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Components and specific gravity of colostrum from Anatolian buffalo cows and effects on growth of buffalo calves

H. Erdem[#], I.C. Okuyucu & H. Demirci
Department of Animal Science, Faculty of Agriculture, University of Ondokuz Mayis, 55139- Samsun, Turkey

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Abstract

This study aimed to determine the relationship between specific gravity (SG) of colostrum and its components, namely dry matter, fat and protein, on the growth of Anatolian buffalo calves. The study used 62 Anatolian buffalo cows and their calves (32 females and 30 males). The SG of the colostrum was measured with a colostrometer™, and the components were analysed with a milk analyser after calving. A single value for analysis was obtained by taking the arithmetical mean of the SG values of the colostrum two hours after birth. The values were classified as below average (Group 1: <1.070 g/ml) and above average (Group 2: ≥1.070 g/ml). All calves were weighed with an electronic scale at birth and on days 15, 30, 45, and 60 afterwards. Body measurements were recorded at these times. Calves that received high SG colostrum were heavier on days 15 and 30. The chest girth measurements of Group 2 were greater at all ages. At days 30, 45, and 60 after calving, Group 2 had greater wither heights as well. Thus, Group 2 realized greater growth during the neonatal period compared with Group 1. Feeding calves with high SG colostrum is important to obtain adequate immunity and to increase growth.

Keywords: age of dam, calving season, colostrometer, growth, physical dimensions
[#]Corresponding author: hserdem@omu.edu.tr

Introduction

Profitable livestock breeding of buffaloes is possible with high vitality, sufficient immunity, optimum growth, and healthy calves. However, these aspects are often neglected in the early life of the calves. Poor growth, high morbidity, and mortality are common in weaned buffalo calves (Gupta *et al.,* 2019), with the mortality rate of buffalo calves being between 9.4% (Zaman *et al.,* 2006) and 17.98% (Khan *et al.,* 2007). The death rate of buffalo calves between birth and 30 days old was 26.5% (Khatun *et al.,* 2009). In a similar study, Kharkar *et al. (*2019) reported that among total calf deaths, the highest deaths were in buffalo calves less than a month old (15.89%). However, for sustainable buffalo breeding, neonatal calf (0–90 days) mortality should be less than 5%. High mortality rates in calves occur mostly because of insufficient passive immunity and inappropriate management conditions (Tyler *et al.,* 1999; Zaman *et al.,* 2006; Gulliksen *et al.,* 2008; Hang *et al.,* 2017). Therefore, most calf mortality could be reduced with appropriate management and colostrum (Kehoe *et al.,* 2007; Raboisson *et al.,* 2013; Kharkar *et al.,* 2019; Rashmi *et al.,* 2020).

Colostrum is defined as the first milk secreted from the udder in mammals after birth, which is rich in nutrients necessary to activate the immune system and enhance the growth of calves, such as antimicrobials and growth factors. However, calves do not have sufficient passive immunity after birth because of the placenta structure in buffaloes (Erdem & Okuyucu, 2020). The calf is born agammaglobulinemic, but immediately after birth, its immunity is developed by transferring maternal immune factors through the colostrum. Subsequently, the immune system develops gradually and gains functionality (Cortese, 2009; Novo *et al.,* 2017; Chaudhary *et al.,* 2018).

The high levels of antimicrobial and growth factors in colostrum decline rapidly after birth (Erdem & Okuyucu, 2020). Changes occur in the structure of colostrum and in the digestive system of the calf during this period. Proteolytic activity in the digestive systems of newborn calves is low. The high levels of trypsin inhibitors in colostrum help immunoglobulins to pass through the abomasum without being digested and absorbed by the intestines (Aydogdu, 2014). At 24–36 hours after birth, immunoglobulins and various

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macromolecules from the small intestine mucosa are absorbed by pinocytosis. This absorption decreases rapidly in the following hours owing to the changes in the intestinal structure (Weaver *et al.,* 2000). Therefore, it is important for calves to drink a sufficient quantity of high SG colostrum in the shortest possible time after birth.

