OnLine Journal of Biological Sciences

Original Research Paper

Effect of Plant-Based Whole Milk Substitute on Calves' Growth Rate

Kulbaram Bayazitova, Ayaz Ramazanov, Tleubergen Bayazitov, Dmitrii Il and Yelena Il

Department of Food Security, Agrotechnological Faculty,
Manash Kozybaev North Kazakhstan University, Petropavlovsk, Kazakhstan

Article history
Received: 10-12-2022
Revised: 06-02-2023
Accepted: 09-02-2023

Corresponding Author:
Dmitrii Il
Department of Food Security, Agrotechnological Faculty, Manash Kozybaev North Kazakhstan University, Petropavlovsk, Kazakhstan
Email: deil@ku.edu.kz

Abstract: One of the tasks of animal husbandry is the development of methods for rearing young animals to obtain healthy calves with specified indicators of productivity and early insemination. The purpose of the study is to evaluate the effect of a plant based whole milk substitute on the growth rate of calves. For the study, three groups of calves of eight heads each were formed according to the principle of analog pairs. The control group was fed with milk according to the scheme adopted on the farm, while the calves of the first and second experimental groups were given a plant based whole milk substitute. 10 mL of vegetable oil per head was added to the whole milk substitute for the first experimental group of calves and they were accustomed to starter compound feed. The average live weight of calves in groups at birth was within 38 kg. At 3 months of age, the weight of the calves of the control group exceeded the weight of the second experimental group by 2.5 kg but was less than the weight of the calves of the first experimental group by 8.3 kg. At the age of 6 months, the weight of calves of the first experimental group was 175.63 kg, which was more than in the control group by 5.13 kg and exceeded the second experimental group by 8.5 kg. With the beginning of receiving a plant based whole milk substitute, the calves' interest in compound feed increased; by the 20^{th} day, calves could eat up to 0.6-0.7 kg of the feed per day, bringing the increase in eating to the 45^{th} day up to 3 kg of compound feed.

Keywords: Growth Rate of Calves, Whole Milk Substitute, Plant Based Feed

Introduction

Animals with a high genetic potential of productivity with unsatisfactory feeding are significantly inferior in live weight gain to animals of the same age with lower productivity inclinations (Ulyanov *et al*., 2021). Researchers study the growth characteristics of heifers and the possibility of their insemination at an early age. However, there is no consensus on the intensity of replacement heifer rearing (Whittier, 2018; Osorio, 2020; Swedzinski *et al*., 2020).

The formation of an animal from the moment of its birth to a highly productive cow must necessarily be carried out according to scientifically sound technology (Aghakhani *et al*., 2022).

Early training of calves to eat concentrated energy feeds contributes to the development of villi, rumen enlargement, intensive development of the skeleton and muscles, as well as thickening of the mucous membrane with simultaneous stimulation of the development of its papillae. The surface of the rumen walls and the suction area increase as well. The resulting fatty acids strengthen the micron basis of the intestinal walls. Starter concentrated feed should contain more than 18% crude protein, 12.5-13 Megajoules (MJ) of Metabolizable Energy (ME), up to 15% crude fat, and up to 10% crude fiber in 1 kg of dry matter (Lopreiato *et al*., 2020).

Some calves start eating a dry starter feed from the age of 7 days. Limiting the supply of whole milk or Whole Milk Substitute (WMS) to calves contributes to early starter feed consumption. It is necessary to wean calves from milk either when they consume 0.5-0.7 kg of starter feed daily, their weight reaches 60 kg, or they reach the age of 28 days (Fallah, 2019).

The rate of development of the digestive organs depends on the correct ratio of nutrients and microelements in the feed so that the villi and microbiota in the calf's rumen actively develop (Stanton, 2009).

In the modern practice of raising calves, the nutritional needs of calves have been widely studied and various WMS types have been proposed based on these studies (Shiasi Sardoabi *et al*., 2021).

The purpose of our study is to evaluate the effect of a plant-based WMS on the growth rate of calves.

Materials and Methods

Study Area and Period

The study was carried out from January to July 2022 at the Poltavskoye LLP (Akkayyn district, North Kazakhstan).

Simmental Cattle

The breeding of Simmental cows is conditioned by the fact that they give a good yield of meat and milk and are less demanding on the conditions of maintenance and care, which is very important for medium sized farms. For Simmental and other breeds of dairy and meat cows with productivity up to six months of age, the average daily weight gain is 800-900 g. At the age of 6-12 months, it equals 750-800 g. At the age of 12-18 months, it amounts to 650-750 g (Kokaeva *et al*., 2020), which ensures the normal development of heifers and an intensive increase in their live weight over age periods, meeting the standard requirements for the formation of high milk productivity of the future cow.

