

Comparison of Passive Transfer Between Lambs Receiving Colostrum by Natural Suckling and Lambs Given Colostrum by Bottle

Celal Eđdir^{1a}, *Naci Öcal^{2b}

¹Kırıkkale University, Health Sciences Institute, Veterinary Internal Medicine, Kırıkkale, Türkiye

²Kırıkkale University, Faculty of Veterinary Medicine, Department of Veterinary Internal Medicine, Kırıkkale, Türkiye

^aORCID: 0000-0002-3700-107X; ^bORCID: 0000-0002-8679-2111

*Corresponding Author

E-mail: dmaciocal@yahoo.com

Received: December 15, 2022

Accepted: January 09, 2023

Abstract

Since the syndesmochorial placental structure of sheep does not allow the passage of large molecules from mother to offspring in intrauterine life, lambs are born hypogammaglobulinemic. The aim of this study is to compare passive transfer of immunity, neonatal morbidity and mortality, and live weight gains at day 120 between lambs receiving colostrum by suckling naturally and lambs given colostrum by bottle. 61 (n=61) lambs born to 43 sheep were randomly divided into two groups. One of the groups (NL group) received the desired amount of colostrum from the mother as they desired after birth. For the other group (BL group), access to the mothers' udder was restricted by a pouch after the lambs were born. BL group lambs were given colostrum roughly 8% of their birth weight by bottle as soon as possible after birth. Afterwards, colostrum freshly obtained from the mother was given to these lambs *ad libitum* every 4-6 hours during the first 24 hours. Approximately 50 ml of colostrum was taken into sterile containers from all sheep included in the study within the first 30 minutes after birth. Blood samples were taken from lambs for IgG analysis 36-48 hours after the first colostrum intake. Both serum and colostrum IgG analyses were performed by Radial Immunodiffusion (RID) method. Serum IgG concentrations of lambs in the BL group (3155.41±1245.25 mg/dl) were found to be higher than serum IgG concentrations of lambs in the NL group (2097.02±1213.07 mg/dl). When the results were compared using Independent Samples T test, the difference between the two groups was very statistically significant ($p<0.001$). Neonatal morbidity and mortality were higher in lambs in the NL group (46.6%, 23.2%, respectively) than in lambs in the BL group (22.6%, 12.9%, respectively). Failure of Passive Transfer of Immunity (FPT) in lambs in the NL group (30%) was much higher than in lambs in the BL group (6.45%). Although the average Live Weight (LW) of lambs in the BL group (40.70 +7.84 kg) was higher than the average of lambs in the NL group (36.47+10.46 kg), this difference was statistically insignificant. In conclusion, giving lambs colostrum by bottle as soon as possible after birth without waiting for lambs to naturally receive colostrum from the mother results in better Passive Transfer and, accordingly, lower neonatal morbidity and mortality, and thus can help reduce economic loss in sheep breeding enterprises.

Keywords: Bottle-fed, colostrum, IgG, lamb, passive transfer.

INTRODUCTION

Since sheep have syndesmochorial placental structure and can not transfer macromolecules such as immunoglobulin G (IgG) to their offspring, lambs are born either agammaglobulinemic or hypogammaglobulinemic (Loste et al., 2008; Hernández-Castellano et al., 2015a; Zhu et al., 2021). Lambs, which are born with an underdeveloped immune system, receive the necessary immune components from colostrum in order to live (Gökçe and Erdoğan, 2009; Alves et al., 2015). Colostrum is a body secretion that begins to be released before birth and accumulates in the breast alveoli, is very rich in immune components, especially immunoglobulins (Ig), and is extremely different both physically and biochemically from normal milk (Kessler et al., 2019). Lambs must receive sufficient quantity and quality of colostrum as soon as possible after birth (Keskin et al., 2007; Zhu et al., 2021). When there is a disruption in the intake of colostrum, a sufficient amount of immune components cannot pass to the offspring. This condition is called Failure of Passive Transfer of Immunity (FPT) (Britti vd., 2005). FPT is not a disease, but a condition that

predisposes the newborn to diseases, especially in the neonatal period (Kara and Ceylan, 2021). In lambs, a serum IgG concentration of 1500 mg/dl between 24-48 hours after birth is considered the threshold for FPT (Alves vd., 2015). Passive Transfer of Immunity (PTI) can be evaluated by Radial Immunodiffusion (RID) and Enzyme-Linked Immunosorbent assay (ELISA) methods directly using the measurement of IgG. PTI can also be evaluated by measuring levels of Total Protein or GGT enzyme activity with spectrophotometers and refractometers, as well as by indirectly estimating the amount of IgG by Zinc Sulfate Turbidity Test, Sodium Sulfate Turbidity Test or Glutaraldehyde Coagulation Test (Alves et al., 2015; Hernández-Castellano et al., 2015a; Hernández-Castellano et al., 2015b; Demis et al., 2020; Gokce et al., 2021 Sarica, 2022).

Newborn lambs can be given colostrum with a bottle or an esophageal tube, as well as by suckling from their mother naturally (Gökçe et al., 2013; Shiels et al., 2022). In studies conducted on calves, the advantages and disadvantages of colostrum delivery methods compared to each other have been reported in detail (Besser et al., 1991;

Filteau et al., 2003; Godden, 2008). Since the amount, quality and time of colostrum intake are unknown and the process may become more fragile when calves receive colostrum from the mother by suckling naturally, bottle or esophageal tube feeding is seen as superior for preventing FPT in today's world (Desjardins-Morrisette et al., 2018). In contrast, it was seen that extensive studies on the comparison of these methods in lambs were limited in number.

The aim of this study is to compare passive transfer of immunity, neonatal (0-4 weeks) and post-neonatal (5-12 weeks) morbidity and mortality, and live weight at slaughter (LW) gains between lambs receiving colostrum by natural suckling and lambs given colostrum by bottle ad libitum as soon as possible after birth.