The optimum growth performance of buffalo calves depends on good nutrition in the neonatal period. The growth performance of calves before and after weaning is associated with colostrum and milk feeding programmes for newborn calves (Morrill et al., 2012; Goncu et al., 2014). Yuceer & Ozbeyaz (2010) and Erez & Goncu (2012) emphasized that calves fed high-quality colostrum have sufficient colostral immunity and better growth traits. Therefore, the quality of colostrum should be measured to determine appropriate colostrum management (de Souza et al., 2020). However, routine colostrum quality screenings and sensitive colostrum management are often neglected in buffalo farms.

Researchers often associate colostrum quality with high levels of immunoglobulin (Hoyraz *et al.,* 2015). Similarly, Çolakoğlu *et al.* (2021) emphasized that colostrum with high levels of immunoglobulin G, immunoglobulin M and immunoglobulin A is defined as 'good quality colostrum'. A simple method to estimate the quality of colostrum at dairy farms is to use a colostrometer. The KRUUSE colostrum densimeter (KRUUSE UK Ltd, Langeskov, Denmark) assesses the quality of the colostrum based on its SG (Kaygisiz & Kose, 2007; Puppel *et al.,* 2019). In addition, dry matter (DM), fat, non-fat dry matter, protein, lactose, vitamin, and mineral levels in colostrum are used as quality indicators. All these elements are important for the future of the calf. Feeding calves with high-quality colostrum reduces pre-weaning morbidity and improves growth performance (Turini *et al.,* 2020).

In dairy cattle, there are many studies on the assessing the quality of colostrum and the effects of environmental factors on the growth of calves (Kaygisiz & Kose, 2007; Erdem & Okuyucu, 2020). Some studies focused on the DM, fat, protein, and lactose components of colostrum in buffaloes (Abd El-Fattah *et al.,* 2012; Yonis *et al.,* 2014; Ashmawy, 2015). However, reports on the effects of colostrum quality on growth performance of buffalo calves are limited. An understanding of the relationship between growth in buffalo calves, and the components of colostrum and its SG would facilitate future sustainable and profitable breeding. The objectives of this study were i) to determine the relationship between the SG of colostrum from Anatolian buffalo and its components at various periods of colostrum, ii) to evaluate the effects of cow age and calving season on the SG and components of colostrum at various stages, and iii) to determine the relationship between the growth of calves and SG of colostrum.

Materials and Methods

All experimental procedures and animal care protocols were performed in accordance with guidelines and were approved by the local Ethics Committee of Ondokuz Mayis University (Protocol number: 2014/20).

The study was carried out on 62 healthy primiparous and multiparous Anatolian buffalo cows and their calves (32 females and 30 males) in two semi-intensive farms in Samsun, Turkey. The buffalo farms are situated in the Black Sea region of Turkey (40° 50'–41° 51' N, 37° 08'–34° 25' E). The buffalo cows were housed in an open barn system with a concrete floor. The calves were housed in barns in groups of 10. The farms were visited five times a week. The ages of the cows and their calving seasons were recorded regularly and their health status was monitored continuously.

The cows were fed with wheat straw, corn silage, and concentrate under similar feeding conditions and management practices in the two farms. All buffalo cows were fed the same rations throughout the experiment and the routine feeding and management practices followed in farms were not changed. After birth, the calves were free to suckle for five days. The cows were milked once a day in the morning. During the milking, two udder quarters were milked with a milking machine, and the other two were suckled by the calf. Milk drinking programmes were not applied during suckling. After birth, fresh water and calf starter were supplied. Moreover, dry grass of good quality was given on the eleventh day after birth.