The Simmental breed is one of the oldest in the world. The modern Simmental breed was obtained by Swiss breeders who improved the characteristics of local cattle varieties. The name is associated with the Simme river, on the banks of which the first herds of cattle appeared. Today, the Simmental cow is considered one of the most productive combined varieties of farm animals and is bred on all continents. Due to the good ability of this breed to acclimatize, it has become widespread throughout the world. The color of the breed is fawn, fawn motley, red motley, and red with a white head.

The animals are characterized by a strong constitution and proportional physique. The height at the withers is 135-140 cm, the body length is 160-165 cm and the girth of the metacarpus is 20-21 cm. The head is large with a wide forehead, the chest is deep (with a developed dewlap in bulls), the back is wide, the sacrum is sometimes raised, the muscles are well developed, the skin is thick, the udder is often rounded and the nipples are large. Adult cows weigh 550-650 kg and bulls 900-1,200 kg. The maximum weight of cows reaches 870 kg and bulls 1,300 kg. Among the shortcomings of the physique, there are the incorrect setting of the hind limbs, sagging of the back, poor development of the anterior udder lobes, as well as insufficient development of the chest in width. Cows are not precocious; the first offspring can be obtained at about 2.5 years, but young animals are born large and quickly gain weight (Fig. 1).

Fig. 1: A Simmental cow

The Simmental breed is widespread in the northern regions of Kazakhstan because of its low demands for the conditions of feeding and maintenance. According to the DALRANKR (2022) to date, the number of Simmental cattle in Kazakhstan is 57,871 heads, including 20,894 heads in the North Kazakhstan region. Milk productivity reaches 4 thousand kg with a milk fat content of 3.7-4.1%, depending on optimal conditions of maintenance and full feeding.

Study Sample and Feeding Scheme

The farm has 300 forage cows calving year-round. For the experiment, more than 20 heads of newborn calves were selected from freshly calved cows according to the analog pair principle, healthy, with a live birth weight of about 38 kg, out of which three groups were formed, eight heads each. Animals of all groups were kept in the same conditions of care and daily routine adopted by the farm. The calves were fed according to different schemes. The schemes of calves' feeding are presented in Table 1.

As can be seen from the scheme, during the first week, calves of all three groups were given colostrum in the amount of 6 kg per day. From the second week of life, calves of the control and first experimental groups were given whole milk in the amount of 6 and 5 kg per day, respectively, and calves of the second experimental group were given WMS in the amount of 5 kg per day.

In the control group, the calves were fed with Neomilk WMS (Maslosyrkombinat Tyukalinsky LLC) and in the experimental groups, the calves were given the WMS prepared at the farm using the MFU-200 (multifunctional device) equipment (Agrostimul LLC, Russia) (Fig. 2) according to a certain scheme from fillers produced on the farm. Besides that, vegetable oil in the amount of 10 mL per head per day was added to the WMS for the first experimental group of calves.

The above equipment is equipped with four levels of grinding of organic material from 0.001- 20 microns for the production of WMS from plant-based raw materials for young cattle. Such milk does not transmit diseases from the cow to the calf. For the calf's gastrointestinal tract to develop faster, all substances in the WMS undergo hydrolysis: Starches and polysaccharides break down to glucose and galactose, as in cow's milk, and protein to a protein, peptide, and amino acid mixture (Jongman *et al*., 2020; Park *et al*., 2022). The cooking process takes from 30-60 min.

According to the calves' feeding scheme (Table 1), in the control group, calves were given 70 kg more whole milk than in the first experimental group and 210 kg more than in the second experimental group. The calves of the control group were fed with a WMS from the age of 7 weeks at 6 kg per head per day (the WMS was diluted in a ratio of 1:10). The first experimental group received for 5 weeks 182 kg of whole milk and the age of 6-13 weeks; the calves were fed with a WMS in the amount of 280 kg.

The calves of the II experimental group were fed with colostrum during the first week, from calving adult cows, and from the second week to 7 weeks of age, they received a WMS with a total amount of 210 kg. In the experimental groups, WMS was prepared in a ratio of 1.2:10. The feeding scheme was aimed at using a limited amount of whole milk. Hay was introduced into the diet of calves of all groups from the age of 10 days and at the same age, starter feed was also included in the diet (Table 2).

The nutritional value of 1 kg of starter concentrate is (g): Crude protein 165.3; digestible protein 116; crude fat 55.9; crude fiber 99.7.

Calculation of Indicators

The growth and development indicators of calves were determined by individual weight measurements, based on which the absolute and average daily increase in live weight was calculated (Cramer and Ollivett, 2020).

