Evaluation of quality of colostrum on different sized dairy farms

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Abstract

Colostrum plays a crucial role in the passive transfer of immunity (PTI) in calves. The quality and quantity of colostrum have a significant impact on PTI. The objective of this study was to assess the quality of colostrum on dairy farms of different sizes. A total of 660 colostrum samples were obtained from 28 farms in 11 provinces in Türkiye. The colostrum samples were divided into five groups according to dairy farms size: Group I (1–100, n = 26), Group II (101–200, n = 37), Group III (201–500, n = 200), Group IV (501–1000, n = 235), Group V (> 1000, n = 162). Colostrum quality was assessed by a Brix refractometer (≤ 22% indicates poor quality colostrum) and evaluated statistically. The mean colostrum Brix% was 27.74 ± 0.14. The Brix% in Groups I–V were 24.04 ± 0.72, 25.70 ± 0.93, 28.11 ± 0.26, 28.46 ± 0.23 and 27.30 ± 0.21, respectively. The rate of poor quality colostrum for the total of 660 cows was 8.03%, for Groups I–V it was 34.61%, 29.72%, 6.0%, 5.53% and 4.93%, respectively. The rates of primiparity for Groups I–V were 65.38%, 54.05%, 49.0%, 35.31% and 43.2%, respectively. The colostrum Brix% was significantly (P = 0.014) lower in primiparous cows (27.08 ± 0.23) than in multiparous cows (28.25 ± 0.18). The highest rate of poor quality of colostrum was found in Groups I and II. This situation on small farms may be due to inadequate management and feeding.

Cattle, passive transfer of immunity, Brix%

Ruminants have a syndesmochorial placenta that prevents the transplacental transfer of maternal immunoglobulins, so calves are born agammaglobulinaemic. Therefore, colostrum consumption is necessary for calves to acquire IgG and other immune factors (Godden et al. 2019; Lombard et al. 2020). The ingestion of colostrum and transfer of immunoglobulins into the blood of the calf has been termed "passive transfer of immunity (PTI)" or more recently, "transfer of passive immunity (TPI)" (Lombard et al. 2020; de Souza et al. 2021). The transfer of passive immunity to newborn calves occurs through colostrum consumption within the first 24 h after birth (Godden et al. 2019; de Souza et al. 2021). Calves that do not achieve adequate passive transfer are classified as having failure of transfer of passive immunity (FTPI) (Buczinski et al. 2018; Fischer-Tlustos et al. 2021). Calves with FTPI have higher mortality and morbidity rates (Lora et al. 2018), poor growth performance (Windeyer et al. 2014; Elsohaby et al. 2019) and even reduced milk production compared to calves with adequate transfer of passive immunity (Faber et al. 2005).

Colostrum, the first milk produced by a cow after parturition, is the first source of nutrition for a newborn calf and is rich in several nutrients (Godden 2008; Lopez and Heinrichs 2022). Feeding adequate amounts of high quality colostrum immediately after birth is the most important protective factor in preventing calf exposure to FTPI

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(Lorenz et al. 2011; Godden et al. 2019). The four most crucial factors for successful passive transfer related to colostrum management are colostrum quality, quantity, timing of feeding and cleanliness (McGuirk and Collins 2004; Godden et al. 2019; Lopez and Heinrichs 2022). The quality of colostrum is defined by its immunoglobulin G (IgG) concentration, which should be greater than 50 g/l, and by its bacterial contamination, which should be less than 100,000 CFU/ml for total bacterial count and less than 10,000 CFU/ml for total coliform count (McGuirk and Collins 2004; Godden et al. 2019). There are varying recommendations regarding the appropriate amount of colostrum to feed a newborn calf (Besser et al. 1985; Conneely et al. 2014). Conneely et al. (2014) recommended administering 8.5% of the calf's body weight as colostrum in the first 2 h after birth; whereas Chigerwe et al. (2009) recommended that at least 3 l of colostrum should be given within 4 h of birth, and if the calf is unable to drink, this amount should be targeted with oro-esophageal intubation. In addition, the colostrum contains numerous other crucial elements, such as growth factors, hormones, antimicrobial substances, and leukocytes, oligosaccharides, mRNA, and nutrients; the actual role of all of these constituents is not yet fully comprehended (Godden et al. 2019; Lopez and Heinrichs 2022).

