible impact of management and environmental factors, including housing circumstances, food composition, and health status.

***Table 5**. Results of the experiment on individual steers of Shalabai LLP (Abai region) (Group 1)*

Experimental animal number	RFI	Wt1	Wt60	ADG	DMI
KZF193688117	-1.56	268.42	272.82	0.09	6.12
KZF194601515	-1.08	196.45	200.37	0.08	5.38
KZF194764568	-1.03	204.94	216.2	0.23	6.08
KZF194601487	-0.73	207.44	227.04	0.4	6.99
KZF194764514	-0.6	194.96	201.82	0.14	6.02
KZF194601551	-0.48	213.8	227.02	0.27	6.92
KZF194761909	-0.36	219.24	226.1	0.14	6.69
KZF193688161	-0.13	240.01	266.47	0.54	8.6
KZF194761920	-0.11	219.54	226.89	0.15	6.98
KZF194601482	-0.04	249.23	264.91	0.32	8.09
KZF193688001	0	271.89	291.49	0.4	8.75
KZF194761906	0.08	230.22	235.12	0.1	7.18
KZF194601497	0.21	242.96	258.16	0.31	8.21
KZF193688152	0.25	260.35	272.11	0.24	8.29
KZF194764502	0.63	260.98	277.15	0.33	8.97
KZF194764507	0.66	202.92	206.34	0.07	7.19
KZF194764587	0.74	230.32	235.72	0.11	7.87
KZF193688131	0.79	227.34	228.32	0.02	7.57
KZF193688153	1.35	217.21	228.97	0.24	8.69
KZF194764545	1.41	198.62	209.9	0.23	8.4

***Note:** experiment date: 2023-12-17/2024-02-04*
***Source:** created by the authors*

ADG readings range from a very low 0.02 kg/day to a higher 1.72 kg/day of ADG. The steers' diverse growth rates demonstrate that there isn't always a clear correlation between ADG and RFI. It's interesting to note that while some steers with greater RFI values showed better growth, others with lower or negative RFI values showed low ADG. This suggests that the variation in growth rates cannot be explained by feed efficiency alone. ADG is probably influenced by a number of factors, including the animal's metabolic efficiency, genetic propensity for growth, and the calibre of the feed it consumes. As a result, concentrating solely on RFI might not account for all the elements that influence an animal's growth performance.

The steers' daily consumption ranged from 6.12 kg to 9.72 kg in terms of DMI. The data shows a more nuanced relationship between RFI and DMI than one may anticipate. The diversity in DMI across steers with similar RFI values indicates that there are individual differences in intake, even though steers with lower RFI values tended to consume less feed. These variations may be caused by the metabolic rates of the cattle, the feed's digestibility, or variations in appetite. This makes the connection between feed efficiency and intake even more difficult to understand. The results imply that other biological or environmental elements must be taken into account when evaluating the steers' overall performance because DMI alone cannot adequately explain feed efficiency.

RFI levels for steers at Shalabai LLP (Abai region) in Group 2 range from -1.59 to 1.89, with both positive and negative values present, according to the data in Table 6. Better feed efficiency is indicated by negative RFI readings, which show that steers are using their feed resources more efficiently by consuming less feed in relation to their growth. But as the range of positive RFI readings shows, some steers are less productive and use more feed than is necessary for their growth. The genetic variability in feed efficiency within the group is highlighted by this range in RFI values, which also raises the possibility that environmental factors like feed quality, management techniques, and health may have a big impact on feed utilisation.

***Table 6**. Results of the experiment on individual steers of Shalabai LLP (Abai region) (Group 2)*

Experimental animal number	RFI	Wt1	Wt60	ADG	DMI
KZF194601607	-1.59	177.24	196.36	0.39	4.73
KZF194601732	-1.34	197.39	207.19	0.2	5.26
KZF194602286	-1.02	225.66	244.28	0.38	6.68
KZF194601642	-0.97	264.9	277.14	0.25	7.6
KZF194601705	-0.92	242.03	261.63	0.4	7.26
KZF194601648	-0.84	210.67	227.33	0.34	6.37
KZF194601637	-0.81	243.66	260.32	0.34	7.32
KZF194601582	-0.73	215.59	222.45	0.14	6.29
KZF194601640	-0.73	253.51	263.31	0.2	7.45
KZF194601562	-0.61	234.38	240.76	0.13	6.93
KZF194764492	-0.53	247.69	258.47	0.22	7.52
KZF194601592	-0.44	214.24	222.56	0.17	6.58
KZF194602438	-0.18	213.68	220.06	0.13	6.77
KZF194601722	0.11	243.58	251.9	0.17	7.96
KZF194601576	0.17	201.62	213.38	0.24	6.95
KZF194601634	0.17	218.93	242.45	0.48	7.85
KZF194601657	0.23	215.36	224.68	0.19	7.33
KZF194602370	0.26	267.96	279.22	0.23	8.88
KZF194602400	0.33	213.97	223.77	0.2	7.4
KZF194601798	0.41	242.67	265.21	0.46	8.72
KZF194602390	0.46	234.1	242.42	0.17	8.05
KZF194601569	0.68	221.44	235.16	0.28	8.1
KZF194601720	0.76	227.02	229.48	0.05	7.95
KZF194602290	0.76	198.74	215.4	0.34	7.63
KZF194602324	0.76	204.19	224.77	0.42	7.93
KZF194601571	0.82	214.22	229.9	0.32	8.1
KZF194601659	0.86	214.54	227.78	0.27	8.06
KZF194602419	0.92	195.68	205	0.19	7.45
KZF194601646	1.14	234.82	253.92	0.39	9.11
KZF194601563	1.89	237.17	249.91	0.26	9.72