Absolute gain is understood as an increase in live weight or measurements of young animals for a certain period (day, decade, month, year), expressed in kg and cm. The absolute gain of animals is the difference between the final and initial body weight:

$$A = W_1 - W_0 \quad (1)$$

Fig. 2: MFP-200 equipment for the preparation of WMS

Table 1: Calves feeding scheme

Group								
Control			1st experimental			2nd experimental		
	Amount of milk (kg)			Amount of milk (kg)			Amount of milk (kg)	
Week of life	Colostrum + milk	WMS	Week of life	Colostrum + milk	WMS	Week of life	Colostrum	WMS
1	Colostrum 6		1	Colostrum 6		1	6	–
2	6		2	5		2		5
3	6		3	5		3		5
4	6		4	5		4		5
5	6		5	5		5	–	5
6	6		6	–	5	6	–	5
7	–	6	7	–	5	7	–	5
8	–	6	–	–	5	–	–	–
9	–	6	–	–	5	–	–	–
10	–	6	–	–	5	–	–	–
11	–	6	–	–	5	–	–	–
12	–	6	–	–	5	–	–	–
13	–	6	–	–	5	–	–	–
Total	252	294		182	280		42	210

Table 2: The technology of preparation of starter concentrate for feeding calves, %

Ingredients	%
Coarse corn grain	30.00
Flattened oat grain	20.00
Protein concentrate	20.00
Flaxseed flour	10.00
Wheat bran	10.00
Polysaccharide	5.00
Chalk	0.15
Mineral supplement	0.15
Magnesium oxide	0.02
Iodized salt	0.08
Vitamin A, D, E	0.02

The absolute average daily increase in live weight is calculated by the formula:

$$A = \frac{w_1 - w_0}{t} \quad (2)$$

where, A is the absolute average daily gain; W_1 is the final live weight; W_0 is the initial live weight; t is time.

The absolute gain in body weight per unit of time does not characterize the true growth rate. For this purpose, the relative increase is calculated, which is expressed as a percentage and calculated using the brody formula:

$$K = \frac{w_1 - w_0}{0.5 \times \left(w_1 + w_2\right)} \times 100\% \quad (3)$$

To calculate the economic efficiency, the indicators of consumption of milk, WMS, and compound feed for 6 months were taken. The cost of milk for all groups was 180 tenges and the WMS in the control group cost 600 tenges. In the first experimental group, it cost 210 tenges since vegetable oil was added in the amount of 10 g of 20 tenges, and in the second group 190 tenges. The dollar-to-tenge exchange rate amounted to 468.2 tenges. The price of 1 kg of compound feed in the control group was 370 tenges and in the experimental group 148 tenges. Let us determine the cost of 1 kg of weight gain:

$$C = \frac{H}{G} \quad (4)$$

where, C is the cost of 1 kg of increment, tenge; H is the cost of milk, WMS, and compound feed, tenge; G is the gross gain, kg.

Statistical Analysis

The obtained study results were processed using the method of variational statistics. All data were statistically processed and presented in the form of the arithmetic Mean (M) and arithmetic mean error (m) (Sokolov *et al*., 2018).

Results

The obtained data on the live weight of experimental calves indicate the availability of feed to them and the nutritional value of the feed (Table 3).

The average weight of calves in the groups at birth was about 38 kg. At the age of 3 months, the weight of the calves of the control group exceeded the weight of the second experimental group by 2.5 kg but was less than the weight of the calves of the first experimental group by 8.3 kg. At 6 months, the weight of calves of the first experimental group was 175.63 kg, which was more than in the control group by 5.13 kg and exceeded the second experimental group by 8.5 kg. The probability threshold is $p<0.95$. The data showing changes in live weight are presented in Fig. 3.

Based on Table 3 and Fig. 3, we can conclude that the first experimental group scored more than the second experimental and control groups in all indicators. Therefore, the early transition of the second experimental group to WMS influenced the growth dynamics of these calves. The reliability of the difference in the weight of calves at 3 months of age between the control and the first experimental is $p>0.999$.

The increase in the live weight of calves by growing periods is shown in Table 4 and Fig. 4.