Factors such as breed, age, and parity of dam, prenatal feeding, calving season, prenatal vaccination of dam, length of dry period, amount of colostrum produced at first milking, delay in colostrum collection all influence the colostrum quality (Conneely et al. 2013; Godden et al. 2019; Batmaz 2021; Soufleri et al. 2021).

Several tests and tools are commonly used to evaluate the quality of colostrum (Röder et al. 2023). These tests include radial immunodiffusion (RID), ELISA, lateral flow assay methods (determines the IgG concentration (mg/ml) in colostrum based on an antigen-antibody reaction) (Faber et al. 2005; Godden 2008; Godden et al. 2019; Fischer-Tlustos et al. 2021). Radial immunodiffusion is the gold standard for colostrum IgG analysis because of its accuracy, but it can be costly and time consuming (Chelack et al. 1993). However, RID and ELISA tests are expensive and require laboratories and skilled personnel, so it is common in the field to use practical devices such as colostrometer, which provides information on the amount of IgG by measuring the density of the colostrum (Chigerwe and Hagey, 2014; Godden et al. 2019; Batmaz 2021). Indirect tests, such as Brix refractometry (Quigley et al. 2013; Kaçar et al. 2021), measurement of gamma-glutamyl transferase enzyme activity (Kaçar et al. 2021), and determination of total protein can be used as a cost-effective, on-site alternative to measuring IgG in colostrum. The IgG content of colostrum can be reliably measured indirectly by assessing the total solids concentration using a Brix refractometer. This method is inexpensive, easy to use and can be performed in the field (Bielmann et al. 2010; Bartier et al. 2015; Batmaz 2021; Kaçar et al. 2021).

Dairy farms test the concentration of IgG in first-milking colostrum using the Brix refractometer. A single threshold of > 22% is often used to ensure that the concentration of IgG is at least 50 g/l (Elsohaby et al. 2019; Godden et al. 2019). This threshold ensures a minimum IgG concentration of 50 g/l and has become the gold standard for first milk colostrum (Elsohaby et al. 2019; Batmaz 2021).

Comparison of colostrum quality based on the farm size is critical to understanding the differences between small and large farms. While many studies have been conducted on the factors that affect colostrum quality, few have specifically looked at this comparison. The purpose of this study was to evaluate colostrum quality on dairy farms of different sizes.

Materials and Methods

This study was approved by the Local Ethics Committee for Animal Research of Bursa Uludag University (2023-13/04).

Animals and management

A total of 660 colostrum samples used in the study were collected from 28 different farms in Türkiye between September 2023 and February 2024. The study included farms in 11 different provinces and 20 districts. The provinces where the colostrum samples were collected (Fig. 1) and the farms grouped according to their size and the number of colostrum samples from these farms are shown in Table 1. They were sampled once during the study period and the herd sizes ranged from 2 to 3,000 dairy cows.

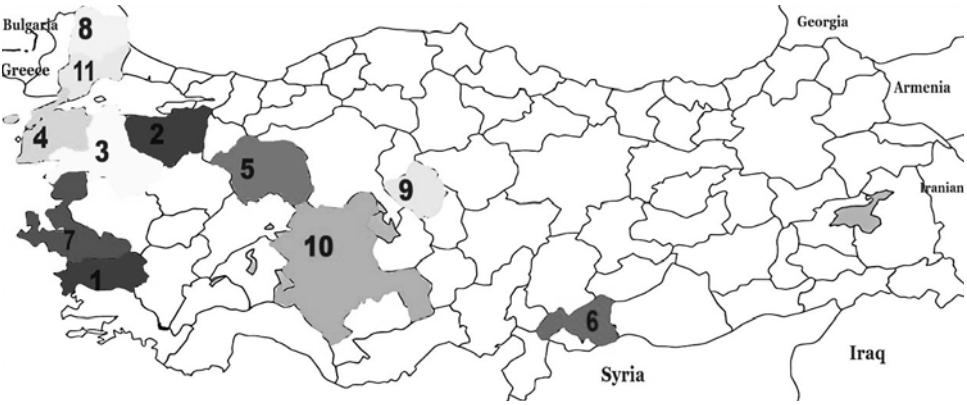

Fig. 1. Provinces of Türkiye where colostrum samples were collected

Table 1. Distribution of colostrum samples by provinces.