MATERIALS AND METHODS

Experimental Animals

The subjects of the study were 43 sheep between the ages of 2-9 which gave birth between August 2021-September 2021 and 61 lambs born to these sheep, taken from a flock of 215 Karya breed of sheep located in Denizli province in Western Anatolia. All the sheep included in the study were grazed in the first two trimesters of pregnancy (approximately first 100 days) and were switched to intensive feeding with barley (for each sheep 1,4 kg/day), barley straw (ad libitum) and dried green oat straw (for each sheep 0.7 kg/day) in the last trimester (approximately last 50 days). The births took place among the herd (without being taken to single paddocks) under the 24-hour supervision of the breeder. The lambs stayed with their mothers for the first 3 weeks. The lambs were separated from their mothers and were left with their mothers for about 1 hour three times a day between weeks 3-9, twice a day between weeks 9-16.

The sheep were vaccinated with enterotoxaemia vaccine (Coglavax®, CEVA, France) twice with 21 days between doses and septicemia vaccine (VBR K99+C, ATAFEN, Turkey) once during the gestation period. In addition, the sheep received injectable vitamin A, D, E, K (Ademin®, CEVA, France) and selenium (Yeldif®, CEVA, France) in the last trimester of pregnancy.

Experimental Groups

61 lambs (n=61) born to 43 sheep were divided into two groups: naturally suckling lambs (NL) (n=30) and bottle-fed lambs (BL) (n=31). Similarity between the groups in terms of maternal age, maternal Body Condition Score (BCS), type of birth, lamb gender and lamb weight were paid attention to when selecting subjects. After colostrum samples were taken from their mothers after birth, lambs in the NL group (n=30) suckled colostrum after starting to walk on their own. Lambs that did not walk straight away or that had difficulty finding the udder suckled colostrum after the breeder helped them to walk and find the udder. On the other hand, the lambs in the BL group (n=31) were given a bottle of colostrum roughly 8% of the live weight of the lamb after birth following hygiene rules, after some of the colostrum obtained by hand milking was taken as a sample. In order to prevent the lambs from reaching their mother's udder, a cloth pouch was placed on the udder of the sheep for 24 hours. Following their first colostrum intake, the lambs in this group were fed ad libitum with colostrum or transitional milk every 4-6 hours by bottle. Lambs in both groups did not receive any other colostrum than their own mother's colostrum. In addition, the lambs in both groups were weighed before receiving the first

colostrum and their weight was recorded. Then the lambs were kept under observation until reaching the age to be sold. Clinical examinations of the lambs that were sick, and postmortem examinations of the lambs that died were conducted, and the cause of illness or death was determined. LW measurements were made when the lambs were roughly 120 days old.

Collection, Transportation and Storage of Samples

Approximately 50 ml of colostrum sample was taken from both udder lobes from every mother into sterile containers, within the first half hour after birth, before the lambs suckled. 36-48 hours after the first colostrum intake, blood samples from the Vena Jugularis of lambs were taken into sterile tubes not containing anticoagulants in order to obtain serum. After being allowed to coagulate at room temperature, the samples were centrifuged at 3000 rpm for 5 min. The obtained colostrum and serum samples were stored at -20°C until they were transferred for analysis. After all the samples were collected, they were sent to the laboratory for analysis in cool-packs wrapped in Styrofoam, while paying attention to cold chain standards.

Laboratory Analysis

Frozen serum and colostrum samples were thawed at room temperature. Serum and colostrum IgG concentrations were determined using Radial Immunodiffusion (RID) test kits (Triple J Farms, Bellingham, USA). The test procedure was carried out as specified by the manufacturer.

Statistical Analyses

The arithmetic averages, standard deviations, and minimal and maximal values (Xmin-Xmax) of the values obtained for both groups in the study were calculated. Whether the calculated values showed a normal distribution was determined by the Kolmogorov-Smirnov method. After it was determined that the obtained values showed a normal distribution, parametric tests were performed using the SPSS 15 package program. For this purpose, One-Way Variation Analysis (ANOVA) was applied in order to determine the relationship between the two groups. The geometric averages of the obtained values were evaluated with 95% confidence interval cutoff. A level of significance of $p < 0.05$ was considered significant in all analyses. All statistical evaluations were performed using the SPSS package program.

RESULTS

When the two feeding groups were compared, the serum IgG concentrations of the bottle-fed lamb group (BL group) (3155.41 ± 1245.25 mg/dl) were found to be higher than the serum IgG concentrations of the lamb group who received colostrum by suckling from the mother (NL group) (2097.02 ± 1213.07 mg/dl) (Table 1). When the results were compared using Independent Samples T Test, the difference between the two groups was statistically significant ($p < 0.001$). Although the average colostral IgG concentration of the NL group mothers (8366.89 ± 3047.84 mg/dl) was higher than that of the BL group mothers (7045.29 ± 3690.37 mg/dl), this difference showed no statistical significance ($p = 0.084$). The two groups were selected to be similar in terms of average maternal age (NL group 4.40 ± 1.79 ; BL group 4.04 ± 1.24 years), and the difference was statistically insignificant ($p = 0.082$). Again, although there were slight differences in terms of average maternal BCS (NL group 3.25 ± 0.70 ; BL group 3.35 ± 0.65), this difference did not have statistical

significance ($p=0.38$). While the average LW of lambs in the NL group at day 120 (36.47 ± 10.46 kg) was found to be lower compared to the average LW of lambs in the BL group at day 120 (40.70 ± 7.84), this situation was found to be statistically insignificant ($p=0.1$).

There was no significant correlation between maternal colostrum IgG concentration and lamb serum IgG concentration ($r=0.018$).

Table 1. Statistical evaluation of the effect of serum IgG concentration, maternal colostrum IgG concentration, maternal age, maternal BCS and lamb birth weight on fattening performance in lambs receiving colostrum by natural suckling and by bottle.