Table 3: Change in live weight of calves with age, kg (M ± m)

	Live weight indicators (kg)		
Age of calves	Control	1st experimental	2nd experimental
At birth	38.13±0.61	38.01±0.910	38.00±0.870
3 months	103.00±1.53	111.13±4.620	100.50±1.160
6 months	170.50±1.05	175.63±3.730	167.13±6.800

Table 4: Live weight gain of calves by growing periods, kg (M ± m)

	Live weight indicators (kg)		
Age of calves	Control	1st experimental	2nd experimental
0-3	64.88±0.9400	73.13±4.3300	62.50±1.750
3-6	67.50±2.1700	64.50±0.9400	66.63±6.270
0-6	132.28±1.1300	137.63±3.6700	129.13±7.560

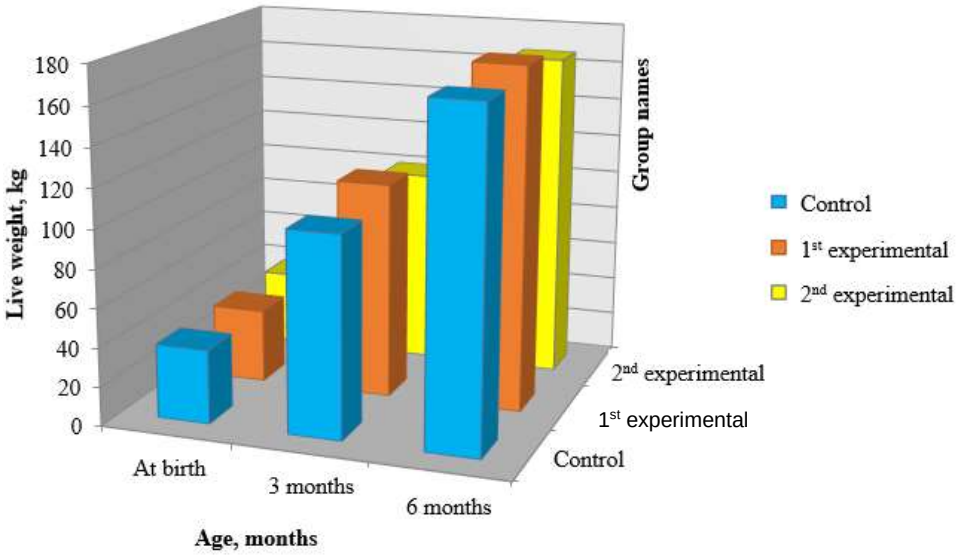

Fig. 3: Change in live weight of calves with age, kg

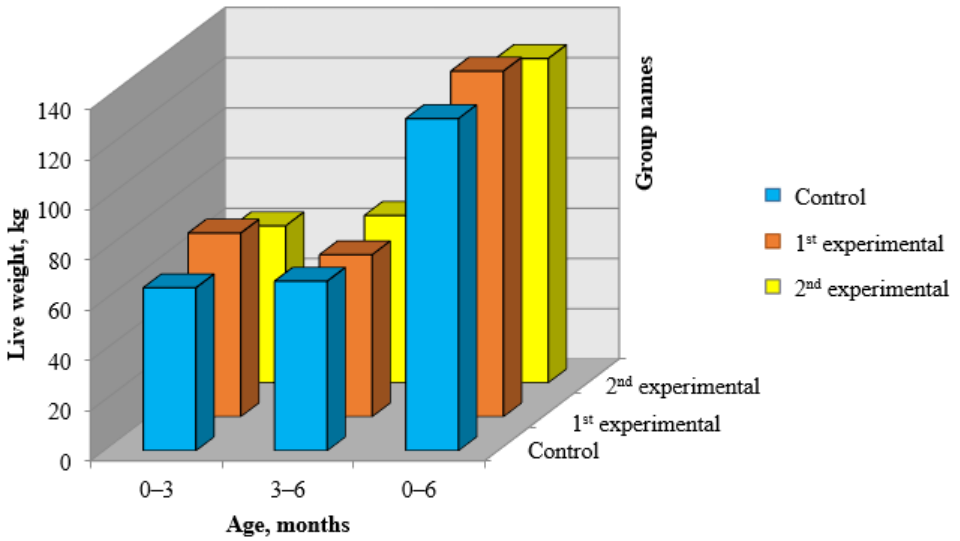

Fig. 4: Live weight gain of calves by growing periods, kg

In some periods of life, the live weight gain of heifers did not show significant differences between the groups. However, for the period from birth to 3 months, the heifers of the first experimental group showed somewhat better results than the control group and the second experimental group, scoring more by 8.25 kg ($p>0.95$) and 10.63 kg ($p>0.95$), respectively. At the age of 3 to 6 months, the calves of the control group were slightly ahead of the experimental groups by 3.0 kg ($p<0.95$) and 0.87 kg ($p<0.95$), respectively. Despite this, the advantage for the entire growing period from 0-6 months of age remains with the calves of the first experimental group, with a difference from 5-8.5 kg at $p<0.95$.

The essence of the application of the early transition of calves to WMS is that the newborn animal feeds on high quality hay and grain concentrates, which provoke rumen development.

Table 5 and Fig. 5 show the average daily weight gain of calves.

