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COMPARATIVE STUDY ON HOLSTEIN CALVES FEEDING TECHNOLOGY

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Abstract

The Holstein-Friesian breed is the best known and most representative breed that produces large quantities of the best quality milk. A healthy Holstein calf weighs 40 kg at birth. Holstein bulls can weigh up to 1180 kg. The growth and development of calves are influenced by environmental conditions, but also by feed. For this study, the calf breeding group from the 0-3 months category was used. Calves were tested from a nutritional point of view, both in terms of the lactating diet and the concentrate mixture at different protein levels. The consumption of the mixture of concentrates per animal was measured, following the development of calves in this category and metabolic problems. The rations were differentiated by protein level. It was found that there are statistically significant differences in feed consumption due to the different ratios applied and the type of milk administered according to the feeding schedule.

***Key words**: calf, cow, diet, feed ingredients, milk, substituent.*

INTRODUCTION

Raising animals has been one of the most important activities of man, from ancient times to the present day. Among them, raising dairy cows is one of the most important sectors in raising and exploiting farm animals.

The Holstein breed is a breed of cattle, exploited for milk production, bearing different names depending on the country in which it is raised (for example: Holstein (Dutch Frieze), Canadian Friesian cattle, Israeli Holstein, American Friesian, Romanian Black Spotted). In Romania, the breed was imported and participated in the formation of the Romanian Black Spotted breed. It is a breed that is suitable for both the intensive exploitation system (Figure 1), and the extensive exploitation system and has a good resistance to leucosis disease.

Successful calves production, especially the management of dairy calves, is a key point for the profitability and sustainability of the dairy industry (Khan et al., 2016).

Calves feeding also has a key role. In the first months of life, the calf has to deal with three challenges: extra-uterine life, maintaining the prolonged pre-ruminant stage and weaning (Ignatescu (Timpau) et al., 2018).

It is important that new-born calves receive adequate colostrum intake as soon as possible after calving. Immunoglobulin concentration and intestinal permeability decrease rapidly in the first 24 hours after calving (Moore et al., 2005). The colostrum, the neonates first milk, is rich in nutrient and biologically active elements. Colostrum feeding has a major impact on post-natal development (Blum & Hammon, 2000).

After colostrum, milk or milk replacer containing high-protein should be preferred in feeding of Holstein calves, during the suckling period (Bayril et al., 2016).

The amount of milk and the feeding regime are different depending on the size of dairy cattle farms (Irimia et al., 2021).

Adherence to feeding procedures in the first part of life leads to obtaining healthy animals that are able to produce viable offspring and milk production (Dorobat et al., 2018).

Two to three weeks can make all the difference when it comes to developing the rumen and calf to be physically able to cope with weaning. Regardless of the nutrition received by a calf, when weaning is done early (at the age of 6 weeks), it struggles to cope with new nutritional changes, compared to a calf that is weaned at 8 or 9 weeks.

Figure 1. Feeding front of dairy cows (Original photo)

Mainly, young calves metabolize carbohydrates in the lower intestine, a function that decreases naturally at weaning. But the transition to carbohydrate metabolism in the rumen begins when the calf is 8 or 9 weeks old, regardless of previous diet. The starter consumed before this date results in the filling of the intestine compared to the real growth, because the rumen is not prepared to deal with high levels of cereals or fiber. Cows at the age of 8 or 9 weeks have a greater ability to consume and properly metabolize the initiator needed to meet nutritional needs. The physical size of the rumen is larger, the composition of the rumen microbiome is more diverse and mature, and there are several rumen tissues available for the absorption and metabolism of early feed.
When calves are weaned too early, the result is often a gap in the gut's ability to absorb and metabolize the original diet, and calves often experience a post-weaning increase. The microbiome of a 6-week-old calf is also very different from that of an 8- or 9-week-old calf. Research has shown that delaying the transition from a dairy diet to an exclusively solid diet (weaning) has reduced the severity of the microbiome change.
Calves weaned at eight weeks experienced a more gradual change in the microbiota than calves weaned at six weeks.
The transition from milk to solid feed can be a shock to a calf, so the slower the transition, the smaller the shock. A gradual transition allows the calf to slowly increase its initial intake of solid feed as milk intake decreases, maintaining an optimal nutrient range (Sharma et al., 2019).