To evaluate the quality of the colostrum of buffalo milk at 2, 24, 48, and 72 hours after birth, colostrum samples (approximately 0.5 L in total per cow) were collected from all mammary quarters before the calves had suckled and stored at approximately −22 °C. The samples were analysed after heating to 20 °C to 22 °C in a hot water bath. Specific gravity was measured with a KRUUSE© colostrum densimeter (Kaygısız & Kose, 2007). The DM, fat, and protein percentages of the colostrum were measured with a Lactostar milk analyser (Funke-Gerber, Berlin, Germany).

The calves were weighed and measured at birth, and at 30, 45, and 60 days old. All calves were weighed with an electronic scale on a smooth surface. Chest girth (CG), wither height (WH), chest width (CW), chest depth (CD), rump height (RH), and body length (BL) were recorded.

The cows were divided into two age groups with one group containing cows that were less than or equal to 80 months old, and the second group contained the older cows. Calving season was classified as spring or summer. The specific gravity values recorded in the first two hours after birth were averaged to provide a single value for analysis. Calves that received colostrum with SG less than 1.070 g/ml were allotted to Group 1 and those allotted to Group 2 received colostrum with higher SG. The statistical analyses were performed with the general linear model procedure of SPSS 21.0 (IBM Corp., Armonk, New York, USA). This model was used to determine the effects of age and calving season on the DM, fat, protein and specific gravity of the colostrum at 2, 24, 48, and 72 hours after birth.

$$y_{ijk} = \mu + a_i + b_j + e_{ijk}$$

where y_{ijk} = an observation of DM, fat, protein or specific gravity; μ = the overall mean; a_i = the effect of the age of the cow (i = 1, 2); b_j = the effect of calving season (j = 1, 2); and e_{ijk} = the random error. To evaluate the effects of SG on live weight (LW), chest girth (CG), wither height (WH), chest width (CW), chest depth (CD), rump height (RH), and body length (BL) at birth, 15, 30, 45, 60 days old, the following model was used:

$$y_{ij} = \mu + a_i + e_{ij}$$

where y_{ijk} = an observation of LW, CG, WH, CW, CD, RH, and BL; μ = the overall mean; a_i = the effect of the colostrum group (i = 1, 2); and e_{ijk} = the random error. To determine the effects of age of the cow, calving season, SG and gender on the live weight gain (LWG) and of the calves between 0 and 15 days, 16 and 30 days, 31 and 45 days and 46 and 60 days, and the average daily LWG between 0 and 60 days old (DLWG), the linear model was as follows:

$$y_{ijklm} = \mu + a_i + b_j + c_k + d_l + e_{ijklm}$$

where y_{ijklm} = an observed value of LWG or DLWG; μ = the overall mean; a_i = the effect of the age of the cow (i = 1, 2); b_j = the effect of calving season (j = 1, 2); c_k = the effect of the colostrum groups (k = 1, 2); d_l = the effect of gender (l = 1, 2); and e_{ijklm} = the random error. Estimates were calculated of the correlation between the SG produced at various colostral periods and LW, CG, WH, CW, CD, RH, and BL of the calves at various ages.

Results and Discussion

The SG of the first milking colostrum in buffaloes (1.060 g/ml) was lower (Yonis *et al.*, 2014) than in the present study. After calving, the SG decreased rapidly with time. The SG in colostrum from the cows that were older than 80 months was significantly higher than that from the younger cows at two hours (P <0.001) and 48 hours (P <0.05) after birth. Similarly, in a study of Holstein cows, Erdem & Okuyucu (2020) noted that the effect of cow's age on SG was statistically significantly different at two and 48 hours after calving. These researchers reported that the SG decreased rapidly during subsequent milkings, in agreement with this investigation. However, in the present study no differences were found in the SG between calving seasons at 2, 24, 48, and 72 hours after birth. Thus, buffalo calves should be given sufficient quantities of good quality colostrum in a short time after birth to obtain sufficient passive immunity and optimum growth performance. The average SG values of colostrum at various times after birth are shown in Table 1.