The development of heifers is characterized by a change in the value of the average daily weight gain. The difference in the average daily gain in the first three months of calves' life with statistical reliability $p>0.999$ between the control and first experimental groups was 91.17 g with the advantage of experimental calves; between the control and second experimental groups, the difference was 26.83 g in favor of control calves at $p<0.95$.

A more objective judgment about the speed of calves' growth and its intensity is shown by indicators of the relative growth rate (Table 6, Fig. 6).

The relative growth rate in the period from birth to 3 months of age in the first experimental group compared with the control group was higher by 6.1%, at $p<0.95$. The second experimental group had a lower growth rate compared to the control group of 1.71% in the absence of a significant difference.

At the age of 3-6 months, the second experimental group showed a higher growth rate than the first two groups of calves; the difference amounted to 7.54 and 3.94, respectively.

From birth to 6 months of age, the higher growth rate remained in the first experimental group, where the calves started receiving a plant-based WMS from 6 weeks of age. The difference with the control group was 7.1% ($p>0.999$) and with the second experimental group 3.5% ($p<0.95$), respectively. Thus, the transfer of calves to a plant-based WMS with the addition of vegetable oil at the age of 6 weeks gave a good effect.

The economic efficiency of the dairy cattle industry largely depends on the intensity of growth of replacement heifers. One of the main tasks of dairy cattle breeding is to reduce the cost of raising calves and milk production (Table 7).

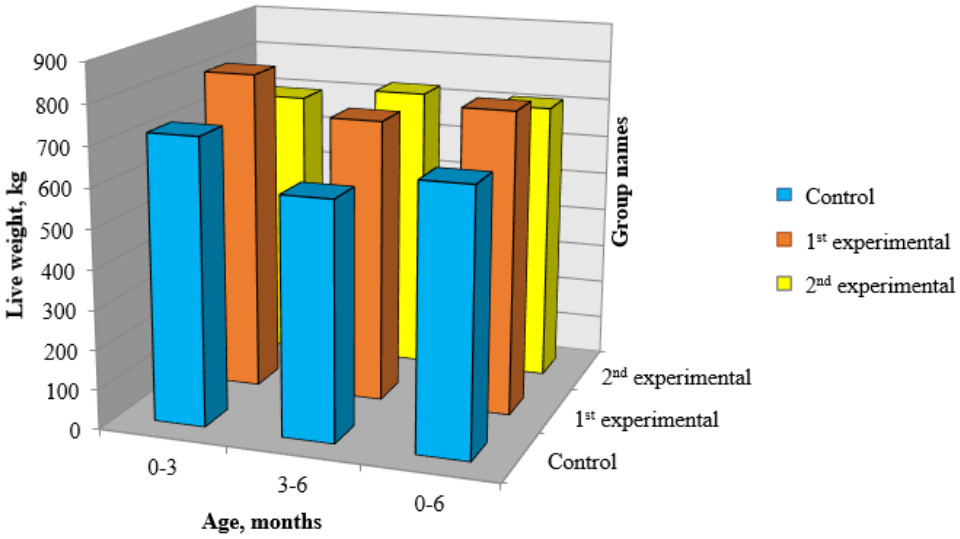

Fig. 5: Average daily gain in live weight of calves by age periods, g

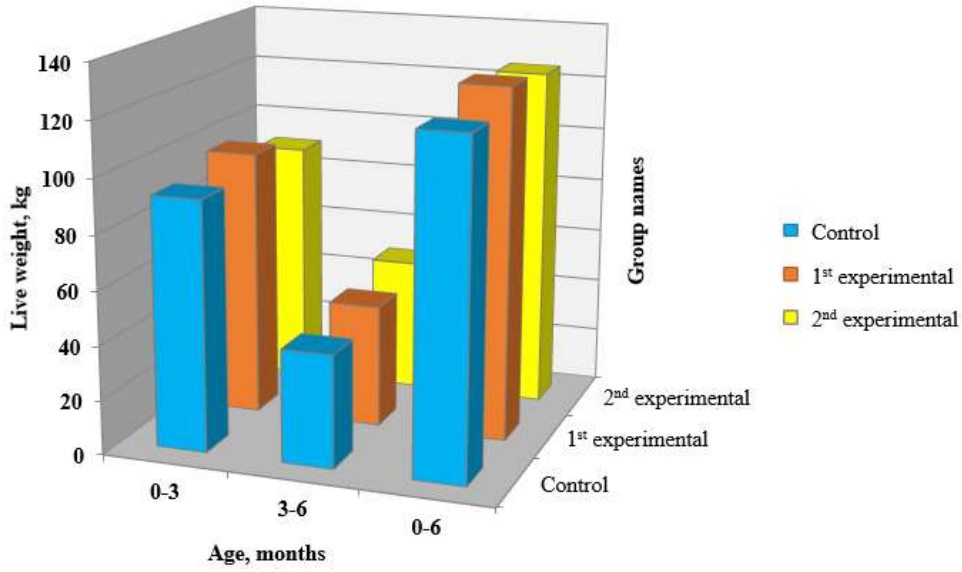

Fig. 6: Relative growth rate by life periods, %

Table 5: The average daily gain in live weight of calves by age periods, g (M ± m)