MATERIALS AND METHODS

For this study, the growth group from the 0-3 months category was used, a group that was nutritionally tested both from the point of view of the lactating diet and the concentrate mixture at different protein levels.
Following the development of calves in this category and metabolic problems, the rations were differentiated by protein level (Figure 2).
The biological material consisted of 90 bulls aged between 3 and 6 weeks. The subdivision was made according to age, as follows:
- Lot 1 was composed of calves aged between 3 and 4 weeks, and within the group 3 groups were formed, 10 calves each;
- Lot 2 was composed of calves aged between 4 and 5 weeks and 3 groups within the lot;
- Lot 3 was composed of calves over 6 weeks old and the same as in the case of the first and second lots; 3 groups were formed within the lot.

Regarding the feed, the experimental plan considered the use of 3 types of rations, as follows:
- Group 1 in each lot received the A1 ratio (23.96% protein level in the concentrated mixture);
- Group 2 in each lot received the A2 ratio (17.90% protein level in the concentrated mixture);
- Group 3 in each lot received the A3 ratio (15.36% protein level in the concentrated mixture).

Figure 2. Overview of the calf rearing area (Original photo)

In order to have a statistical validation and to be able to say exactly whether or not there are significant differences in the intake of bulls from the three groups that received the 3 ratios, two statistical tests were used, Student and Fisher Tests.
The Student test was calculated according to the following formula (Sandu, 1995):

$$\hat{t} = \frac{\bar{X}_1 \cdot \bar{X}_2}{\sqrt{\frac{(\sum X_1^2 + \sum X_1^2)\cdot(n_1+n_2)}{(n_1+n_2-2)\cdot(n_1 \cdot n_2)}}} \qquad (1)$$

The Fisher test was calculated by ANOVA (Analysis of Variance) (Sandu, 1995) (Table 1).

Table 1. Analysis of Variance (ANOVA) parameters

Source of Variation	DF	SS	MS	F
Between Groups (I)	$DF_I = n-1$	$SS_I = \sum C - \sum TC$	$MS_I = SS_I / DF_I$	
Within Groups (i)	$DF_i = p-1$	$SS_i = \sum X^2 - \sum TC$	$MS_i = SS_i / DF_i$	$F = MS_I / MS_i$
Total	$DF_T = N - 1$	$SS_T = \sum X^2 - \sum C$		

NB: n - the total number of individuals in a group, p-the number of groups; N - the number of individuals; DF – degrees of freedom; SS – sum of square; MS – mean of squares; ∑C – sum of corrections; ∑TC – sum of total corrections; $\sum X^2$ – the sum of the values squared.

Nutrition is, according to Georgescu (1998), the most important technological link in calf rearing.

The calves were analysed over a period of three weeks, each mixture of concentrate being administered for one week. The differences consist in the protein level of the concentrate mixture on feeding schedule with a colostrum administration and a staged passage in 3 days:

- 2/3 colostrum milk 1/3 milk substitute day 1;
- 1/2 colostrum and 1/2 milk substitute day 2;
- 1/3 colostrum and 2/3 milk substitute day 3.

From the fourth day, only the milk substitute was administered (Table 2).

Powdered milk has been used as a substitute to avoid fluctuations in whole milk fat and calves metabolic problems. Whole milk fat is a limiting factor for ingestion and can cause gastrointestinal upset. The colostrum and milk substitute feeding schedule of calves was used for a period of 70 days (Table 3).

Table 2. Milk substitute composition

Analytical components	Value	Unit
Skimmed milk powder	50	%
Start+ safety concept	included	
Crude protein	22	%
Crude fat	17	%
Crude Ash	7.7	%
Crude fiber	0	%
Calcium	1	%
Phosphorus	0.8	%
Sodium	0.7	%
Vitamin A	25000	IU/kg
Vitamin D3	5000	IU/kg
Vitamin E	150	mg/kg
Iron sulphate	100	mg/kg
Copper sulfate	9	mg/kg
Zinc sulfate	100	mg/kg
Manganous sulphate	30	mg/kg
Calcium iodate	1	mg/kg
Sodium selenite	0.2	mg/kg
Zinc-L-selenomethionine	0.1	mg/kg
Bacillus subtilis DSM 5750	1.3×10^9	CG+FU/kg

Table 3. Colostrum and milk substitute feeding schedule (quantity and meals number/day)

Age	Colostrum		Milk substitute	
	Quantity (l)	Meals (no.)	Quantity (l)	Meals (no.)
0-3 days	3.5-4	1	6	3
4-18 days	-	-	6	2
19-53 days	-	-	8	2
54-60 days	-	-	6	2
61-65 days	-	-	3	1
66-70 days	-	-	1.5	1

In the experimental period, in each lot, the first group of calves received a mixture of concentrate with a protein content of 23.96% (A1); the second group received a mixture of concentrate with a protein content of 17.90% (A2), and the third group received a mixture of concentrate with a protein content of 15.36% (A3). The mixture of concentrates was distributed *ad libitum*, and the consistency and size of the particles were similar.