Table 1 Specific gravity values of colostrum (g/ml) at various periods according to buffalo cow age and calving season

Cow age	N	Time after birth			
		2 hours	24 hours	48 hours	72 hours
≤ 80 months	27	1.069 ± 0.0005[a]	1.050 ± 0.0006	1,037 ± 0.0008[a]	1.026 ± 0.0003
> 80 months	35	1.072 ± 0.0004[b]	1.051 ± 0.0005	1.039 ± 0.0005[b]	1.026 ± 0.0003
Calving season					
Spring	28	1.071 ± 0.0004	1.051 ± 0.0005	1.037 ± 0.0007	1.026 ± 0.0003
Summer	34	1.071 ± 0.0005	1.051 ± 0.0006	1.038 ± 0.0006	1.027 ± 0.0003
Mean	62	1.071 ± 0.0003	1.051 ± 0.0004	1.038 ± 0.0005	1.026 ± 0.0002

[a,b] Within an effect and column means with a common superscript did not differ with probability P =0.05

Table 2 presents the changes in colostrum content at various times after calving. In this study, the DM and protein percentages at two hours after calving were higher than those obtained by Abd El-Fattah *et al.* (2012), Yonis *et al.* (2014), and Ashmawy (2015). However, the fat percentage was lower than that obtained by Abd El-Fattah *et al.* (2012) and Yonis *et al.* (2014). At 2, 24 and 48 hours after birth, the fat percentage in colostrum from the older buffalo cows was significantly higher than that from the younger cows (P <0.05). However, the effect of parity on fat percentage was not significant in an experiment conducted with Holstein cows (Erdem & Okuyucu, 2020).

Table 2 Colostrum components (%) at various times after birth as affected by the age of Anatolian buffalo cows and calving season

	Cow age	N	Time after birth			
			2 hours	24 hours	48 hours	72 hours
Dry matter	≤80 months	27	28.71 ± 0.445	23.32 ± 0.302	20.90 ± 0.225	15.18 ± 0.193
	>80 months	35	29.76 ± 0.337	24.03 ± 0.346	20.64 ± 0.440	15.73 ± 0.210
	Calving season					
	Spring	28	29.45 ± 0.413	23.71 ± 0.358	20.78 ± 0.189	15.54 ± 0.283
	Summer	34	29.19 ± 0.379	23.73 ± 0.323	20.73 ± 0.462	15.45 ± 0.141
	Mean	62	29.30 ± 0.277	23.73 ± 0.238	20.75 ± 0.265	15.49 ± 0.148
Fat	Cow age					
	≤80 months	27	8.10 ± 0.258[a]	6.14 ± 0.168[a]	5.28 ± 0.117[a]	5.61 ± 0.118
	>80 months	35	8.63 ± 0.182[b]	6.57 ± 0.128[b]	5.62 ± 0.106[b]	5.68 ± 0.126
	Calving season					
	Spring	28	8.21 ± 0.211	6.23 ± 0.150	5.34 ± 0.124[a]	5.56 ± 0.133
	Summer	34	8.55 ± 0.222	6.51 ± 0.146	5.58 ± 0.105[b]	5.72 ± 0.115
	Mean	62	8.40 ± 0.155	6.38 ± 0.106	5.47 ± 0.081	5.65 ± 0.087
Protein	Cow age					
	≤80 months	27	16.98 ± 0.237	12.69 ± 0.271	5.65 ± 0.176[a]	5.44 ± 0.108
	>80 months	35	17.58 ± 0.309	13.21 ± 0.303	6.17 ± 0.155[b]	5.67 ± 0.088
	Calving season					
	Spring	28	17.45 ± 0.353	13.14 ± 0.339	6.06 ± 0.202	5.59 ± 0.112
	Summer	34	17.32 ± 0.205	12.98 ± 0.209	5.95 ± 0.120	5.57 ± 0.069
	Mean	62	17.20 ± 0.239	12.85 ± 0.261	5.86 ± 0.143	5.55 ± 0.088

[a,b] Within an effect and column means with a common superscript did not differ with probability P =0.05

At 24 hours after calving, Yonis *et al. (*2014) observed were lower percentages of DM and protein, and a higher percentage of fat than was seen in present study. Ashmawy (2015) also reported lower DM and protein percentages compared with the current findings.