Parameters	Groups	n	Average $\pm$ SD	Min-Max	t	p
Lamb RID Value (mg/dl)	NL	30	2097.02 $\pm$ 1213.07	192.71 – 4857.05	3.36	0.001
	BL	31	3155.41 $\pm$ 1245.25	273.97 – 5160.40		
Maternal RID Value (mg/dl)	NL	20	8366.89 $\pm$ 3047.84	2739.66 – 12851.16	-1.268	0.084
	BL	23	7045.29 $\pm$ 3690.37	1534.41 – 15306.81		
Maternal Age / Year	NL	20	4.40 $\pm$ 1.79	2.00 – 9.00	-1.76	0.082
	BL	23	4.04 $\pm$ 1.24	2.00 – 7.00		
Maternal BCS	NL	20	3.25 $\pm$ 0.70	2.50 – 4.55	0.87	0.38
	BL	23	3.35 $\pm$ 0.65	2.00 – 4.50		
Lamb Birth Weight / kg	NL	30	3.70 $\pm$ 0.75	2.30 – 5.30	1.79	0.077
	BL	31	4.12 $\pm$ 1.01	2.30 – 6.50		
End of Fattening Weight of Lamb /kg	NL	23	36.47 $\pm$ 10.46	18.00 – 65.00	1.63	0.1
	BL	27	40.70 $\pm$ 7.84	27.05 – 58.45		

The degree of significance was accepted as $P < 0.05$.

The rates of illness and death, the average serum IgG concentrations of healthy, sick and lost lambs, number of cases of FPT, FPT rates and average live weights at day 120 of lambs in both groups were given in Table 2. While 16 lambs in the NL group (53.3%) did not develop any diseases, a total of 14 lambs (46.7%) were clinically diagnosed with disease, and 7 of the lambs who were sick died at different ages (23.3%) (Table 2). The average serum IgG concentrations were calculated as 2404.41 mg/dl, 1617.67 mg/dl and 2013.22 mg/dl in healthy, recovered, and lost lambs in this group, respectively. The number of lambs with FPT was calculated as 3, 3, 3 and the FPT rate was calculated as 18.75%, 42.86%, 42.86% in healthy, recovering, and lost lambs in this group, respectively. The average LW at day 120 was 39.95 kg for

the healthy lambs in this group, while it was measured as 24.46 kg for lambs that were diseased. On the other hand, while 24 lambs (77.4%) in the BL group did not contract any diseases, a total of 7 lambs (22.6%) contracted diseases and 4 of these lambs (12.9%) died at various ages (Table 3). The average serum IgG concentrations were calculated as 3357.94 mg/dl, 2542.44 mg/dl and 2097.75 mg/dl in healthy, recovered, and lost lambs in this group, respectively. The number of lambs with FPT was calculated as 1, 1, 0, and the FPT rate was calculated as 4.16%, 33.3%, 0% in healthy, recovered, and lost lambs in this group, respectively. The average LW at day 120 was 41.96 kg for the healthy lambs in this group, while it was measured as 29.01 kg for lambs that were diseased.

Table 2. Table of morbidity, mortality and FPT of lambs.

Colostrum Intake Method	Lamb Health	Lamb Number	% Rate	Average IgG Concentration (mg/dl)	Average LW at 120th day	Number of FPTs	FPT rate (%)
Natural Suckling (NL Group)	Healthy	16	%53,3	2404,41	39,95	3	18,75
	Diseased (recovered)	7	% 23,3	1617,67	24,46	3	42,86
	Diseased (lost)	7	% 23,3	2013,22	-	3	42,86
Bottle Fed (BL Group)	Healthy	24	%77,4	3357,94	41,96	1	4,16
	Diseased (recovered)	3	%9,7	2542,44	29,01	1	33,3
	Diseased (lost)	4	%12,9	2097,75	-	0	0

While the FPT rate of the lambs in the NL group was 30%, the FPT rate was found to be 6.45% in the bottle-fed group. The total FPT ratio of the lambs in both groups was calculated as 18.03%. FPT was detected in 9 of the 30 lambs in the NL group. 6 of the lambs with FPT were diseased (5 pneumonia, 1 trauma), and 3 of them (2 pneumonia, 1 trauma) were lost. On the other hand, FPT was detected in only 2 out of 31 lambs in the BL group. One of these two lambs did not contract any disease, while the other contracted pneumonia and later recovered (Table 6). All

the lambs with FPT in both groups who contracted disease and/or were lost were in the neonatal period. In other words, 6 out of 14 lambs in the NL group that got sick had FPT, and 3 out of 7 lambs that died from among the lambs that got sick had FPT. Looking at the lambs in the NL group individually (Table 5), it was found that while lambs numbered 6, 19, 26 and 27 had sufficient IgG and were lost, lambs numbered 7, 9, 16, 22 and 29 did not contract disease, or survived the disease if they did, despite having insufficient IgG. In the BL group, FPT was found in only

1 out of 7 lambs who got sick, and none of the 4 lambs that died from among the lambs that got sick had FPT.

Information about the sexes and birth weights of the lambs were shown in Table 3. In short, a total of 61 lambs, including 17 male and 13 female in the NL group and 18 male and 13 female in the BL group, took part in the study. While the average birth weight of the female lambs in the NL group was 3.42 kg, the average birth weight of the male lambs in the same group was 3.95 kg. The average birth

weight of the female lambs in the BL group was 3.56 kg, and the average birth weight of the male lambs in this group was 4.53 kg. The average birth weight of all female lambs in the study was calculated as 3.49, while the average birth weight of all males was 4.25 kg. In addition, while the average birth weight of the lambs in the NL group (3.70 ± 0.75 kg) was lower compared to the average birth weight of the lambs in the BL group (4.12 ± 1.01 kg), this difference was statistically insignificant ($p=0.077$).

Table 3. Average birth weights of lambs according to gender.