	Live weight indicators (g)		
Age of calves	Control	1st experimental	2nd experimental
0-3	720.83±13.030	812.00±25.330	694.44±15.00
3-6	598.00±22.620	716.67±12.600	726.39±33.03
0-6	659.50±12.690	764.38±23.990	710.25±36.58

Table 6: Relative growth rate by life periods, % (M ± m)

	Group		
Age of calves	Control	1st experimental	2nd experimental
0-3	91.94±1.45	98.02±1.72	90.23±1.310
3-6	41.46±4.74	45.06±1.00	49.00±1.770
0-6	121.80±1.04	128.90±1.12	125.40±1.550

Table 7: Economic efficiency of raising calves to 6 months of age

	Group		
Indicator	Control	1st experimental	2nd experimental
Expenditure			
Milk, kg	252.0	182.0	42.0
WMS, l	294.0	280.0	210.0
Compound feed, kg	170.0	187.0	220.0
Cost of 1 kg of compound feed	370.0	148.0	148.0
Cost of 1 kg of milk, tenge	180.0	180.0	180.0
Cost of 1 l of WMS	600.0	210.0	190.0
Weight gain, kg	132.3	137.6	129.1
Cost of the consumed milk, tenge			
Milk, tenge	43,360.0	32,760.0	7,560.0
WMS, tenge	176,400.0	58,800.0	39,900.0
Compound feed, tenge	62,900.0	27,676.0	32,560.0
Total costs, tenge	294,490.0	119,236.0	80,020.0
Cost per 1 kg of weight gain, tenge	2,141.4	866.5	618.8

Table 7 presents data on the consumption and cost of feed: Milk, WMS, and compound feed when growing heifers. The lowest cost of 1 kg of growth over the entire growing period was noted in the second experimental group where the difference from the control group was 1,522 tenges and the difference from the first experimental group equaled 248 tenges.

Discussion

The data of the conducted studies in the conditions of the North Kazakhstan region prove the advisability of using a plant-based WMS when raising calves. The conditions of maintenance and the composition of the basic diet of all groups of animals were relatively the same. Intensive rearing of young animals in the first months of life depends more on the proper organization of their feeding and maintenance. In the first decades of life, the main food for calves is milk. Therefore, it is very important to ensure its supply following the needs of a growing organism (Liu *et al*., 2021).

In the first 2 h after birth, the calf needs to drink 3-4 l of colostrum. It contains several times more dry matter, protein, and immunoglobulins than milk (Ma *et al*., 2021). In our studies, in the first 7 days of life, all calves received 6 l of colostrum in the diet.

The use of a WMS of plant origin prepared with the use of MFP-200 equipment in the diet of calves made it possible to obtain gains that are not inferior to the growth of calves fed with natural milk in the amount of 252 kg. Data from literary sources (Lehenbauer, 2014; Ban and Guan, 2021; Ma *et al*., 2021) indicate the benefits of early use of WMS and starter feed in calf feeding.

On dairy farms, it is common practice to wean calves from their mother shortly after birth. This usually occurs within 6-24 h after calving. It is believed that early weaning of a calf reduces the risk of transmission of diseases from cow to calf (for example, John's disease, cryptosporidium). Grain and concentrate consumption is also lower in dairy fed calves (Verdon and Tilbrook, 2021).

Scientists recommend early weaning as the best practice, which promotes early eating of coarse feed, accelerates rumen development, and minimizes labor and feed costs. Calves consume a large amount of dry food when they stop having milk, which led to the accumulation of dry matter and body weight gain (Wilms *et al*., 2022).

It was proved that calves who received a limited dairy diet digested coarse feed more efficiently in the future. Thus, calves are more effectively fed with a limited amount of milk and consume more coarse feed, which is associated with rumen development. The practice of restricted milk feeding promotes earlier consumption of coarse feed and rumen development, which facilitates weaning at an early age (often up to 2 months of age; the United States Department of Agriculture (USDA), 2016). In addition, feeding a limited amount of milk (<6 l/day) is known to affect the size of the rumen and the development of rumen papillae. In general, there is more information indicating that a limited dairy diet at an early age can have important consequences for calves (Cantor *et al*., 2019).