	Province	District	Number of farms	Group I	II	III	IV	V	Number of colostrum samples
1	Aydın	2	2	1	1	-	-	-	17
2	Bursa	5	6	2	-	3	1	-	190
3	Balıkesir	2	2	-	-	1	1	-	54
4	Çanakkale	1	1	-	-	1	-	-	13
5	Eskişehir	1	1	-	1	-	-	-	20
6	Gaziantep	1	1	-	-	-	-	1	70
7	İzmir	3	10	5	2	2	1	-	98
8	Kırklareli	2	2	-	-	-	1	1	111
9	Kırşehir	1	1	-	-	-	1	-	45
10	Konya	1	1	-	-	1	-	-	8
11	Tekirdağ	1	1	-	-	-	-	1	34
Total		20	28	8	4	8	5	3	
Number of colostrum samples				26	37	20	235	162	660

Group I: dairy farms with 1–100 cows; Group II: dairy farms with 101–200 cows; Group III: dairy farms with 201–500 cows; Group IV: dairy farms with 501–1000 cows; Group V: dairy farms with > 1000 cows.

Collection of colostrum samples and assessing colostrum quality

The first milking colostrum samples were collected within the first 4 h after calving. All cows were observed on the day of calving and any cows showing signs of disease or abnormal appearance of the colostrum (such as watery, clotted, or bloody colostrum) were excluded from the study. Colostrum samples of healthy animals were taken into tubes (10 ml sterile dry tubes) from the milking bucket after colostrum milking. After the collection, the colostrum sample was stored in a deep-frozen state at approximately −20 °C on site at the farm. All colostrum samples were transported in a frozen state on ice in a polystyrene box to the Bursa Uludag University Animal Hospital Centre Laboratory. In the laboratory, all samples were thawed in the refrigerator at a temperature ranging from 4 to 8 °C. The tube containing the colostrum was subjected to at least 10 cycles of agitation

in order to ensure an even distribution of constituents. The colostrum quality was evaluated in colostrum by digital Brix refractometer (Milwaukee MA882, Szeged, Hungary) at room temperature of 18–24 °C . Calibration was carried out routinely at the beginning of the analysis and following the measurement of 10 colostrum samples. A measurement of ≤ 22% was considered to be an indication of poor quality colostrum (Bielman et al. 2010). In addition, the quality of the colostrum was divided into 3 groups according to the Brix% values as poor (≤ 22%), good (23%–26%), and very good (≥ 27%) (Batmaz 2021).

Grouping of colostrum sampled animals

The cows from which colostrum samples were taken were classified according to the farm size. The colostrum samples were divided into five groups based on the size of the dairy farms: Group I (1–100), Group II (101–200), Group III (201–500), Group IV (501–1000), and Group V (> 1000).

Statistical analysis

The statistical analyses were performed with the use of IBM SPSS software (IBM Corp. 2015, IBM SPSS Statistics for Windows, version 23.0. IBM Corp, Armonk, NY, USA). Statistical evaluation of the groups was performed using Fisher's exact test, Pearson's chi-square test, and Kruskal-Wallis test. The statistical significance level was set at $P < 0.05$ for all cases.

Results

Although the number of colostrum samples was small in Groups I and II, the colostrum samples were collected from 8 farms in Group I and 4 farms in Group II, similar to the other groups. The highest (41.80%) and lowest (10.00%) Brix values in all samples were in Group III.

The breeds of the 660 healthy cows were Holstein (523), Simmental (76), Jersey (54), and crossbred (7). In the whole population, the mean colostrum Brix% was 27.74 ± 0.14. Brix% was 27.59 ± 0.17 in Holsteins, 28.40 ± 0.33 in Simmentals, and 28.00 ± 0.29 in Jerseys. No significant difference was found when comparing Brix values between breeds.

As shown in Table 2, when comparing the mean Brix values between groups, Groups I and II were significantly lower than Groups III, IV, and V ($P < 0.05$). Figure 2 shows the numbers and proportions of poor quality colostrum for each group. Brix values were categorized (Table 3). The percentage of very good quality and poor quality colostrum in all samples were 64.24% and 8.03%, respectively. As can be seen in Table 3, 50.00% of Group I was found to be of good quality, while only 15.38% was found to be of very good quality. The highest number of colostrum samples with very good quality was found in Group III (66.50%), Group IV (72.34%), and Group V (59.87%). All groups within the same Brix value range were statistically evaluated. In comparison between the groups with very good colostrum value, significant differences were found between Group I and all the other groups ($P < 0.001$), and between Groups IV and V ($P = 0.004$).

Table 2. Mean Brix values of colostrum samples in different groups.