***Note:** experiment date: 2023-12-17/2024-02-04*
***Source:** created by the authors*

The values for ADG vary significantly in growth performance, ranging from 0.02 kg/day to 1.8 kg/day. It's interesting to note that while some steers with greater RFI values shown superior growth, others with negative RFI values had comparatively low ADG. This implies that ADG is not solely determined by feed efficiency as determined by RFI. The variation in growth rates suggests that when assessing growth performance, additional elements including genetics, feed quality, and general animal health must also be taken into account. The DMI values, which range from 6.29 kg/day to 8.72 kg/day, thus lend credence to the notion that growth and feed efficiency are influenced by factors other than feed intake. This highlights how difficult it is to choose animals only on the basis of RFI and implies that in order to maximise cattle productivity, a more thorough approach that takes into account additional physiological and environmental aspects is required.

Thus, the essence of the experiment is to empirically assess the relationship between residual feed intake, average daily weight gain, and dry matter intake in Kazakh white-headed bulls under identical feeding conditions in order to identify animals that convert feed into body weight with optimal efficiency. The main advantage of this feeding strategy, controlled by Vytelle-sense technology, is its ability to identify bulls with negative RFI values that achieve comparable or higher weight gain while consuming less feed, thereby reducing production costs without compromising growth. This method improves economic sustainability, especially on large farms where feed costs account for up to 75% of total production costs. However, a significant drawback is that high-performing bulls do not always demonstrate the most efficient RFI values, as growth results are additionally influenced by genetic, metabolic, and environmental variables. Therefore, although this approach is a reliable selection tool, it should be used in conjunction with comprehensive genetic and phenotypic evaluations. Scalability is ensured by automated monitoring systems that reduce labor intensity and increase accuracy, making it suitable for both industrial and medium-sized enterprises. This strategy facilitates data-driven breeding stock selection, contributing to sustainable improvements in herd productivity and resource efficiency in beef production.

The benefits of this feeding strategy are evident from the data: choosing animals with lower RFI can minimise feed expenses without sacrificing growth. Cattle farming can be made more sustainable by using steers that grow as well or better while consuming less feed. The lack of a distinct, reliable relationship between RFI and ADG, as well as the variation in DMI among steers with comparable RFI values, are additional drawbacks that the findings also highlight. This implies that growth success cannot be predicted just by feed efficiency. This implies that, in order to maximise cow productivity, RFI should be used in conjunction with other elements like genetics, health, and feed quality, even though it is a helpful tool for identifying animals that use feed efficiently. This approach can be applied universally across beef cattle farms, especially those aiming to improve feed efficiency and reduce costs. By selecting animals with lower RFI values, farmers can potentially enhance the profitability of their operations. Furthermore, as the study demonstrates, using advanced technologies like Vytelle-sense for continuous monitoring of RFI, ADG, and DMI can provide more accurate and timely data, allowing for more informed decision-making in breeding programmes. The results underscore the importance of a holistic approach to cattle breeding, one that integrates feed efficiency with other productivity indicators to ensure the sustainable and profitable growth of beef production.

The following results were obtained, which were identical on all four farms: RFI varied on the enterprises from -2 to 2.01; ADG was 0.95 kg; average daily DMI per experimental steer was 11.03 kg/day. The most efficient feed utilisation was in steers with an RFI of -2. A very interesting positive correlation between ADG and DMI indices was found ($P = 0.011$). Thus, it is necessary to conclude that intensive DMI provoked intensive weight gain in steers, with a parallel absence of any correlation between RFI and ADG. The total number of steers with excellent RFI values (those with negative values) was 52, of which 24 had above average daily gain. These 24 steers had DMI which varied from 9.59 to 12 kg/day. Thus, out of 116 experimental bulls only 24 had outstanding RFI and excellent DMI, these experimental bulls can be kept separately to produce progeny with the same performance in future. But also, the range of recorded average daily gains ranged from 0.1 to 1.81 kg/day and the average ADG was 0.95 kg/day. DMI varied from 7.82 kg/day to 13.91 kg/day, with a median value of 11.03 kg/day obtained.