If the correct technology is followed, it is possible to get a rumen of an adult animal in a calf at the age of three months. To do this, in the first three weeks it is important to introduce pre-starter feeds into the diet, stimulating early feed intake and the development of rumen walls and microflora in it. From the age of five days, the consumption of starter feed should be unlimited, and from 14 days so does the consumption of water. The calf stops receiving milk when the starter feed consumption reaches 1.5 kg with a live weight of 60 kg in calves and at least 70 kg in heifers (Osorio, 2020).

Our research in the production environment also confirms this advantage. Thus, the growth of calves over the entire period of rearing young animals in the first experimental group was 137.6 kg and the control group (132.3 kg) occupied an intermediate position between the two experimental groups. The calves of the second experimental group, whose weight gain was about 129.1 kg, did not have enough nutrients for a larger weight gain. This shows that it is necessary to increase protein content in the diet.

Economic calculations show that the efficiency of rearing replacement heifers with the use of a plant-based WMS and compound feed prepared according to a special recipe of technology on farm feed, remains at a fairly high level, that is, 2 times higher than the aforementioned group (Silva and Bittar, 2019; Hendricks *et al*., 2022; Wilms *et al*., 2022).

Conclusion

The growth of calves in the first experimental group was 4.52 kg higher compared to the calves of the control group and 5.7 kg higher than in the second experimental group. The cost of 1 kg of growth with a slight difference in growth in calves of all groups has a high economic effect. The difference between the first experimental group of calves and the control group was 1,522 tenges and the difference between the first and the second experimental group was 248 tenges.

The whole milk substitute, prepared according to the technology on the farm, allows for earlier habituation and adaptation of the gastrointestinal tract to the consumption of plant-based feed and better digestion of the nutrients of the diet in subsequent age periods.

Acknowledgment

The paper was published based on the results obtained during the performance of applied research in the field of the agro-industrial complex under the scientific and technical program "Development of technologies for keeping, feeding, growing and reproduction in dairy cattle breeding based on the use of adapted resource-energy-saving and digital technologies for various natural and climatic zones of Kazakhstan" for 2021-2023 under budget program No. 267 "increasing the availability of knowledge and scientific research" under subprogram 101 "Program targeted financing of scientific research and activities".

Author's Contributions

All authors equally contributed to this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues are involved.

References

Aghakhani, M., Shahraki, A. D. F., Tabatabaei, S. N., Toghyani, M., & Rafiee, H. (2022). Cow-level factors associated with colostrum yield and quality of Holstein dairy cows. *Animal Production Science*, *62*(15), 1518-1526. https://doi.org/10.1071/AN21415

Ban, Y., & Guan, L. L. (2021). Implication and challenges of direct-fed microbial supplementation to improve ruminant production and health. *Journal of Animal Science and Biotechnology*, *12*(1), 109. https://doi.org/10.1186/s40104-021-00630-x

Cantor, M. C., Neave, H. W., & Costa, J. H. (2019). Current perspectives on the short-and long-term effects of conventional dairy calf raising systems: A comparison with the natural environment. *Translational Animal Science*, *3*(1), 549-563. https://doi.org/10.1093/tas/txy144

Cramer, C., & Ollivett, T. L. (2020). Behavior assessment and applications for BRD diagnosis: Preweaned dairy calves. *Animal Health Research Reviews*, *21*(2), 188-191. https://doi.org/10.1017/s1466252320000213

DALRANKR. (2022). Official website. Department of Agriculture and Land Relations of the Akimat of the North Kazakhstan region. https://www.gov.kz/memleket/entities/sko-agro/activities/directions?lang=ru

Fallah, R. (2019). Effects of adding whey and molasses on corn silage quality, growth performance, and health of Simmental fattening calves. *Journal of Livestock Science*, *10*(2), 91-96. https://doi.org/10.33259/JLivestSci.2019.91-96

Hendricks, J., Weary, D. M., & von Keyserlingk, M. A. (2022). Veterinarian perceptions on the care of surplus dairy calves. *Journal of Dairy Science*, *105*(8), 6870-6879. https://doi.org/10.3168/jds.2022-22051

Jongman, E. C., Conley, M. J., Borg, S., Butler, K. L., & Fisher, A. D. (2020). The effect of milk quantity and feeding frequency on calf growth and behaviour. *Animal Production Science*, *60*(7), 944-952. https://doi.org/10.1071/AN19049

Kokaeva, M. G., Temiraev, R. B., Dzhaboeva, A. S., Osikina, R. V., Gazzaeva, M. S., Shugusheva, L. H., ... & Efendiev, B. S. (2020). Method for increasing the ecological and food values of milk and dairy products. *Journal of Livestock Science*, *11*(1), 14. https://doi.org/10.33259/JLivestSci.2020.14-19

