Turkish Journal of Agriculture - Food Science and Technology, 12(4): 675-681, 2024
DOI: https://doi.org/10.24925/turjaf.v12i4.675-681.6654

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

The Effect of Commercial Essential Oil Mixture Applied to Neonatal Simmental Calves on Growth, Development and Health Parameters

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ARTICLE INFO

Research Article

Received : 05.01.2024
Accepted : 27.03.2024

Keywords:
Calf
Simmental
Growth
Essential Oil
Development

ABSTRACT

This study, investigated the effectiveness of commercial essential oil mixture application in preventing calf losses due to diarrhea and on the growth, development and health parameters of calves. For this purpose, 24 newborn Simmental calves were used. Following birth, 20 ml of essential oil mixture was given orally via syringe to the calves in the treatment group after drinking milk in the morning for 5 days. The average birth weight of calves was 39.0 ± 0.72 kg. Birth weights of male and female calves were 42.3 ± 1.01 and 38.6 ± 0.96 kg respectively, the difference between groups were found to be significant. First month weight was 45.7 ± 1.67 and 42.4 ± 1.65 kg in the control and treatment groups, respectively. There was no difference between the control and treatment groups in terms of body measurements taken at birth, but a significant difference was observed in chest circumference in favor of the control group in terms of measurements obtained at the 1st month. There was no difference between the treatment and control groups in terms of hematological parameters detected in the blood taken on the 10th day and in the 1-month period. No differences were observed between groups in terms of immunoglobulin levels (IgM and IgG). The commercial essential oil mixture had no effect on the fecal score of the calves included in the trial. It was revealed that the essential oil mixture does not make any difference in the growth, development, and health of Simmental calves in a one-month period. In future studies on the subject, it is recommended that higher doses of the essential oil mixture be investigated.

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Introduction

In dairy cattle enterprises, 60% of the total income consists of milk, and 40% is obtained from the calf sales (Demir et al., 2019). However, in some regions, especially Eastern Anatolia, due to the inadequacy of the cold chain infrastructure in the preservation of raw milk and the problems experienced in marketing, calf sales are the main source of income for the enterprises. There has been an increase in calf deaths both in the world and in Turkey in recent years (Bayram et al., 2016a; Bleul, 2011). While the mortality rate in dairy calves is reported to be 10% worldwide, it was reported to be over 15% in Turkey (Şahal et al., 2018).

It is estimated that approximately 900 thousand to 1 million calves die every year in Turkey (Şahal et al., 2018; Günlü, 2018). In a recent study (Günlü, 2018), it was reported that 5 594 000 calves were born in Turkey in 2018, and approximately 17.6% of these calves (987 000 heads) died. In order to meet the need for breeding heifers and beef cattle in dairy and beef cattle enterprises as a result of high calf losses, huge expenditures have been made/are being made to import live animals. According to official reports, in 2018, 1 460 741 heads of cattle were imported, 116 081 of these cattle were used for breeding, 1 211 756 heads were used for fattening and 132 904 heads were slaughtered and used in the meat industry, and the total cost of this import was reported to be 1 692 068 152 US dollars to Turkey (Günlü, 2018). The current average prices of one-week-old Holstein-Friesian, Brown-Swiss and Simmental calves were reported to be 13, 19 and 23 thousand TL, respectively (Anonymous, 2023). Both, high average calf prices and animal imports as a result of high calf losses leading to serious economic burdens for the cattle enterprises in Turkey. At least 25% of these losses could be prevented with effective care, nutrition and protection measures for the calf and the dams in cattle farms. According to current data, average carcass obtained from cattle in Turkey is 296 kg/head (Anonymous, 2022), reducing calf losses by 25% will considerably increase the red meat production and thus, animal based protein consumed per person.

The majority of calf deaths (80%) occur in the birth-28-day period, this period is called the neonatal period (Karslı & Evci, 2018). The most significant reasons for calf losses in this period are calf diarrhea (45.2%), respiratory tract (22.2%), and foot and mouth disease (19.3%) (Demir et al., 2019). The causes of calf diarrhea are generally classified as microbial (infectious) and non-microbial (non-infectious). While infectious diarrhea is caused by parasitic, viral or microbial pathogens, non-infectious diarrhea occurs as a result of inadequate environmental conditions and nutrition (Karslı & Evci, 2018). The most fundamental reason for calf losses due to diarrhea is that newborn calves are not given timely and sufficient amount of colostrum. A study conducted in the USA revealed that the main reason for approximately one third (31%) of the calf losses within a week after birth was the insufficient passive immunity, which is caused by not receiving enough colostrum (Walsh et al., 2007). For newborn calves to have sufficient passive immunity serum Ig levels must be above 10 µg/ml (Vicente et al., 2014).