Lamb Birth Weight (kg)					
NL Group (30 lambs)		BL Group (31 lambs)		Total (61 lambs)	
Female (13 lambs)	Male (17 lambs)	Female (13 lambs)	Male (18 lambs)	Female (26 lambs)	Male (35 lambs)
3,42 (2,55-4,2)	3,95 (2,70-5,30)	3,56 (2,30-4,35)	4,53 (2,80-6,50)	3,49 (2,30-4,35)	4,25 (2,70-6,50)

The average maternal BCS was determined as 3.25 ± 0.70 in the NL group and 3.35 ± 0.65 in the BL group. When the two groups were compared, there was no statistically significant difference between maternal BCS values ($p=0.38$).

2000 mg/dl has been accepted as the cutoff value for colostrum quality in sheep; an IgG concentration of 2000 mg/dl and above have been accepted as Quality Colostrum (QC), and an IgG concentration of 2000 mg/dl and below have been accepted as Poor-Quality Colostrum (PQC). The average colostral IgG concentration and the number and proportions of quality colostrum in sheep were given in Table 4. The average of IgG concentration of colostrum samples taken from BL group sheep was 7045.29 ± 3690.37

mg/dl, and 21 out of 23 colostrum samples (91.30%) were found to be QC. The average of IgG concentration of colostrum samples taken from NL group sheep was 8366.89 ± 3047.84 mg/dl, and all 20 of the colostrum samples (100%) were found to be QC. While the IgG concentrations of all 43 colostrums in both groups individually varied between 1534.41 mg/dl and 15306.81 mg/dl, the average IgG concentration was calculated as 7659.99 ± 3432.33 mg/dl, and 41 of these colostrums (95.35%) were found to be QC (Table 3). Although there were differences between the groups in terms of average IgG concentrations, it was determined that this difference was statistically insignificant ($p=0.084$) (Table 1).

Table 4. Colostral IgG concentrations and colostrum quality.

Groups	n	Average IgG concentration (mg/dl)	The number of Quality Colostrum (QC)	QC rate (%)
NL	20	8366.89 ± 3047.84	20	100
BL	23	7045.29 ± 3690.37	21	91,30
Total	43	7659.99 ± 3432.33	41	95,35

Table 5. Detailed information of lambs in the NL group.

Lamb No	Birth Weight (kg)	Gender	Multiple Birth Siblings	Serum IgG concentration (mg/dl)	Maternal Colostrum IgG concentration (mg/dl)	Maternal Age	Maternal BCS (out of 5)	The Health of the Lamb	LW at 120th Day (kg)
NL1	3,40	M	2	1225,982	12851,16	2	2,5	Survived pneumonia at day 13	31,5
NL2	4,10	F	2	1530,681	12851,16	2	2,5		38
NL3	4,80	M	1	4857,054	5393,93	3	4		65
NL4	5,05	M	1	4272,032	9438,53	4	3		45,5
NL5	3,00	M	1	1053,996	9984,73	3	4	Died on day 20 (pneumonia)	-
NL6	5,30	M	1	2814,480	2739,66	4	3	Died on day 25 (pneumonia)	-
NL7	3,45	M	2	2354,045	12851,16	5	4	Survived pneumonia at day 16	27,5
NL8	3,80	F	2	2354,045	12851,16	5	4		32,3
NL9	3,60	M	2	734,401	5393,93	7	2,5		42,9
NL10	4,20	F	2	1285,116	5393,93	7	2,5		18

Table 5. (Continue).

Lamb No	Birth Weight (kg)	Gender	Multiple Birth Siblings	Serum IgG concentration (mg/dl)	Maternal Colostrum IgG concentration (mg/dl)	Maternal Age	Maternal BCS (out of 5)	The Health of the Lamb	LW at 120th Day (kg)
NL11	4,00	F	1	3223,002	8373,21	4	3,5	Survived pneumonia at day 18	24,5
NL12	4,80	M	1	1790,691	9438,53	3	2,5		51,5
NL13	4,20	M	1	3448,668	12851,16	6	4		31,65
NL14	3,75	F	1	2065,146	6350,91	4	2,5	Survived pneumonia at day 14	30,3
NL15	4,35	M	2	1658,880	9438,53	6	3		43,45
NL16	4,20	M	2	447,306	9438,53	6	3	Survived pneumonia at day 21	28,9
NL17	2,55	F	3	2207,790	24519,64	4	2,5	Survived pneumonia at day 23	28,5
NL18	2,70	M	3	1724,334	12259,82	4	2,5		39,8
NL19	2,70	F	3	2280,466	12259,82	4	2,5	Died on day 25 (pneumonia)	-
NL20	3,15	M	1	3852,224	8901,34	3	2,5		52
NL21	3,45	M	2	2136,016	5393,93	3	4,5		40,5
NL22	3,50	F	2	943,853	5393,93	3	4,55		39,5
NL23	4,19	F	1	3852,224	9438,53	3	2,5		36,55
NL24	2,30	F	1	539,393	3588,31	4	4	Died on day 27 (pneumonia)	-
NL25	4,10	M	1	1658,880	5867,91	6	3,5		33,2
NL26	4,10	M	2	2503,912	9438,53	9	4	Died on day 35 (tetanus).	-
NL27	3,50	F	2	2735,483	9438,53	9	4	Died on day 30 (pneumonia)	-
NL28	2,85	F	3	2975,180	7344,01	5	3		30,25
NL29	3,05	F	3	0,000	7344,01	5	3	Survived pneumonia at day 16	27,5
NL30	3,10	M	3	192,713	7344,01	5	3	Died on day 7 (trauma)	-

Table 6. Detailed information of lambs in the BL group.