This efficient way of identifying the most cost-effective steers is easy to use in practice, because this Vytelle-sense continuous weight and feed monitoring technology makes it possible to accurately identify representatives of the total cattle breeding herd with the performance required by the company where these animals are reared. Another important positive aspect of using such a system in daily practice is the possibility to do it in a short time. This makes it possible to make accurate weight gain charts and even to forecast the profit made. The system is not labour-intensive and allows the owner to carry out even several such calculation tests per year. A separate positive phenomenon of using such a system is the influence on the qualitative and quantitative composition of the rations, because by calculating the sufficiency of dry matter in the feed and the index breeding value it is possible to adjust the ration to the RFI needs of the animal.

RFI is a moderately inherited measure of feed efficiency, actually a technological index used to select for

more productive beef cattle (Dossybayev *et al.*, 2024). Evaluation of the various weight changes of the animals experimented on, both long term and short term, provided information that steers with low RFI values gave better performance than animals with higher RFI values. Observations of experimental animals gave information that herd members with low RFI values were calmer, rested more, and if these animals did not have the opportunity to lie down, they became restless. Using RFI as a genetic selection tool, it is possible to predict that offspring purchased from cattle with low RFI will eat less without weight loss. In this case, RFI is not related to sex, height, body parameters, quality of carcasses obtained. Calm cattle are an outward sign of low RFI. Unsatisfactory housing and feeding, as well as high density of animals can change these genetic properties. The obtained data suggest that bulls of Kazak Akbas or Kazakh white-headed cattle breed have lower indicators of average daily gain than representatives of other cattle breeds.

This means that improvement of this indicator using RFI as a selection tool will allow reaching the indicators of such breeds as Angus-Hereford or Simmental. Thus, obtaining improved daily weight gain should be seen as the most important objective of breeding programmes that will aim to improve the breeding performance of this breed. But, if Table 6 is scrutinised, it can be seen that DMI for the Kazakh Whitehead cattle breed has advantages over other varieties of beef, dairy, and meat and dairy cattle breeds. There is also noted mutual correlation on ADG and DMI indicators, but complete absence of similar correlation on ADG and RFI indicators. It turns out that outdated concepts that good weight of cattle is an outstanding economic and technological indicator, do not reflect the actual state of modern technology and the efficiency of feed utilisation is much more important in beef cattle breeding. Now technologists in Kazakhstan are faced with the task of breeding temperamentally calm cattle that consume less feed but are feed efficient while spending the least amount of time on feed consumption (Korbych, 2023). The easiest way to achieve this, as practical research has shown, is to select bulls by their RFI. L. Cavani *et al.* (2024) find that RFI has a moderate heritability, with a range of 26% to 58%. This would mean that selected bulls will either consume less feed than unselected bulls while achieving the same ADG, or they will consume more feed but achieve higher ADG. The purpose of such selection is to select animals for beef cattle breeds, but in parallel, according to D.P. Berry *et al.* (2019), the production of greenhouse gases by animals will be reduced. And at the current growth of beef production in Kazakhstan, it can be of great importance.

Data of average daily growth according to L.S. Brunes *et al.* (2021) are a simple mathematical way to check the effectiveness of selected technological strategies. But this method is controversial and cannot be considered in the modern technological process of cultivation as the main argument in the choice of cultivation strategy. These indicators, according to S.R. Chacko Kaitholil *et al.* (2024), depend largely on many factors such as the number of years a farmer has been involved in dairy farming, reduction in the quality and quantity of milk given to calves, the presence of diseases that could be transmitted with this milk, problems of postvaccinal reactions and diseases of contagious and non-contagious aetiology. Technological parameters, according to S.C. Archer (2021), which can also affect the indicators of average daily gains of calves are the time of pre-weaning, as well as technological parameters of cows from which calves were obtained: what weight of the cow was at the first insemination, the number of calvings and the age of the cow, the stability of cow production indicators on a particular farm. The calves that became the object of the study are not much affected by environmental temperature conditions, because their genetic potential made it possible to easily tolerate the climate of Kazakhstan. However, the ambient temperature and when calves were born and developed in the first three months of life should be taken into account when analysing technological indicators. That is, comparing the performance of calves born in winter and summer will be incorrect. The presence of adequate nutrition will influence ADG performance. Thus, ADG is certainly an important technological argument, but should only be considered in conjunction with RFI, as demonstrated in this study.