In the cattle industry, antibiotics have been widely used to prevent diarrhea and accelerate growth and development in calves. However, as a result of scientific evidences presenting that frequent use of antibiotics results in antibiotic resistance in disease-causing microorganisms and creates residues in animal-based products, thus its use as a growth factor in animal nutrition was first banned in Sweden in 1986, in all EU member countries in 2005, and in Turkey on January 1, 2006 (Ünlü & Erkek, 2013). These bans, both in Turkey and other countries, have triggered scientists to search for new safe and natural feed additives as an alternative to antibiotics (Özdemir et al., 2022). Essential oils stand out among alternative products with their wide range of proven benefits to health. As a natural product essential oils are reported to be effective in preventing diarrhea, modifying intestinal microflora as well as increasing feed utilization and daily live weight gain in calves (Uetaka, 2013; Jounany & Morgavi, 2007).

There are two different opinions regarding the effectiveness of essential oils on calves. First is increasing the utilization of nutrients as a result of increased enzyme amount and activity due to the stimulation of endogenous enzymes, and the second is protecting animal health by regulating the gut microbial flora (Bilgin & Kocabağlı, 2010; Zhang et al., 2005). Thymol, carvacrol, and eugenol are reported to be the major components of essential oils as a result of chemical analysis. The composition of essential oils varies depending on the geographical feature of the plant from which it is obtained. Especially carvacrol the component found in essential oils has a strong antimicrobial effect even at low concentrations (Bilgin & Kocabağlı, 2010; Dusan et al., 2006). Essential oils are known for their antiseptic, antioxidant, digestive stimulant, antimicrobial and enzymatic effects. Due to these properties, various studies have been carried out to investigate the effects of essential oils in protecting animal health and increasing the development and performance. In some of these studies, essential oils are reported to control harmful and disease-causing bacteria in the rumen and intestines and inactivate them (Selvi, 2018; Sağdıç & Özcan, 2013).

This study investigated, the effects of a commercial essential oil mixture obtained from 27 different aromatic medicinal plants, mainly thyme, clove, eucalyptus oil and licorice, on growth, development and health parameters in neonatal Simmental calves.

Material and Method

Animal Material

The animal material of the study consisted of Simmental calves born in Atatürk University Food and Livestock Research and Application Center Cattle Breeding Unit. Calves were divided into two groups: control (12 heads) and treatment (12 heads). Following the routine practices specified in the enterprise and colostrum feeding the calves were taken to the individual pens. The calves in the treatment group were fed with 20 ml of commercial essential oil mixture orally via syringe, immediately after the morning milk feeding, for 5 days, starting from the 3rd day of birth. All the experimental protocols adhered to and were approved by the guidelines of the Animal Ethics Committee of Ataturk University (Approval date: 11 August 2022; Decision No.: 2022/154).

Feeding

The calves, were taken into individual pens, and fed with whole milk obtained from the Atatürk University Food and Livestock Research and Application Center Cattle Breeding Unit. The milk given to the calves kept constant at 10% of their birth weight. Calf starter feed was offered to the calves starting from one week of age. The starter was purchased from a commercial feed mill. In addition to the starter dry hay was given to the calves. Dry hay was obtained from Atatürk University Plant Production Application and Research Center. The nutritional contents of the liquid and solid feeds used in the study are given in Table 1.

Table 1. Composition of solid and liquid feeds used in the study

Nutrients (%)	Milk	Calf Starter	Dry Hay
Dry matter	12.0	89.8	93.1
Crude Protein	3.8	19.1	7.1
Ether Extract	4.1	4.8	3.8
Crude Ash	0.7	8.0	8.4
Crude Cellulose	_	12.0	28.1

The commercial essential oil mixture was purchased from a private company, the essential oil mixture contained oils from 27 different aromatic medicinal plants (TERASİNN-TR33-K-026869/09.04.2018). TERASINN, which is a completely herbal product, contains pectin, essential oil mixture and betane. Thyme, clove, eucalyptus oil and licorice root, were the main components found in the product. The component of the product consists of carvacrol, 1.8 cineole as well as organic minerals. 20 ml of commercial essential oil mixture was given to newborn calves orally following the morning milk feeding for 5 days by using a syringe and serum hose.