Lamb No	Birth Weight (kg)	Gender	Multiple Birth Siblings	Serum IgG concentration (mg/dl)	Maternal Colostrum IgG concentration (mg/dl)	Maternal Age (years)	Maternal BCS	The Health of the Lamb	LW at 120th Day (kg)
BL1	4,3	F	1	2503,912	7854,09	3	4,0		46,10
BL2	3,2	F	2	5160,400	15306,81	4	3,5		39,50
BL3	3,0	F	2	3317,760	15306,81	4	3,5		35,50
BL4	6,05	M	1	2503,912	2739,66	3	3,5	Survived pneumonia at day 25	27,05
BL5	4,1	M	2	1530,681	1534,41	4	4,0	Died on day 25 (pneumonia)	-
BL6	4,5	M	2	586,791	1534,41	4	4,0		42,95
BL7	5,15	M	1	4708,090	7344,01	5	3,0		43,45
BL8	4,3	F	1	3717,760	4928,98	7	3,5		31,60
BL9	6,5	M	1	4130,292	6350,91	6	4,0		58,45
BL10	4,2	M	2	4130,292	4473,06	2	4,5		42,75
BL11	4,0	F	2	2975,180	4473,06	2	4,5		45,50
BL12	4,8	M	1	2428,527	5393,93	5	3,0		46,35
BL13	5,2	M	1	1658,880	7344,01	6	4,5		52,25
BL14	5,5	M	1	4272,032	4026,17	3	3,5		47,10
BL15	4,7	M	1	4272,032	11104,22	5	2,5		43,80
BL16	5,9	M	1	2975,180	6842,92	3	3,5		52,90
BL17	3,7	F	2	4415,58	9438,53	4	3,5		42,70

Table 6. (Continue).

Lamb No	Birth Weight (kg)	Gender	Multiple Birth Siblings	Serum IgG concentration (mg/dl)	Maternal Colostrum IgG concentration (mg/dl)	Maternal Age (years)	Maternal BCS	The Health of the Lamb	LW at 120th Day (kg)
BL18	3,5	F	2	2503,912	9438,53	4	3,5		36,50
BL19	3,0	F	1	4857,054	3159,47	5	4,0		39,40
BL20	4,05	M	1	3317,760	6350,91	4	3,5		31,05
BL21	3,9	F	2	3317,760	10539,96	3	3,0		35,15
BL22	4,2	M	2	3056,885	10539,96	3	3,0		45,07
BL23	3,15	F	1	1658,880	4026,17	3	2,0	Died on day 17 (pneumonia)	-
BL24	4,35	F	1	4130,292	11104,22	4	3,0		38,40
BL25	3,85	M	1	3825,000	9438,53	3	2,0		47,35
BL26	2,80	M	2	3448,668	4473,06	2	3,0	Died on day 15 (trauma)	-
BL27	2,30	F	2	2065,146	4473,06	2	3,0	Died on day 35 (pneumonia)	-
BL28	3,0	M	2	1995,178	3588,31	5	2,5		32,40
BL29	2,80	M	2	273,966	3588,31	5	2,5	Survived pneumonia at day 11	30,20
BL30	4,20	M	2	3223,002	14679,35	4	3,5		35,30
BL31	3,55	F	2	4857,054	14679,35	4	3,5	Had pneumonia at day 18	29,60

DISCUSSION AND CONCLUSION

Since lambs are born agammaglobulinemic or hypogammaglobulinemic due to the syndesmochorial placental structure of sheep, it is of utmost importance for lambs to receive colostrum in sufficient quantity and quality as soon as possible after birth (Gokce et al., 2014). There are various ways for lambs to get colostrum. Bottle feeding and feeding by esophageal probe are widely used in sheep farms in many countries (Shiels et al., 2022). In contrast, since the use of these methods in farm practice is very limited in our country, the intake of colostrum by naturally suckling from the mother is quite common (Gökçe et al., 2013a). However, our study showed that the serum IgG concentration of lambs who received colostrum naturally from the mother (NL group) was statistically significantly lower at 36-48 hours compared to the group given colostrum by bottle (BL group) ($p < 0.001$). Similar results have been obtained in studies conducted on calves (Besser et al., 1991; Gökçe and Erdoğan, 2013). When bottle feeding and feeding by esophageal tube were compared in calves, it was reported that both methods were successful in providing Passive Transfer of Immunity (PTI) (Desjardins-Morrisette et al., 2018). In contrast to our study, other studies conducted on lambs showed no significant difference between natural suckling and bottle feeding (Halliday and Williams, 1979; Altiner et al., 2005; Hernández-Castellano et al., 2015a).

There is a strong relationship between serum IgG concentration and neonatal morbidity and mortality in lambs. In our study, serum IgG concentrations of lambs in the NL group were measured as 2097.02 ± 1213.07 mg/dl, while the serum IgG concentrations of lambs in the BL group were found to be 3155.41 ± 12455 mg/dl. Neonatal morbidity and mortality of lambs in the NL group (46.6%, 23.3%, respectively) were found to be higher than neonatal morbidity and mortality of lambs in the BL group (22.6%, 12.9%, respectively). It was observed that the neonatal morbidity and mortality rate of lambs in the NL group was consistent with the results found by Gökçe and Erdoğan, (2009) (48.6%; 20.8%, respectively). The fact that the results of the NL group and the results of the study were

similar constitutes significance since the lambs in both studies received colostrum through natural suckling. On the other hand, the same parameters for lambs in the BL group (23.3%; 12.9%, respectively) were lower than both the NL group and the results found by Gökçe and Erdoğan, (2009). In another study that examined 336 Akkaraman breed lambs, neonatal morbidity and mortality for bottle-fed lambs were found to be 16.9% and 3.8%, respectively (Gokce et al., 2014). Moreover, the results of the study conducted by Gokce et al., (2014) are lower than the results of both groups in this study. The reason for this may be other factors that affect neonatal morbidity and mortality. Neonatal mortality rates for bottle-fed lambs in our study are higher than the results reported by Shiels et al., (2022). The reason for this may be that colostrum has been given to lambs that have difficulty standing up and that did not have a suckling reflex using an esophageal probe in the sheep farms included in this study.