	Group I n = 26	Group II n = 37	Group III n = 200	Group IV n = 235	Group V n = 162
Mean Brix values (%) ± SEM	24.04 ± 0.72[a]	25.70 ± 0.93[a]	28.11 ± 0.26[b]	28.46 ± 0.23[b]	27.30 ± 0.21[b]
Min	18.00	11.00	10.00	12.00	19.00
Max	33.00	37.70	41.80	36.20	31.00

Group I: dairy farms with 1–100 cows; Group II: dairy farms with 101–200 cows; Group III: dairy farms with 201–500 cows; Group IV: dairy farms with 501–1000 cows; Group V: dairy farms with > 1000 cows.

[a,b] Different superscripts in the same row indicate a significant difference between the groups ($P < 0.05$)

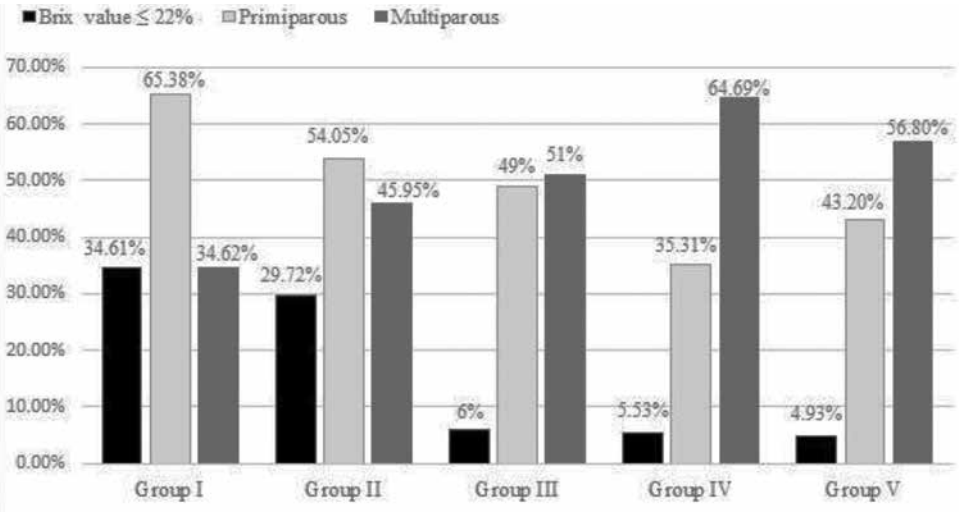

Fig. 2. Brix values of poor colostrum samples in different groups and percentage distribution by group

Table 3. Categorization of Brix values according to groups.

Brix values	n	Mean Brix values	Group I	Group II	Group III	Group IV	Group V
Poor quality ≤ 22%	53	19.70 ± 0.44	9 (34.62%)	11 (29.74%)	12 (6.00%)	13 (5.54%)	8 (4.95%)
Good quality 23%–26%	183	25.19 ± 0.07	13 (50.00%)	6 (16.21%)	55 (27.50%)	52 (22.12%)	57 (35.18%)
Very good quality ≥ 27%	424	29.84 ± 0.10	4^{a} (15.38%)	20^{bc} (54.05%)	133^{bc} (66.50%)	170^{b} (72.34%)	97^{c} (59.87%)

Group I: dairy farms with 1–100 cows; Group II: dairy farms with 101–200 cows; Group III: dairy farms with 201–500 cows; Group IV: dairy farms with 501–1000 cows; Group V: dairy farms with > 1000 cows.

$^{a, b, c, bc}$ Different superscripts in the same row indicate a significant difference between the groups ($P < 0.05$)

Parity distribution was 289, 155, 122, 56 and 38 cows for parities 1, 2, 3 and 4, > 5 respectively. Primiparous cows accounted for 43.63% and multiparous cows for 56.37% of all colostrum samples collected for the study. When the ratio of primiparous cows was compared between the groups, in Groups I (65.38%) and II (54.05%) the share of primaparous cows was higher than in the other groups (Fig. 2). In the whole population, the Brix value of colostrum was significantly (P = 0.014) lower in primiparous cows (27.08 ± 0.23) than in multiparous cows (28.25 ± 0.18). The mean Brix values of the cows in the 1st, 2nd, 3rd, 4th and ≥ 5th lactation were 27.08 ± 0.23, 28.30 ± 0.30, 27.91 ± 0.31, 28.67 ± 0.47, 28.55 ± 0.39 respectively. However, no significant difference was found when comparing the Brix values of cows classified by number of lactations.