Method

The calves included in the trial were examined in terms of various parameters. These parameters are given below:

Live weight and various body measurements (height at withers, chest depth, heart girth, body length, cannon bone girth) were determined at birth and one month of age. In order to determine the effect of commercial essential oil mixture on diarrhea, fecal consistency scoring method developed by Larson et al. (1977) was utilized. In accordance with the mentioned method, the classification

of the manure of the calves were performed as follows; 1: normal, soft, solid consistency, not fluid, 2: soft, semi-solid, mostly solid, 3: fluid, semi-solid, mostly fluid, 4: aqueous, completely fluid.

Blood and Serum Sampling

Blood samples were collected from the serum tubes without anticoagulant (8 ml) and K2 EDTA tubes (3 ml) from the jugular vein of the calves. Hematological analysis were performed on blood samples taken into EDTA tubes. Blood samples were centrifuged at 3500 rpm for 10 minutes to separate plasma and serum. Subsequently, serum was transferred to eppendorf tubes and calf numbers and sample collection dates were written on them. Immunoglobulin analyses were made on serum samples separated from the whole blood. Blood serums were kept at -20 °C for 24 hours, then frozen and stored in a deep freezer at -80 °C until biochemical analysis was performed.

Hematological and Biochemical Analyzes

Blood samples taken from the calves first within 24 hours following birth, then on the 10th day and at the 1-month of age was utilized for hematological analysis. The blood samples taken were counted on the same day using the Abacus Junior Vet5 hemogram device in the Laboratory of Internal Medicine Department of Atatürk University Faculty of Veterinary Medicine. White blood cell (WBC), lymphocyte (LYM%), neutrophil (NEU%), red blood cells (RBC) and hematocrit (HCT) values were determined and recorded. Serum IgM and IgG analysis were performed in accordance with the procedure described by the manufacturer (Bioassay Technology Laboratory).

Statistical Analysis

GLM procedure available in the SPSS 20.0 (SPSS, 2013) package program was utilized to analyze the data obtained. In the research, analysis of variance was performed using a 2×2 factorial experimental plan. The data conformed to normal distribution. In the statistical model, commercial essential oil mixture and calf gender were included in the model as factors. To eliminate the effects of colostrum quality resulting from birth order, calves born from heifers were used in the study. Non-parametric fecal consistency scores, which are scored categorically as 1, 2, 3, and 4 were analyzed according to the Chi-Square (X2) independence test (Yıldız & Bircan, 1994).

Results and Discussion

Weights and Body Measurements

Birth weight is a significant factor affecting growth and development of calves in the postnatal period and is also used as a selection criterion in cattle farms. Birth and 1st month weights of Simmental calves are given in Table 2.

Simmental calves' average birth weight was 39.9 ± 0.72 kg. While average birth weight of the calves was close to the values reported by Koçak et al. (2008), it was lower than the results of similar studies (41.5-42.1 kg) (Özen, 2022; Aydoğdu & Karslı, 2020; Baykan, 2016). To eliminate the effect of maternal age, only the calves obtained from heifers included in the study. This might be the primary reason for the lower calf birth weights observed in this study.

The average birth weight of the control and treatment groups were determined as 39.9 ± 0.74 and 39.3 ± 1.30 kg, respectively. There was no statistically significant difference in terms of the birth weights between groups.

The male and female calves' birth weights were 42.3 ± 1.01 and 38.6 ± 0.96 kg, respectively. Male calves were determined to be 3.7 kg heavier than the female calves at birth ($P<0.05$). The findings of the study are comparable with the results of various studies conducted on Simmental calves (Baykan, 2016; Koçak et al., 2008; Özlütürk et al., 2006; Kaygısız, 1998).

The study's average 1st-month weight of Simmental calves was 44.0 ± 1.00 kg. One-month weight of the calves determined in this study was found to be lower than the average 1st month weights reported for Simmental calves (49.5-62.0 kg). The first reason for lower one-month weight of Simmental calves obtained in this study may be slower growth performance of the calves having lower birth weight. And the second reason for this result is thought to be the effect of the season since the study was carried out under harsh winter conditions of Erzurum Province, which is located over 2000 m from the sea level.