In various other studies, the FPT rate in bottle-fed lambs has been found to be between 8.5% and 39.5% (Carvalho et al., 2009; Flaiban et al., 2009; Gökçe and Erdoğan, 2009; Turquino et al., 2011; Alves et al., 2015; Demis et al., 2020; Dunière et al., 2022). In our study, the FPT rate of lambs in the NL group was found to be 30%, while the FPT rate of lambs in the BL group was 6.45%. The FPT rate of lambs in the NL group found in our study was lower than the results reported by Alves et al., (2015) (39.5%), but higher than the results found by Carvalho et al., (2009) (%24,4), Flaiban et al., (2009) (%21.42), Gökçe and Erdoğan, (2009) (%19), Turquino et al., (2011) (%12.4), Demis et al., (2020) (8.5%) and Dunière et al., (2022) (20%). In contrast, The FPT rate of lambs in the BL group found in our study was lower than all the results found in the studies mentioned above. Considering the results of our study and of other studies conducted under various conditions and on different breeds, it was observed that giving colostrum to lambs by bottle caused a significant decrease in the FPT rate.

It has been reported that passive immune transfer in newborn ruminants is not only related to immunity, but also closely related to the growth performance of neonates

(Massimini et al., 2007; Yalcin et al., 2010; Gökçe et al., 2013). In our study, although the average live weight of lambs in the BL group at day 120 were higher than the lambs in the NL group, this difference was not statistically significant. The results of our study, while showing similarities with the results of some studies (Halliday and Williams, 1979; Ac et al., 2018), differed from the results of other studies (Massimini et al., 2007; Gökçe et al., 2013). In their study, Hernández-Castellano et al., (2015a) have reported that their NL group had a higher LW increase before weaning compared to the bottle-fed group. However, this was reported to be reversed after weaning, and it was emphasized that the lambs in the NL group may have experienced stress after weaning, while the other group may have experienced a greater LW increase due to compensatory growth. Therefore, although there is a relationship between LW and PTI, many other factors can affect LW increase. In our study, it has been also found that the LW averages of lambs who had never contracted disease in both groups at day 120 were found to be higher compared to those who contracted disease and recovered. This suggest that morbidity in the neonatal or post-neonatal stage causes economic losses, aside from mortality.

The individual diversity of the colostral IgG concentrations of the sheep included in our study (1534.41 mg/dl to 15306.81 mg/dl) showed similarities with the results of many previous studies (Tabatabaei et al., 2013; Boucher, 2014; Gokce et al., 2014; Alves et al., 2015; Kessler et al., 2019). An IgG concentration of 2000 mg /dl and above is accepted to qualify colostrum of sheep as quality colostrum. In our study, although the colostral IgG concentration averages in both groups were different, it was found that this difference was not statistically significant. This was expected due to the fact that the sheep included in the study were of the same flock, exposed to the same environmental conditions, and were randomly divided into two groups. The total average IgG concentration of colostrums in both groups was measured at 7659.99 ± 3432.33 mg/dl. While the average colostral IgG concentration of Karya breed of sheep used in this study was higher than those of Awassi, Lori-Bakhtiari, Shaul, Rambouillet, Targhee, Columbia, Finnish Landrace and Finn hybrid breeds of sheep grown in various regions across the world, (Gilbert et al., 1988; Higaki et al., 2013; Tabatabaei et al., 2013; Vatankhah, 2013), it was lower than the colostral IgG concentration of Polypay, Merino, Caracal and Dorper breeds of sheep (Gilbert et al., 1988; Hashemi et al., 2008; Boucher, 2014). In addition, it was found that the colostrum of Karya breed of sheep had a higher colostrum quality than that of Akkaraman breed of sheep, which are widely found in Turkey, especially in Central and Eastern Anatolia (Maden et al., 2003; Gokce et al., 2014) and had a lower colostrum quality than that of Kivircik-Merino crossbreed of sheep, which are especially found western Anatolia (Sarica, 2022). These differences may be caused by many reasons, such as the nutritional characteristics, the year of birth, the birth season, the vaccination status during pregnancy, and especially the racial factor of the sheep included in the study, as well as the method of analyzing the quality of colostrum.

As previously reported in different studies (Boucher, 2014; Gökçe and Atakişi, 2019; Dunière et al., 2022), there was no correlation between maternal colostrum IgG concentration and offspring serum IgG concentration found in our study ($r = 0.018$). In contrast, in the studies conducted by Ac et al., (2018) and Vatankhah, (2013) on

sheep, it was suggested that there is a positive relationship between the two parameters mentioned. Similarly, in a study recently conducted by Kara and Ceylan, (2021) on cows, it was reported that there is a strong positive relationship between the quality of colostrum and the serum IgG concentration of neonates, and the probability of developing FPT increases by about 15 times in calves fed with poor-quality colostrum. The reason for the inability to establish this correlation in our study may be due to the insufficient sample size of the study.

As a result of our study, it was found that PTI did not occur sufficiently in lambs receiving colostrum by naturally suckling since these lambs received as much colostrum as they desire to at will, and that this causes a higher rate of FPT. In contrast, it was found that since colostrum quality, colostrum intake timing and colostrum quantity, which all affect PTI sufficiency, could be controlled in lambs that were bottle-fed, the risk of FPT was lowered for this group. In addition, it was also found that neonatal morbidity and mortality were lower in bottle-fed lambs since PTI was higher. Taking the results of this study into account, economic losses can be minimized by reducing FPT, which is one of the biggest predisposing factors of neonatal morbidity and mortality, which is common in Turkey, by bottle-feeding lambs, especially within the first 24 hours after birth.

Acknowledgements

This study is produced from C. Egdir's masters' thesis, a student at the Institute of Health Sciences, Kırıkkale University.

Conflict of Interest

The authors declare that they have no competing interests.

Authorship contributions

Concept: C.E., N.O., Design: C.E., N.O., Data Collection or Processing: U.E., N.E., M.E., C.E., Analysis or Interpretation: M.A, N.O., C.E., Literature Search: C.E., N.O., Writing: C.E., N.O.