The fat and protein percentages that Yonis *et al.* (2014) found 48 hours after calving were higher than in the present study. Moreover, the effect of the age of the buffalo cow was significant for the protein percentage of colostrum at 48 hours after calving in this study (P <0.05), with the older females producing colostrum with a higher concentration of protein than the younger buffaloes. Similarly, in a study on Holstein cows (Erdem & Okuyucu, 2020), the effect of parity on the protein percentage of colostrum was statistically significantly different at two and 24 hours after calving. The variations among these findings might be explained by differences in breed, calving season, length of dry period, and management of the buffaloes.

The colostrum quality at two and 24 hours after calving in summer in this study were not consistent with the values for the Romanian buffalo breed that originated from water buffalo reported by Coroian et al. (2013) for one day postpartum for cows also calving in summer. Additionally, the effect of calving season on fat percentage was statistically significant in the current study (P <0.05) at 48 hours after calving. The fat percentage in cows calved in summer was higher than for those calved in spring. Similarly, Gulliksen *et al.*

(2008) and Erdem & Okuyucu (2020) reported that calving season had a statistical effect on the colostrum quality in dairy cows.

The changes in colostrum components are shown in Table 3. Dry matter and fat were affected positively by SG at two and 24 hours (*P* <0.05) after calving. Dry matter and fat percentages were higher in the colostrum with SG ≥1.070 g/ml. Similarly, at 48 hours after calving, fat and protein percentages were higher in colostrum with higher SG (*P* <0.05); and at 72 hours after calving, the protein percentage was again higher in colostrum with high SG compared to that with low SG (*P* <0.05). Thus, the level of SG could be an important indicator of colostrum quality.

Table 3 Colostrum components (%) of milk from Anatolian buffalo cows as affected by the specific gravity of the colostrum and time after calving

Time after calving	Specific gravity (g/ml)	N	Dry matter	Fat	Protein
2 hours	<1.070	19	28.43 ± 0.607^{a}	7.93 ± 0.345^{a}	16.91 ± 0.383
	≥1.070	43	29.69 ± 0.283^{b}	8.61 ± 0.155^{b}	17.50 ± 0.240
24 hours	<1.070	19	23.00 ± 0.514^{a}	6.00 ± 0.236^{a}	12.47 ± 0.449
	≥1.070	43	24.05 ± 0.245^{b}	6.55 ± 0.103^{b}	13.21 ± 0.221
48 hours	<1.070	19	19.98 ± 0.784	5.21 ± 0161^{a}	5.55 ± 0.237^{a}
	≥1.070	43	21.10 ± 0.149	5.59 ± 0.088^{b}	6.12 ± 0.131^{b}
72 hours	<1.070	19	15.11 ± 0.161	5.56 ± 0.148	5.33 ± 0.137^{a}
	≥1.070	43	15.66 ± 0.197	5.69 ± 0.108	5.68 ± 0.075^{b}

^{a,b} Within a time point and column means with a common superscript did not differ with probability *P* =0.05

Chest girth and depth values of the calves of Group 2 were higher two hours after birth than of those in Group 1 (*P* <0.05) (Table 4). Gupta *et al.* (2019) recorded the birth weights of calves born to multiparous and primiparous buffalo females and were unable to detect differences in LW. Singh & Saini (2020), Bharti *et al.* (2018), and Qureshi *et al.* (2009) all reported birth weights for buffalo calves higher than those in the present study. At 15 days after birth, the LW (*P* <0.05) and CG (*P* <0.01) of calves in Group 2 were higher than those in Group 1. At 30 days after calving, the SG affected the LW (P <0.05), CG (P <0.01), and WH (P <0.05) values with the calves of Group 2 being larger, whereas the effect was not statistically significant for CW, CD, RH, and BL (*P* >0.05). In addition, the lowest CG and WH were observed in the calves of cows with low SG at days 45 and 60 after calving.