The raw materials used and their percentages in composing of the experimental recipes A1, A2 and A3, are presented in Tables 4-6.

Ratio A2 is characterized by a mixture of medium protein concentrate from both high-quality protein sources such as soybean meal and lower protein such as soybean peel (which has a lower protein content and digestibility than soybean meal).

Table 4. Structure of A1 ratio

Raw materials	Quantity (kg)	%
Maize	370.00	37.00
Soybean meal	158.00	15.80
Lucerne hay	200.00	20.00
Rapeseed meal	240.00	24.00
Premix starter	20.00	2.00
Calcium carbonate	10.00	1.0
Salt	2.00	0.2
Total	1000.00	100.00

Table 5. Structure of A2 ratio

Raw materials	Quantity (kg)	%
Maize	300.00	30.00
Soybean peel	250.00	25.00
Soybean meal	200.00	20.00
Lucerne hay	80.00	8.00
Rapeseed meal	80.00	8.00
Triticale	60.00	6.00
Premix starter	20.00	2.00
Calcium carbonate	6.00	0.60
Salt	4.00	0.40
Total	1000.00	100.00

Table 6. Structure of A3 ratio

Raw materials	Quantity (kg)	%
Maize	270.00	27.00
Soybean peel	220.00	22.00
Triticale	200.00	20.00
Soybean meal	120.00	12.00
Lucerne hay	80.00	8.00
Rapeseed meal	80.00	8.00
Premix starter	20.00	2.00
Calcium carbonate	6.00	0.60
Salt	4.00	0.40%
Total	1000.00	100.00

Ratio A3 is characterized by a mixture of low protein concentrate from both high-quality protein sources such as soybean meal, and lower protein such as soybean peel (which has a lower protein content and digestibility than soybean meal) with a higher weight of soybean peel versus mixed soybean meal.

RESULTS AND DISCUSSIONS

Three ratios (A1, A2, A3) were administered for each group of calves, and was followed the individual ingesta during experimental period. For a good statistical analysis, in the first stage it was verified the homogeneity of the intakes for the 30 calves from the 3 lots based on the primary statistics (mean, variant, standard deviation, coefficient of variability).

Based on the average intake per batch, it can be seen that there are quite large differences between the 3 groups of lot 1 (Table 7).

Table 7. Average ingesta of calves in the 3-4 weeks age group

Statistics parameters	A1 ratio	A2 ratio	A3 ratio
1	604	252	126
2	162	648	312
3	432	214	50
4	478	272	60
5	508	178	84
6	446	150	484
7	484	292	436
8	342	624	456
9	466	160	434
10	580	264	350
n	10	10	10
$\bar{X}$	450.2	305.4	279.2
s^2	15680.4	32735.2	32221.5
s	125.2	180.9	179.5
CV%	27.8	59.2	64.3

A1 ratio had the best ingesta (450.2 g/day) compared to A2 ratio (305.4 g/day), and A3 ratio (279.2 g/day). This is also supported by the coefficient of variability which shows that lot 1, the one that received the ratio A1, has the lowest coefficient of variability (27.8 %). As a result, the A1 ratio was adapted to the needs of the calves.

Table 8. Average ingesta of calves in the 5-6 weeks age group

Statistics parameters	A1 ratio	A2 ratio	A3 ratio
1	222	556	338
2	800	350	191
3	560	710	530
4	394	476	536
5	520	524	504
6	576	461	386
7	1358	1020	356
8	824	814	442
9	1002	740	504
10	1312	482	486
n	10	10	10
$\bar{X}$	756.8	613.3	427.3
s^2	142369.1	41217.8	12043.6
s	377.3	203.0	109.7
CV%	49.9	33.1	25.7

According to the variability coefficient, in the calves groups of 5-6 weeks age, the most homogeneous group is the one that received the A3 ratio (CV - 27.8%) (Table 8). As in the case

of the 3-4 weeks old calf group, the group that received the A1 ratio recorded the highest ingesta (756.8 g/day) compared to A2 ratio (613.3 g/day), and A 3 ratio (427.3 g/day).
The results of the primary statistical analysis for calves in the age group over 6 weeks are similar to those in calves with age between 4 and 5 weeks (Table 9).