Financial Support

This work was supported by Scientific Research Projects Coordination Unit of Kırıkkale University. Project number 2021/103

Ethical Approval

This study was conducted with the permission of the Kırıkkale University Local Ethics Committee for Animal Experiments with the decision No. 2021/03 - 16 dated 20.03.2021.

REFERENCES

- Ac B, Hassid G, Leibovich H, Solomon, D, Dm H, Mf C. 2018. A field trial evaluating the health and performance of lambs fed a bovine colostrum replacement. *Journal of Animal Research and Nutrition*, 3(1:6): 1–4. <https://doi.org/10.21767/2572-5459.100044>
- Altiner A, Özpınar A, Erhard M. 2005. Serum immunoglobulin G levels in lambs fed colostrum and dam milk or cow milk and milk replacer after birth. *Medycyna Weterynaryjna*, 61(10): 1135–1137.
- Alves AC, Alves NG, Ascari IJ, Junqueira FB, Coutinho AS, Lima RR, Pérez JRO, De Paula SO, Furusho-Garcia IF, Abreu LR. 2015. Colostrum composition of Santa Inês sheep and passive transfer of immunity to lambs. *Journal of Dairy Science*, 98(6): 3706–

3716. <https://doi.org/10.3168/jds.2014-7992>.

Besser TE, Gay CC, Pritchett L. 1991. Comparison of three methods of feeding colostrum to dairy calves. *Journal of the American Veterinary Medical Association*, 198(3): 419–422.

Boucher Z. 2014. Breed and diet effects on ewe colostrum quality, lamb birthweight and the transfer of passive immunity. Charles Sturt University, Wagga Wagga.

Britti D, Massimini G, Peli A, Luciani A, Boari A. 2005. Evaluation of serum enzyme activities as predictors of passive transfer status in lambs. *Journal of the American Veterinary Medical Association*, 226(6): 951–955. <https://doi.org/10.2460/javma.2005.226.951>.

da Costa Flaiban KKM, Balarin MRS, de Azambuja Ribeiro EL, de Castro FAB, Mori RM, Lisboa JAN. 2009. Transferência de imunidade passiva em cordeiros cujas mães receberam dietas com diferentes níveis de energia ou proteína no terço final da gestação. *Ciência Animal Brasileira*, 1(0), 181–185. <https://doi.org/10.5216/cab.v1i0.7746>

Demis C, Aydefruh D, Wondifra Y, Ayele F, Alemnew E, Asfaw T. 2020. Maternal immunoglobulin in the serum of newborn lambs and its relation with neonatal mortality. *Online Journal of Animal and Feed Research*, 10(3): 119–124. <https://doi.org/10.36380/scil.2020.ojaf16>

Desjardins-Morrisette M, van Niekerk JK, Haines D, Sugino T, Oba M, Steele MA. 2018. The effect of tube versus bottle feeding colostrum on immunoglobulin G absorption, abomasal emptying, and plasma hormone concentrations in newborn calves. *Journal of Dairy Science*, 101(5): 4168–4179. <https://doi.org/10.3168/jds.2017-13904>.

Dunière L, Renaud JB, Steele MA, Achard CS, Forano E, Chaucheyras-Durand F. 2022. A live yeast supplementation to gestating ewes improves bioactive molecule composition in colostrum with no impact on its bacterial composition and beneficially affects immune status of the offspring. *Journal of Nutritional Science*, 11: 1–18. <https://doi.org/10.1017/jns.2022.3>.

Filteau V, Bouchard É, Fecteau G, Dutil L, DuTremblay D. 2003. Health status and risk factors associated with failure of passive transfer of immunity in newborn beef calves in Québec. *Canadian Veterinary Journal*, 44(11): 907–913.

Gilbert RP, Gaskins CT, Hillers JK, Parker CF, McGuire TC. 1988. Genetic and environmental factors affecting immunoglobulin G1 concentrations in ewe colostrum and lamb serum. *Journal of animal science*, 66(4): 855–863. <https://doi.org/10.2527/jas1988.664855x>.

Godden S. 2008. Colostrum management for dairy calves. *Veterinary Clinics of North America - Food Animal Practice*, 24(1): 19–39. <https://doi.org/10.1016/j.cvfa.2007.10.005>.

Gökçe E, Atakişi, O. 2019. Interrelationships of serum and colostrum IgG (passive immunity) with total protein concentrations and health status in lambs. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, 25(3): 387–396. <https://doi.org/10.9775/kvfd.2018.21035>.

Gökçe E, Atakişi O, Kirmizigül AH, Erdoğan HM. 2013. Risk factors associated with passive immunity, health, birth weight and growth performance in lambs: II. effects of passive immunity and some risk factors on growth performance during the first 12 weeks of life. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, 19(4): 619–627. <https://doi.org/10.9775/kvfd.2013.8442>.

Gokce E, Atakisi O, Kirmizigul AH, Unver A, Erdogan HM. 2014. Passive immunity in lambs: Serum lactoferrin concentrations as a predictor of IgG concentration and its relation to health status from birth to 12 weeks of life. *Small Ruminant Research*, 116(2–3): 219–228.

<https://doi.org/10.1016/j.smallrumres.2013.11.006>.

Gökçe E, Erdoğan HM. 2009. Neonatal kuzu sağlığı üzerine epidemiyolojik bir çalışma. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, 15(2): 225–236. <https://doi.org/10.9775/kvfd.2008.104-a>

Gökçe E, Erdoğan HM. 2013. Neonatal buzağlarda kolostrum immünoglobulinlerin pasif transferi. 4(1): 18–46.

Gökçe E, Kirmizigül AH, Atakişi O, Erdoğan HM. 2013. Risk factors associated with passive immunity, health, birth weight and growth performance in lambs: III-The relationship among passive immunity, birth weight, gender, birth type, parity, dam's health, and lambing season. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, 19(5): 741–747. <https://doi.org/10.9775/kvfd.2013.8441>.