Calculated values for LWG and DLWG are presented in Table 5. The average DLWG values of calves from day 0 to day 60 were calculated. These results were higher than those obtained by Ahmad *et al.* (2004) in calves from birth to three months, but lower than those reported by Mastellone *et al.* (2011) for 30-day-old calves. The findings of Ahmad *et al.* (2004) and Mastellone *et al.* (2011) were not consistent with the present research. These variations among studies might be because of differences in genotype, feeding, and breeding conditions. The current research found that LWG and DLWG were not affected by maternal age, calving season or colostrum group. However, the LWG of male calves was higher than that of female calves from 31 to 45 days and from 0 to 60 days old (*P* <0.05). This result was consistent with the effect of gender on weaning weight and DLWG in Holstein calves (Yaylak *et al*. 2015).

Table 4 Live weight and body measurements of Anatolian buffalo calves at various ages as affected by the specific gravity of the colostrum they received

Period	Specific gravity, g/ml	N	LW, kg	CG, cm	WH, cm	CW, cm	CD, cm	RH, cm	BL, cm
Birth	<1.070	19	29.7 ± 0.63	69.0 ± 0.50^{a}	69.9 ± 0.81	16.7 ± 0.16	20.0 ± 0.53^{a}	70.7 ± 0.90	65.5 ± 1.30
	≥1.070	43	31.4 ± 0.62	71.5 ± 0.70^{b}	71.8 ± 0.76	16.3 ± 0.22	21.9 ± 0.56^{b}	72.8 ± 0.83	63.8 ± 0.99
	mean	62	30.9 ± 0.48	70.7 ± 0.52	71.2 ± 0.59	16.5 ± 0.16	21.4 ± 0.43	72.2 ± 0.64	64.3 ± 0.79
Day 15	<1.070	19	38.5 ± 0.68^{a}	71.4 ± 0.64^{a}	72.0 ± 0.94	18.3 ± 0.21	22.2 ± 0.61	73.2 ± 1.05	66.8 ± 1.27
	≥1.070	43	40.8 ± 0.74^{b}	74.8 ± 0.90^{b}	74.8 ± 0.95	17.8 ± 0.25	24.1 ± 0.59	76.0 ± 1.01	65.6 ± 0.96
	mean	62	40.1 ± 0.57	73.7 ± 0.68	73.9 ± 0.73	18.0 ± 0.19	23.5 ± 0.46	75.2 ± 0.78	65.9 ± 0.77
Day 30	<1.070	19	47.5 ± 0.75^{a}	73.2 ± 0.82^{a}	73.5 ± 1.08^{a}	19.9 ± 0.29	24.1 ± 0.70	75.5 ± 1.23	68.6 ± 1.27
	≥1.070	43	50.2 ± 0.84^{b}	77.2 ± 1.09^{b}	77.3 ± 1.16^{b}	19.3 ± 0.32	25.9 ± 0.61	78.8 ± 1.21	67.3 ± 0.95
	mean	62	49.4 ± 0.64	75.9 ± 0.83	76.1 ± 0.89	19.5 ± 0.24	25.3 ± 0.48	77.8 ± 0.94	67.7 ± 0.76
Day 45	<1.070	19	56.0 ± 0.84	75.0 ± 0.94^{a}	75.3 ± 1.24^{a}	21.6 ± 0.39	25.7 ± 0.77	77.8 ± 1.41	70.2 ± 1.29
	≥1.070	43	58.3 ± 0.96	79.7 ± 1.24^{b}	79.7 ± 1.33^{b}	20.8 ± 0.36	27.7 ± 0.65	81.3 ± 1.37	69.1 ± 0.92
	mean	62	57.6 ± 0.73	78.2 ± 0.94	78.4 ± 1.02	21.1 ± 0.52	27.1 ± 0.52	80.3 ± 1.06	69.4 ± 0.75
Day 60	<1.070	19	64.8 ± 0.99	77.1 ± 1.14^{a}	77.2 ± 1.40^{a}	23.3 ± 0.51	27.4 ± 0.88	80.2 ± 1.60	72.2 ± 1.26
	≥1.070	43	67.1 ± 0.91	82.3 ± 1.40^{b}	82.3 ± 1.50^{b}	22.6 ± 0.43	29.4 ± 0.69	84.2 ± 1.54	71.1 ± 0.90
	mean	62	66.4 ± 0.71	80.7 ± 1.07	80.7 ± 1.16	22.8 ± 0.34	28.8 ± 0.56	83.0 ± 1.19	71.4 ± 0.73