Table 9. Average ingesta of calves over 6 weeks age group

Statistics parameters	A1 ratio	A2 ratio	A3 ratio
1	832	964	366
2	824	1110	512
3	1142	718	304
4	1116	850	352
5	2468	396	442
6	2646	496	184
7	642	468	258
8	558	458	462
9	708	460	518
10	372	592	578
n	10	10	10
$\bar{X}$	1130.8	651.2	397.6
s^2	621027.7	61387.7	15910.9
s	832	964	366
CV%	824	1110	512

The Student's test was used to determine if there were statistical differences in the homogeneity of the ingesta calf average. Three possible combinations between the three groups were analysed, for each lot of animals (Tables 10-12).

Table 10. Student test applied to Lot 1 of calves

Lot 1	Group1 / Group2	Group1 / Group3	Group2 / Group3
t critical	2.11	2.11	2.1
t calculated	2.08	2.47	0.32
p - value	0.05	0.02	0.74

Analysing the data from Table 10 it can conclude that the biggest differences are between group 1 and group 3 (t calculated - 2.47). This fact shows that the protein level and its quality positively influence the ingesta.

Table 11. Student test applied to Lot 2 of calves

Lot 2	Group1 / Group2	Group1 / Group3	Group2 / Group3
t critical	2.14	2.20	2.14
t calculated	1.05	2.65	2.54
p - value	0.3	0.02	0.02

Similar to Lot 1 is the case of Lot 2 of calves (Table 11). On the value of *p* (0.02) for the comparative analysis between group 1 and group 3 shows again the superiority of the ratio with a higher percentage of protein (t calculated - 2.65).

Table 12. Student test applied to Lot 3 of calves

Lot 3	Group1 / Group2	Group1 / Group3	Group2 / Group3
t critical	2.26	2.26	2.16
t calculated	2.79	2.90	2.88
p - value	0.02	0.01	0.01

In Lot 3, consisting of calves over 6 weeks of age, the differences in the homogeneity of the average ingesta are large (CV – 512%). Statistically, there are significant differences in all three combinations of Lot 3 of calves. There is a significant difference $p = 0.02$ between groups 1 and 2 and another highlighted by the value of $p = 0.01$ when comparing groups 1 with 3 and 2 with 3 (Table 12).
From the point of view of the homogeneity of the variants, in Table 13 it can be seen that there are no significant statistic differences in Lot 1 of calves.

Table 13. ANOVA for Lot 1 of calves (Fisher test)

Source of variation	DF	SS	MS	F calculate	P value	F critical
Between groups	2	169648.3	84824.13	3.16	0.058	3.35
Within groups	27	725733.6	26879.02			
Total	29	895381.9				

For Lot 2 of calves, ANOVA test shows that there are statistically significant differences ($p = 0.026$) in terms of homogeneity of variants. This confirms that there are significant differences between the three rations administered and influences the ingesta of calves between 5- and 6-weeks age old (Table 14).

Table 14. ANOVA for Lot 2 of calves (Fisher test)

Source of variation	DF	SS	MS	F calculate	P value	F critical
Between groups	2	545861.7	272930.8	4.185	0.026	3.354
Within groups	27	1760674	65210.14			
Total	29	2306535				

As can be seen when the data were analysed with the Student's test, the biggest differences between calf intakes were when they were older than 6 weeks. Also, in the case of the analysis of the homogeneity of the variants, it shows that the biggest differences from the statistical point of view are between the calf groups from Lot 3 ($p = 0.007$) (Table 15).

Table 15. ANOVA for Lot 3 of calves (Fisher test)

Source of variation	DF	SS	MS	F calculate	P value	F critical
Between groups	2	2773038	1386519	5.956	0.007	3.354
Within groups	27	6284938	232775.5			
Total	29	9057975				

Overall, there is a significantly increased ingesta of concentrate mixture in calves fed with 23.96% protein in ratio. There were also no metabolic problems.

CONCLUSIONS

The study concludes that a controlled and optimized feeding serves the morpho – physiological needs of Holstein calves in order to obtain healthy and productive animals for the future production.

When it is desired for calves to have a good ingesta feed, it is important that the percentage of protein to be about 23%, and that this protein should come from good quality feed.

Only by ensuring a balanced feed with a good palatability will it be possible to wean the calves in the best conditions and with excellent results.

The nutrition in the case of calves during weaning has a critical role in their future development.

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