Average 1st month weights in the control and treatment groups were determined as 45.7 ± 1.19 and 42.4 ± 1.65 kg, respectively. Control group calves had 3.3 kg higher weight at one month of age compared to the calves in the treatment group, however, this difference was determined to be statistically insignificant. In other words, the commercial essential oil mixture used in the study had no significant effect on the growth performance of calves. Similarly, previous studies investigating the effects of thyme oil (Selvi, 2018; Ünlü & Erkek, 2013), laurel oil (İzzadden & Kaygısız, 2018), and thyme juice (Özkaya et al., 2018) on the growth and development of calves showed no significant difference in the weights of calves in the first month or weaning period. In contrast, Liu et al. (2020) reported that the addition of essential oil to the ration resulted in a significant increase in the 1st month weight of Holstein calves. They noted that essential oils extracted from plants had a positive effect on growth performance by increasing feed consumption.

The average 1st month weight was determined as 46.6 ± 1.67 kg in male and 43.2 ± 1.10 kg in female calves, and the difference of 3.4 kg in favor of male calves was statistically insignificant. The findings of the study obtained are compatible with the results of Selvi (2018) who reported 44.3 kg and 42.6 kg first month weight for male and female calves, respectively. Furthermore, İzzadden and Kaygısız (2018) also noted that the effect of gender on 1st month weight of calves was statistically insignificant. They reported that one-month weight of the calves were 58.2 kg and 54.2 kg for male and female calves, respectively.

Body Measurements at Birth and 1st Month of Age

Increases in body measurements of calves are critical parameters in determining the growth and skeletal development of calves. Some body measurements of Simmental calves determined at birth and in the first month are given in Table 3. There was no significant difference between the control and treatment groups in terms of body measurements determined at birth. Nevertheless, the height at withers cannon bone girth of male calves were determined to be 2.1 and 1.1 cm higher than female calves, respectively. The differences between sex groups were statistically significant ($P<0.05$).

Table 2. Birth and 1st-month weights of the calves in control and treatment groups

	Group			Sex		
	Control (N=12) X ± Sx	Treatment (N=12) X ± Sx	S	Female (N=12) X ± Sx	Male (N=12) X ± Sx	S
Birth Weight	39.9 ± 0.74	39.3 ± 1.30	NS	38.6 ± 0.96[b]	42.3 ± 1.01[a]	*
1st month Weight	45.7 ± 1.67	42.4 ±1.65	NS	43.2 ± 1.10	46.6 ± 2.67	NS

S = Significance NS = Not Significant *P<0.05

Table 3. Body measurements at birth and 1st month of age

Body measurements (cm)	Control (N=12) X ± Sx	Treatment (N=12) X ± Sx	S	Female (N = 12) X ± Sx	Male (N=12) X ± Sx	S
Birth						
Height at withers	68.3 ± 0.63	68.7 ± 0.79	NS	67.4 ± 0.56[b]	69.5 ± 0.71[a]	**
Chest Depth	33.0 ± 0.52	32.7 ± 0.27	NS	32.5 ± 0.49	33.2 ± 0.29	NS
Chest Girth	74.5 ± 0.53	75.2 ± 0.98	NS	73.8 ± 0.82	75.8 ± 0.70	NS
Cannon bone girth	14.9 ± 0.28	15.0 ± 0.21	NS	14.4 ± 0.21[b]	15.5 ± 0,16[a]	**
Body Length	68.4 ± 0.96	66.7 ± 0.89	NS	66.6 ± 0.96	68.3 ± 0.89	NS
1 month of age						
Height at withers	72.8 ± 0.75	71.4 ± 0.56	NS	71.2 ± 0.47	73.5 ± 0.85	NS
Chest Depth	35.3 ± 0.36	34.5 ± 0.63	NS	34.7 ± 0.40	35.3 ± 0.54	NS
Chest Girth	80.5 ± 1.28[a]	75.4 ± 1.50[b]	*	76.5 ± 1.04[b]	81.1 ± 1.79[a]	*
Cannon bone girth	15.2 ± 0.29	14.2 ± 0.38	NS	14.1 ± 0.16[b]	15.7 ± 0.28[a]	**
Body Length	74.9 ± 1.29	71.9 ± 1.86	NS	72.2 ± 1.53	75.6 ± 1.37	NS