LW: live weight; CG: chest girth; WH: withers height; CW: chest width; CD: chest depth; RH: rump height; BL: body length

^{a,b} Within a time point and column, means with a common superscript did not differ with probability *P* =0.05

Table 5 Changes of live weight gain and daily live weight gain at various ages of Anatolian buffalo calves as affected by the age of their dam, season in which they were born, the specific gravity of the colostrum they received and their gender

		N	Live weight gain, kg					DLWG
			Days 0 to 15	Days 16 to 30	Days 31 to 45	Days 46 to 60	Days 0 to 60	Days 0 to 60
Cow age	≤80 months	27	9.03±0.422	8.97±0.248	8.26±0.299	8.65±0.263	34.90±0.719	0.582±0.012
	>80 months	35	9.30±0.277	9.67±0.271	8.15±0.303	8.84±0.252	35.96±0.610	0.599±0.010
Calving season	Spring	28	9.32±0.347	9.27±0.307	8.27±0.280	8.73±0.300	35.60±0.689	0.593±0.011
	Summer	34	9.07±0.335	9.44±0.243	8.12±0.317	8.78±0.229	35.42±0.642	0.590±0.010
Colostrum specific gravity, g/ml	<1.070	19	8.73±0.370	9.07±0.319	8.51±0.361	8.74±0.309	35.05±0.784	0.584±0.013
	≥1.070	43	9.38±0.302	9.49±0.236	8.06±0.263	8.77±0.226	35.70±0.580	0.595±0.009
Gender	Female	32	8.79±0.345	9.08±0.237	7.85±0.284^{a}	8.70±0.239	34.42±0.541^{a}	0.574±0.009^{a}
	Male	30	9.61±0.320	9.66±0.298	8.57±0.310^{b}	8.82±0.279	36.65±0.723^{b}	0.611±0.012^{b}
Mean		62	9.18±0.240	9.36±0.191	8.20±0.213	8.76±0.182	35.50±0.466	0.592±0.007

DLWG: daily live weight gain
^{a,b} Within a time point and column, means with a common superscript did not differ with probability *P* =0.05

The correlation of SG with the LW and body measurements of calves at different ages and colostrum periods is shown in Table 6. In this study, correlations that differed significantly from zero were found between the SG of buffaloes and the growth performance of calves at various ages. Specific gravity at two hours after calving correlated positively with LW at birth. Similarly, SG at 24 and 48 hours after calving correlated positively with LW, CG, WH, CD, and RH. However, a negative correlation was found between SG and BL at 48 hours after calving. Specific gravity at two hours after calving correlated positively with CG at 15 days after calving. Also, SG at 24 and 48 hours after calving was correlated positively with the CG, WH, CW, RH, and BL of calves at 15 days after calving. Similarly, the SG of colostrum correlated positively with the CG, WH, CW, RH, and BL of calves at 30, 45, and 60 days after calving. A positive correlation was found between the birth weight of the buffalo calves and the SG secreted by their mothers at 2, 24, and 48 hours after birth. Similarly, Kaygısız & Kose (2007) reported that mothers of high birth weight Holstein calves produced higher quality colostrum. The effect of the quality of the colostrum produced at two hours after calving on the LW and some body measurements at 15, 30, 45, and 60 days old was statistically significant. Buffalo calves in Group 2 exhibited higher growth traits.