In addition to the economic costs of raising beef cattle, consumer demand should always be considered. This implies the meat quality requirements of beef cattle. Every large enterprise with a closed cycle of agricultural production has a sales department for finished products and a network of shops. The data obtained in the course of the study emphasise the reliability and stability of the RFI indicator to physiological and technological nuances of production, but the question of how the selection of animals with low RFI affects the quality of meat, how this indicator affects the ratio (or content) of fat in meat, the marbling of meat of elite breeds of cattle should be studied in more detail. It is an indicator of carcass composition and should also be evaluated holistically, because while technological research is important, sales and consumer demand data can be an important economic study of whether the quality of carcasses from cattle with low RFI meets consumer demand.

The use of seemingly simple and modern methods such as Vytelle-sense as well as the data obtained in this study has a drawback. It is that during summer grasing this programme may not be effective. The essence of the research is that all animals receive a certain amount of feed, the qualitative composition of which is known. When grasing, animals consume different quality and quantity of food, so the programme calculations

will be incorrect. The research of this problem is promising. In addition, the use of Vytelle-sense technology with different diets, rather than one diet as in this study, could provide interesting information for research.

CONCLUSIONS

In this study, Vytelle-sense technology was used on the basis of four farms: Zhana Bereke LLP (Akmola Region), Galitskoe LLP (Pavlodar Region), Sabit communal farm (West Kazakhstan Region) and Shalabai LLP (Abai Region). With the help of this technology the data of direct correlation of RFI indicator and ADG indicator with complete absence of correlation of RFI and DMI were obtained. The following results were obtained: RFI indicator varied on the enterprises from -2 to 2.01; ADG indicator was 0.95 kg; average daily DMI intake per experimental steer was 11.03 kg/day. The most efficient feed utilisation was in steers with RFI -2; a positive correlation between ADG and DMI was observed (P = 0.011). The interval of recorded average daily gains ranged from 0.1 to 1.81 kg/day and the mean ADG was 0.95 kg/day. The DMI varied from 7.82 kg/day to 13.91 kg/day and a median value of 11.03 kg/day was obtained.

The experiment shows that choosing cattle according to RFI can lower feed expenses and increase feed efficiency. However, the inconsistent correlation between RFI and ADG implies that RFI is insufficient on its own to forecast growth performance. Other important factors are health, feed quality, and genetics. The intricacy of cattle performance is highlighted by the weak association found between DMI and growth. Therefore, to maximise productivity and guarantee sustainable and economical beef production, a more thorough breeding strategy that incorporates RFI with other parameters is required. To improve selection criteria, future studies should concentrate on determining the physiological and genetic elements that affect growth performance as well as feed efficiency. Furthermore, enhancing beef production methods will need examining the long-term impacts of RFI-based breeding programmes on cow health, meat quality, and environmental sustainability.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST

None.

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Підвищення ефективності використання кормів у казахської білоголової худоби: роль залишкового споживання корму, приросту та споживання сухої речовини

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Анотація. Метою даного дослідження було вивчення впливу залишкового споживання корму на ключові технологічні параметри вирощування казахської білоголової худоби. Експериментальне дослідження проводилося на чотирьох великих племінних підприємствах, що розводять цю породу: товаристві з обмеженою відповідальністю «Жана Береке» (Акмолинська область), товаристві з обмеженою відповідальністю «Галицьке» (Павлодарська область), комунальному господарстві «Сабіт» (Західно-Казахстанська область) та товаристві з обмеженою відповідальністю «Шалабай» (Абайська область). Збір даних та постійний моніторинг здійснювалися за допомогою автоматизованої системи моніторингу худоби, відомої як технологія Vytelle-sense. Після двотижневого періоду адаптації на кожному підприємстві було відібрано 64 бички казахської білоголової породи. Протягом 60 днів проводилися вимірювання залишкового споживання корму, середньодобового приросту ваги та добового споживання сухої речовини. Результати показали, що на всіх чотирьох підприємствах приблизно половина тварин мала від'ємні значення залишкового споживання корму. Середній добовий приріст ваги становив 0,95 кілограма, а середнє добове споживання сухої речовини на бичка — 11,03 кілограма. Була виявлена позитивна кореляція між залишковим споживанням корму та середнім добовим приростом ваги, тоді як значущої кореляції зі споживанням сухої речовини виявлено не було. Биків, які демонструють негативні значення залишкового споживання корму разом з високим споживанням корму, рекомендується відбирати для програм розведення через потенціал генетично сприятливих ознак. Крім того, середній щоденний приріст ваги становив від 0,1 до 1,81 кілограма, а споживання сухої речовини — від 7,82 до 13,91 кілограма на день

Ключові слова: Казахська білоголова порода; технологічні параметри; технологія Vytelle-sense; м'ясне скотарство; спадковість