* = P < 0.05; **= P< 0.01; S = Significance, NS=Not Significant

Table 4. Hematological parameters at birth, 10-day and 1-month-of ages of calves

Hematological Parameters	Control (N=12) X ± Sx	Treatment (N=12) X ± Sx	S	Reference Range
Birth				
WBC (White Blood Cell)	8.79 ±1.13	7.95 ±1.01	NS	4 - 12
LYM (%) (Lymphocyte)	3.46 ±0.38	3.80 ±0.46	NS	2.5 - 7.5
NEU (%) (Neutrophil)	4.71 ±0.70	3.54 ±0.54	NS	0.6 - 6.7
RBC (Red Blood Cell)	9.60 ±0.30	8.25 ±0.35	**	5 - 10
HCT (Hematocrit)	36.05 ±1.31	32.58 ±1.55	NS	24 - 46
10 days of age				
WBC (White Blood Cell)	11.39 ±1.44	12.34 ±0.88	NS	4 - 12
LYM (%) (Lymphocyte)	5.02 ±0.59	5.35 ±0.55	NS	2.5 - 7.5
NEU (%) (Neutrophil)	5.65 ±0.94	6.17 ±0.57	NS	0.6 - 6.7
RBC (Red Blood Cell)	9.36 ±0.36	8.98 ±0.44	NS	5 - 10
HCT (Hematocrit)	32.42 ±1.53	33.54 ±1.76	NS	24 - 46
1 month of age				
WBC (White Blood Cell)	11.19 ±1.48	12.43 ±0.92	NS	4 - 12
LYM (%) (Lymphocyte)	5.08 ±0.34	5.54 ±0.21	NS	2.5 - 7.5
NEU (%) (Neutrophil)	5.62 ±1.22	6.29 ±0.84	NS	0.6 - 6.7
RBC (Red Blood Cell)	9.40 ±0.35	9.87 ±0.71	NS	5 - 10
HCT (Hematocrit)	28.85 ±1.22	28.86 ±2.09	NS	24 - 46

S = Significance NS = Not Significant * = P < 0.05 **= P < 0.01

The differences in control and treatment groups for body measurements at one month of age were determined to be statistically insignificant except for the chest girth. Chest girth of the calves in the control group was 5.1 cm higher than the treatment group (P<0.01). In addition, chest girth (P<0.05) and cannon bone girth (P<0.01) of the male calves were significantly higher than female calves at one month of age.

Hematological Parameters

Having hematological values in the reference range is critical for calves to be healthy and show ideal growth and development performance (Zwald et al., 2004). Detection of the number and ratio of certain cells in the blood plays a significant role in the early diagnosis of infections in calves.

The results of hematological analysis performed on blood samples taken from Simmental calves at birth, 10th day and 1 month of age are given in Table 4. The analysis results showed that the hematological values of both control and treatment groups were within the reported reference range in the blood samples taken following the birth. Even though the RBC (Red Blood Cell) value in the blood obtained right after birth is within the reference range, control group calves had a significantly higher RBC count than the calves in the treatment group (P<0.01). The differences observed for other hematological values (WBC, LYM, NEU, HCT) were determined to be insignificant.

There was no significant difference between the control and treatment groups in terms of the hematological values

obtained from the blood samples taken at the 10-day and 1-month of ages of calves. In other words, the commercial essential oil mixture did not have a significant effect on blood parameters of Simmental calves. All parameters determined in the control and treatment groups during the ten-day and one-month period were within the reference ranges.

A similar study conducted on calves with and without diarrhea (Çorapsız, 2023), showed that diarrhea did not cause a significant difference in body temperature and live weight of calves, and there was no significant difference between the two groups in terms of white blood cells and lymphocytes counts. In another study conducted to determine the effect of different etiological factors on hemogram parameters in calves with diarrhea during the neonatal period, Atçalı and Yıldız (2020) reported that the WBC (leukocyte) of calves with diarrhea was significantly higher ($P<0.05$) than the control group calves and no significant difference was determined between two groups in terms of LYM, RBC and HCT levels. Comparable results for blood parameters were also reported in studies aimed to determine the effects of plant essential oil supplementation to ration (Özkaya et al., 2018; Ünlü & Erkek, 2013).

Immunoglobulin M and G Levels

Immunoglobulins (Ig) are glycoproteins produced by plasma cells and have crucial functions against diseases. Ig (IgG, IgM) levels detected in the blood serum of Simmental calves at birth, 10th day, and 1 month of age are presented in Table 5. IgM are the first antibodies that respond to body pathogens. As a result of the biochemical analysis, no significant difference was found between IgM levels of calves at birth, 10 days and 1 month of ages. Although the IgM mean of the treatment group was higher, this difference was statistically insignificant. In this study 10th day IgM level determined for both the control (0.6069) and treatment groups (0.9147) was considerably lower than the results reported in two similar studies (3.17-4.30) (Bayram et al., 2016b; Akbulut et al., 2003).