Gokce E, Kirmizigul AH, Atakisi O, Kuru M, Erdogan HM. 2021. Passive immunity in lambs: Colostral and serum γ -glutamyltransferase as a predictor of IgG concentration and related to the diseases from birth to 12 weeks of life. *Veterinarni Medicina*, 66(2): 45–57. <https://doi.org/10.17221/57/2020-VETMED>.

Halliday R, Williams MR. 1979. The absorption of immunoglobulin from colostrum by bottle-fed lambs. *Annales de Recherches Veterinaires*, 10(4): 549–556.

Hashemi M, Zamiri MJ, Safdarian M. 2008. Effects of nutritional level during late pregnancy on colostrum production and blood immunoglobulin levels of Karakul ewes and their lambs. *Small Ruminant Research*, 75(2–3): 204–209. <https://doi.org/10.1016/j.smallrumres.2007.11.002>.

Hernandez-Castellano LE, Suarez-Trujillo A, Martell-Jaizme D, Cugno G, Argüello A, Castro N. 2015. The effect of colostrum period management on BW and immune system in lambs : from birth to weaning. *Animal*, 9(10):1672–1679. <https://doi.org/10.1017/S175173111500110X>.

Hernández-Castellano LE, Morales-delaNuez A, Sánchez-Macías D, Moreno-Indias I, Torres A, Capote J, Argüello A, Castro N. 2015. The effect of colostrum source (goat vs. sheep) and timing of the first colostrum feeding (2h vs. 14h after birth) on body weight and immune status of artificially reared newborn lambs. *Journal of Dairy Science*, 98(1): 204–210. <https://doi.org/10.3168/jds.2014-8350>

Higaki S, Nagano M, Katagiri S, Takahashi Y. 2013. Effects of parity and litter size on the energy contents and immunoglobulin G concentrations of awassi ewe colostrum. *Turkish Journal of Veterinary and Animal Sciences*, 37(1): 109–112. <https://doi.org/10.3906/vet-1111-12>.

Kara E, Ceylan E. 2021. Failure of passive transfer in neonatal calves in dairy farms in Ankara region. *Turkish Journal of Veterinary and Animal Sciences*, 45(3). 556–565. <https://doi.org/10.3906/vet-2011-26>.

Keskin M, Güler Z, Gül S, Biçer O. 2007. Changes in gross chemical compositions of ewe and goat colostrum during ten days postpartum. *Journal of Applied Animal Research*, 32: 25–28. <https://doi.org/10.1080/09712119.2007.9706840>.

Kessler EC, Bruckmaier RM, Gross JJ. 2019. Immunoglobulin G content and colostrum composition of different goat and sheep breeds in Switzerland and

Germany. *Journal of Dairy Science*, 102(6): 5542–5549. <https://doi.org/10.3168/jds.2018-16235>

Loste A, Ramos JJ, Fernández A, Ferrer LM, Lacasta D, Verde MT, Marca MC, Ortín A. 2008. Effect of colostrum treated by heat on immunological parameters in newborn lambs. 117: 176–183. <https://doi.org/10.1016/j.livsci.2007.12.012>.

Maden M, Altunok V, Birdane FM, Aslan V, Nizamlioglu M. 2003. Blood and colostrum/milk serum γ -glutamyltransferase activity as a predictor of passive transfer status in lambs. *Journal of Veterinary Medicine, Series B*, 50(3): 128–131. <https://doi.org/10.1046/j.1439-0450.2003.00629.x>.

Massimini G, Mastellone V, Britti D, Lombardi P, Avallone L. 2007. Effect of passive transfer status on preweaning growth performance in dairy goat kids. *Journal of the American Veterinary Medical Association*, 231(12): 1873–1877. <https://doi.org/10.2460/javma.231.12.1873>.

Sarıca M. 2022. Koyunlarda kolostrum kalitesinin brix refraktometre kullanılarak belirlenmesi. Yüksek Lisans Tezi. Balıkesir Üniversitesi, Sağlık Bilimleri Enstitüsü, Balıkesir.

Shiels D, Loughrey J, Dwyer CM, Hanrahan K, Mee JF, Keady TWJ. 2022. A Survey of Farm Management Practices Relating to the Risk Factors, Prevalence, and Causes of Lamb Mortality in Ireland. *Animals (Basel)*, 12(1): 1–14.

Tabatabaei S, Nikbakht G, Vatankhah M, Sharifi H, Alidadi N. 2013. Variation in colostral immunoglobulin G concentration in fat tailed sheep and evaluation of methods for estimation of colostral immunoglobulin content. *Acta Veterinaria Brno*, 82(3): 271–275. <https://doi.org/10.2754/avb201382030271>.

Turquino CF, Flaiban KMC, Lisboa JAN. 2011. Transferência de imunidade passiva em cordeiros de corte manejados extensivamente em clima tropical. *Pesquisa Veterinária Brasileira*, 31(3): 199–205. <https://doi.org/10.1590/s0100-736x2011000300003>.

Vatankhah M. 2013. Relationship between immunoglobulin concentrations in the ewe's serum and colostrum, and lamb's serum in Lori-Bakhtiari sheep. *Iranian Journal of Applied Animal Science*, 3(3): 539–544.

Yalcin E, Temizel EM, Yalcin A, Carkungoz E. 2010. Relationship with gamma glutamyl transferase activity and glutaraldehyde coagulation test of serum immunoglobulin G concentration in newborn goat kids. *Small Ruminant Research*, 93(1): 61–63. <https://doi.org/10.1016/j.smallrumres.2010.03.017>.

Zhu HL, Zhao XW, Chen S, Tan W, Han RW, Qi YX, Huang DW, Yang YX. 2021. Evaluation of colostrum bioactive protein transfer and blood metabolic traits in neonatal lambs in the first 24 hours of life. *Journal of Dairy Science*, 104(1): 1164–1174. <https://doi.org/10.3168/jds.2020-18340>.