Lehenbauer, T. W. (2014). Control of BRD in large dairy calf populations. *Animal Health Research Reviews*, *15*(2), 184-185. https://doi.org/10.1017/s146625231400022x

Liu, W., La, A. L. T. Z., Evans, A., Gao, S., Yu, Z., Bu, D., & Ma, L. (2021). Supplementation with sodium butyrate improves growth and antioxidant function in dairy calves before weaning. *Journal of Animal Science and Biotechnology*, *12*, 1-9. https://doi.org/10.21203/rs.3.rs-25876/v3

Lopreiato, V., Mezzetti, M., Cattaneo, L., Ferronato, G., Minuti, A., & Trevisi, E. (2020). Role of nutraceuticals during the transition period of dairy cows: A review. *Journal of Animal Science and Biotechnology*, *11*(1), 1-18. https://doi.org/10.1186/s40104-020-00501-x

Ma, T., McAllister, T. A., & Guan, L. L. (2021). A review of the resistome within the digestive tract of livestock. *Journal of Animal Science and Biotechnology*, *12*(1), 1-20. https://doi.org/10.1186/s40104-021-00643-6

Osorio, J. (2020). Gut health, stress and immunity in neonatal dairy calves: The host side of host-pathogen interactions. *Journal of Animal Science and Biotechnology*, *11*(1), 1-15. https://doi.org/10.1186/s40104-020-00509-3

Park, T., Ma, L., Gao, S., Bu, D., & Yu, Z. (2022). Heat stress impacts the multi-domain ruminal microbiota and some of the functional features independent of its effect on feed intake in lactating dairy cows. *Journal of Animal Science and Biotechnology*, *13*(1), 1-15. https://doi.org/10.1186/s40104-022-00717-z

Shiasi Sardoabi, R., Alikhani, M., Hashemzadeh, F., Khorvash, M., Mirzaei, M., & Drackley, J. K. (2021). Effects of different planes of milk feeding and milk total solids concentration on growth, ruminal fermentation, health and behavior of late weaned dairy calves during summer. *Journal of Animal Science and Biotechnology*, *12*, 1-16. https://doi.org/10.1186/s40104-021-00615-w

Silva, F. L. M., & Bittar, C. M. M. (2019). Thermogenesis and some rearing strategies of dairy calves at low temperature-a review. *Journal of Applied Animal Research*, *47*(1), 115-122. https://doi.org/10.1080/09712119.2019.1580199

Sokolov, I. D., Sokolova, E. I., Troshin, L. P., Medved, O. M., Koltakov, O. M., & Naumov, S. Yu. (2018). Biometriya: Uchebnik [Biometrics: Textbook]. KubGAU, Krasnodar. http://lnau.su/wp-content/uploads/2021/04/4.-biometriya.pdf

Stanton, A. (2009). Challenges and opportunities for managing respiratory disease in dairy calves. *Animal Health Research Reviews*, *10*(2), 113-115. https://doi.org/10.1017/S1466252309990132

Swedzinski, C., Froehlich, K. A., Abdelsalam, K. W., Chase, C., Greenfield, T. J., Koppien-Fox, J., & Casper, D. P. (2020). Evaluation of essential oils and a prebiotic for newborn dairy calves. *Translational Animal Science*, *4*(1), 75-83. https://doi.org/10.1093/tas/txz150

Ulyanov, V. A., Kubekova, B. Z., Beishova, I. S., Belaya, A. V., & Papusha, N. V. (2021). Preferred and undesirable genotypes of bGH and bIGF-1 genes for the milk yield and quality of black-and-white breed. *Veterinary World*, *14*(5), 1202. https://doi.org/10.14202/vetworld.2021.1202-1209

Verdon, M., & Tilbrook, A. (2021). A review of factors affecting the welfare of dairy calves in pasture-based production systems. *Animal Production Science*, *62*(1), 1-20. https://doi.org/10.1071/AN21139

Whittier, J. C. (2018). How we got to now in food animal agriculture: animal science innovations that made the modern world in the West. *Translational Animal Science*, *2*(suppl_1), S1-S8. https://doi.org/10.1093/tas/txy067

Wilms, J. N., Ghaffari, M. H., Steele, M. A., Sauerwein, H., Martín-Tereso, J., & Leal, L. N. (2022). Macronutrient profile in milk replacer or a whole milk powder modulates growth performance, feeding behavior and blood metabolites in ad libitum-fed calves. *Journal of Dairy Science*, *105*(8), 6670-6692. https://doi.org/10.3168/jds.2022-21870