IgG is the most abundant antibody in the body, but has the smallest molecule. First, IgG binds to important pathogen surface proteins and inactivates pathogens such as viruses and bacteria, preventing the pathogen from interacting with host cells. Consequently, the antibody neutralizes the pathogen's ability to enter and replicate in its host cells (Thompson, 2016). No statistically significant difference was determined between the IgG levels of Simmental calves at birth, 10th day and 1 month of age. Although the IgG levels were higher in calves in the treatment group, the difference between groups was insignificant. In this study, IgG levels detected on both the 10th day and the 1st month were considerably lower than the average values reported in previous studies on the subject (18.4-21.26) (Baykan, 2016; Akbulut et al., 2003). Comparably, Liu et al. (2020) reported that IgG and IgM levels increased significantly ($P<0.01$) with essential oils supplementation to ration in calves.

Mazengera et al. (1985) and Gilbert et al. (1988) reported that mean serum IgG concentrations were 24.0 mg/ml for the Simmental calf at 36 hours of age. Compared to the relevant result, the result obtained in this study considerably lower (4.34 mg/L and 4.59 mg/L). Furthermore, Liu et al. (2020) reported that calves fed with essential oil combination at 44.1 ppm had higher IgG and IgM levels on days 14, 28, and 42 than the control group.

Fecal Consistency Score

Calf diarrhea is among the most prominent causes of early calf diseases and losses (Urie et al., 2018). Calf diarrhea also results in a decrease in growth performance and a delay in the age of first calving in cattle's early life (Windeyer et al., 2014). In the current study fecal consistency scoring method developed by Larson et al. (1977) were used to determine the diarrheal condition of Simmental calves. Fecal scores of the control and treatment group calves were scored on a scale of 1 to 4, and the results are given in Table 6.

According to the result of the fecal consistency scoring, the difference between the treatment and control group was found to be insignificant ($P > 0.05$). The commercial essential oil mixture seems ineffective on the calves fecal consistency scores. In contrast, results of the previous studies (İzzadden & Kaygısız, 2018; Selvi, 2018; Ghosh et al., 2010), indicated to significant effect of essential oils on the fecal scores through a positive effect on the intestinal microbial population (Ghosh et al., 2010). Also, Katsoulos et al. (2022) reported that use of Greek thyme essential oil mixture significantly reduced the fecal score.

Table 5. Birth, 10th day and 1 month IgM and IgG levels (µg/ml) of calves

Period	IgM		S	IgG		S
	Control	Treatment		Kontrol	Muamele	
Birth	0.4703±0.07553	0.4712±0.0793	NS	4.3455±0.8155	4.5901±0.7912	NS
10. day	0.6069±0.0719	0.9147±0.01921	NS	6.1690±1.3890	7.9971±1.3479	NS
1. month	0.9541±0.1272	0.9760±0.1134	NS	8.0156±0.3278	10.3278±2.5038	NS

Ig: Immunoglobulin S: Significance NS: Not Significant

Table 6. Fecal consistency scores of the control and treatment group calves

			Fecal Score				Total
			1	2	3	4	
Group	Control	Frequency (N= 112)	65	25	19	3	112
		Percentage in the group %	58.0%	22.3%	17.0%	2.7%	100.0%
	Treatment	Frequency (N= 59)	24	17	15	3	59
		Percentage in the group %	40.7%	28.8%	25.4%	5.1%	100.0%
Total		Frequency (N= 171)	89	42	34	6	171
		Percentage in the group %	52.0%	24.6%	19.9%	3.5%	100.0%

Conclusion

According to the results obtained from the study, the commercial essential oil mixture, which was investigated to be a potential alternative to antibiotics in the prevention of neonatal calf diarrhoea, which causes a significant decrease in calf growth, development as well as health parameters and results in a considerable economic loss in the enterprises, showed no significant effect. Furthermore, there was no significant difference on the growth, development, and health of Simmental breed calves. Further, long-term studies investigating different doses of this product should be conducted to clearly understand the effects of the used essential oil mixture.

Acknowledgments

This study is summarised from Fatma EMİR's master's thesis

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