Discussion

The immunoglobulins in colostrum are the best indicator of its quality. Nutritional substances such as fat, protein, and lactose are also included in the evaluation of colostrum

quality (Soufleri et al. 2021). However, besides the nutritional properties of colostrum for calves, immunoglobulins are important for the prevention of diseases and deaths (Lorenz et al. 2011; Lora et al. 2018). For this reason, immunoglobulins are often assessed for quality in many studies (Morrill et al. 2015; Reschke 2017). Although tests such as RID and ELISA give the most accurate results for the assessment of immunoglobulins, they are not widely used in practice because they are expensive and require laboratory conditions and time. For this reason, Brix refractometers have been widely used in practice under field conditions, especially in recent years. Brix refractometry reflects Igs well and there is a high correlation between them (Topal et al. 2018; Gamsjager et al. 2020). In this study, the average Brix value was 27.74 ± 0.14 when colostrum was evaluated by digital refractometer on farms of different sizes. While this result was higher than the Brix values found in some studies (23.8%, Quigley et al. 2013; 22.2%, Morrill et al. 2012), it was similar to those found in some others (27.6%, Kehoe et al. 2007; 26.3%, Bielmann et al. 2010).

In our study, the rate of poor quality colostrum in all samples was determined as 8.03%. This rate was in line with the data from Bielman et al. (2010) (7.7%) and was lower than that of Reschke et al. (2017) (15.5%) and Quigley et al. (2013) (14%).

The mean Brix values of Group I (1–100) and Group II (101–200) were 24.04 ± 0.72 and 25.70 ± 0.93, respectively, and both groups were significantly lower than the other three groups with more cows. In Group I, where the mean Brix% was found to be lower, 34.61% of the colostra were found to be of poor quality with ≤ 22%. In Group II, 29.72% of them were also found to be of poor quality. The higher proportion of primiparous cows in these two groups may explain the higher proportion of poor quality colostrum in Group I and Group II compared to the other three groups. Colostrum quality of primiparous cows was found to be lower in this study, in line with some other studies (Morrill et al. 2012; Conneely et al. 2013; Dunn et al. 2017). However, in one study (Soufleri et al. 2021) the colostrum quality was found to be higher in primarous cows than in second lactation cows. Although the number of primiparous cows in Group III was 49%, the proportion of poor quality colostrum in this group was only 6%. This may be due to the fact that on the farms with less than 100 and 200 cows, their diet was not fully adequate. As a matter of fact, although milk yield and colostrum amounts are generally lower in cows on small farms compared to large farms, the higher proportion of poor quality colostrum may be related to nutritional deficiency (Dunn et al. 2017; Westhoff et al. 2024). On the other hand, on farms with more than 200 cows, the rations are more regular and meeting the animals' needs. These cows are usually fed total mixed rations containing corn silage, wheat straw, soybean meal, and a mineral/vitamin supplement formulated to meet or exceed lactation net energy and metabolizable protein requirements. In addition, on farms with fewer cows, the drying time is sometimes delayed. This can have a negative effect on the quality of the colostrum (Mayasari et al 2015; Dunn et al. 2017). In one study (Soufleri et al. 2021), cows dried for less than 64 days were found to have a slightly lower Brix value.

As can be seen in Table 3, the rate of very good colostrum quality was only 15.38% in the group with 1–100 cows, while this rate was very high in Groups III–IV and V where the number of cows was high. It was found that the proportion of colostrum of very good quality was higher on the larger farms. It can be said that the proportion of very good quality colostrum is high due to feeding on larger farms and better management programs (Dun et al. 2017; Denholm et al. 2018; Godden 2019).

Besides the lactation number, nutrition, and management factors, colostrum quality may also vary according to cattle breeds (Kessler et al 2020; Van Hese et al 2022). In our study, no significant difference was found between colostrum Brix values of Holstein, Jersey, and Simmental breeds. Other possible factors that could influence the variation

in IgG concentration are the amount of milk produced and the time between calving and milking (Puppel et al. 2019; Soufleri et al. 2021). Unfortunately, in this study, although the colostrum sample was collected immediately after birth, the volume of colostrum produced was not recorded and therefore cannot be commented on.

Many factors affect colostrum quality and according to the results of this study, it can be said that farm size can be added to these factors. It is recommended that small farms should be more careful in cattle management and nutrition, and that the owners of these farms should be informed about these issues.

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