Mastellone *et al.* (2011) reported that the serum IG level of buffalo calves at 24 hours after calving affected weight gain positively from birth to 30 days old. In another study, Goncu *et al.* (2014) emphasized that in dairy cows the quality of the colostrum had a positive effect on calf growth after weaning. Thus, good quality colostrum is crucial to obtaining adequate passive immunity and optimum growth performance (Hang *et al.,* 2017; Gupta *et al.,* 2019).

Table 6 Correlation coefficients of specific gravity of colostrum at various times after calving with bodyweight and body measurements of Anatolian buffalo calves

Hours after calving	At calving						
	LW	CG	WH	CW	CD	RH	BL
2	0.279*	0.222	0.202	0.024	0.217	0.190	-0.030
24	0.337**	0.367**	0.369**	-0.002	0.277*	0.359**	-0.196
48	0.283*	0.331**	0.422**	-0.104	0.333**	0.378**	-0.401**
72	0.135	0.111	0.202	0.052	0.184	0.232	-0.233
	15 days old						
2	0.041	0.253*	0.242	0.213	-0.023	0.201	0.188
24	0.097	0.326**	0.350**	0.363**	-0.011	0.304*	0.343**
48	0.095	0.280*	0.311*	0.388**	-0.047	0.343**	0.356**
72	-0.003	0.112	0.119	0.177	0.114	0.186	0.182
	30 days old						
2	0.222	0.290*	0.245	0.198	-0.028	0.185	0.188
24	0.023	0.295*	0.355**	0.334**	-0.031	0.321*	0.316*
48	-0.035	0.237	0.324*	0.361**	-0.020	0.349**	0.323*
72	-0.032	0.090	0.135	0.150	0.201	0.204	0.157
	45 days old						
2	-0.038	0.245	0.250	0.192	-0.066	0.185	0.181
24	0.087	0.287*	0.356**	0.321*	-0.020	0.322*	0.297*
48	0.075	0.232	0.326**	0.354**	0.041	0.353**	0.297*
72	-0.122	0.044	0.141	0.159	0.199	0.197	0.136
	60 days old						
2	-0.033	0.242	0.243	0.182	-0.017	0.189	0.179
24	-0.197	0.242	0.333**	0.311*	-0.043	0.338**	0.284*
48	-0.128	0.203	0.325**	0.363**	0.035	0.371**	0.290*
72	-0.076	0.025	0.143	0.137	0.197	0.214	0.126

LW: live weight; CG: chest girth; WH: withers height; CW: chest width; CD: chest depth; RH: rump height; BL: body length

*P <0.05, **P <0.01

Conclusion

As the SG of colostrum from buffalo cows rose, its DM, fat and protein contents also increased. But DM, fat, protein, and SG decreased rapidly after calving. Therefore, Anatolian buffalo calves should be given good quality colostrum a short time after calving. The current results showed that, SG as measured with a colostrometer at the farms could be a reliable practical indicator of colostrum quality and calves fed high SG colostrum had more rapid growth early in life. Thus, feeding calves colostrum with high SG is important to activate the immune system and to enhance growth and reduce calf mortality.

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Authors' Contributions

HE and HD designed the study and collected the data. HE, ICO and HD conducted the laboratory analysis, and wrote the manuscript. HE and ICO analysed the data analysis and interpreted it, and were involved in the preparation and revision of the manuscript.

Conflict of Interest Declaration

There is no conflict of interest associated with this manuscript

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