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RESEARCH ARTICLE

Investigation of Total Colostral IgG Produced by Holstein Cows in a Lactation

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ABSTRACT

Since dairy cows have greater milk production than beef cows, because of the dilution of Immunoglobulin G (IgG) colostrum of dairy cows assumed to be of poorer quality compared with beef cows. The objective of the present study was to investigate quality of colostrum and total IgG produced in a lactation by Holstein cows (n=80). The average colostrum volume at the first seven milking were measured as 5.42 L, 6.73 L, 8.55 L, 9.26 L, 8.44 L, 9 L, 10.01 L respectively. The average total colostrum produced by cows in the first 3 days period was calculated as 57.41 L. The average colostrum IgG concentration were calculated as 90.81 mg/mL, 68.67 mg/mL, 58.40 mg/mL, 37.33 mg/mL, 15.22 mg/mL, 10.7 mg/mL, 5.9 mg/mL respectively for each milking. In conclusion, enough colostrum and IgG are produced in the first 3 days in Holstein cows for calf feeding. In addition to this, there is huge opportunity that excessive amount of IgG and colostrum could be processed for other by-products.

Keywords: Colostrum, Dairy cow, Holstein, IgG, Mass.

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Holştayn İneklerde Bir Laktasyonda Üretilen Toplam Kolostral IgG'nin Araştırılması

ÖZ

Süt ineklerinin süt üretimi besi ineklerinden daha fazla olduğundan, süt ineklerinin kolostrumunun seyrelmesi nedeniyle besi ineklerine göre daha düşük kalitede olduğu varsayılır. Bu çalışmanın amacı, Holstein ineklerinde (n=80) bir laktasyonda üretilen kolostrumun kalitesi ve toplam immunoglobulin G (IgG) miktarının araştırılmasıdır. İlk 7 sağımdaki kolostrum hacimleri sırasıyla 5.42 L, 6.73 L, 8.55 L, 9.26 L, 8.44 L, 9 L, 10.01 L olarak ölçüldü. İneklerin ilk 3 günlük dönemde ürettikleri ortalama toplam kolostrum 57.41L olarak hesaplanmıştır. Ortalama kolostrum IgG konsantrasyonu her sağım için sırasıyla 90.81 mg/mL, 68.67 mg/mL, 58.40 mg/mL, 37.33 mg/mL, 15.22 mg/mL, 10.70 mg/mL, 5.9 mg/mL olarak hesaplandı. Sonuç olarak Holstein ineklerde buzağı beslenmesi için ilk 3 günde yeterli miktarda kolostrum ve IgG üretilmektedir. Buna ek olarak, artan IgG ve kolostrumun diğer yan ürünler için işlenmesi mümkündür.

Anahtar Kelimeler: Holstein, IgG, Kolostrum, Kütle, Süt ineği

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INTRODUCTION

Colostrum is the secretion, which is secreted from the mammary gland after birth, which has a very different structure from normal milk. Although colostrum is very different in color, taste, consistency and odor from normal milk, the greatest difference is seen in its composition (Godson et al. 2003). This different composition of colostrum changes rapidly and turns into normal milk after a while. Because of this change, it is called colostrum for the first 48 h, while it is called transitional milk (trans-milk) between 48-72 h and is considered normal milk after 72 h (Erdem and Atasever 2005). To promote health of the newborn dairy calf, colostrum that is nutrient-dense and contains immune factors is essential (Blum and Hammon 2000, Godden 2008, Fischer-Tlustos et al. 2020).

High concentrations of immunoglobulin G (IgG) and bioactive compounds are available in colostrum compared with normal milk (Blum and Hammon 2000). Timely supply with high quality colostrum could ensure a sufficient passive transfer (Besser et al. 1991). Since dairy cows have greater milk production than beef cows, because of the dilution of IgG colostrum of dairy cows assumed to be of poorer quality compared with beef cows (Kessler et al. 2020). There are few studies which are related with IgG composition and concentration of colostrum in dairy cows (Guy et al. 1994, Morin et al. 2001, Moore et al. 2005). In last 25 years, with the help of successful genetic selection milk yield per cow has been increased about times (Abuelo et al. 2019, Funda and Serdal 2021). So, it supposed to be more diluted and lower IgG concentrations of colostrum in a lactation. In this context, the objective of the present study was to investigate quality of colostrum and total IgG produced in a lactation by Holstein cows.

MATERIAL and METHODS

Ethical Statement

This study was approved by the Kırıkkale University Animal Experiments Local Ethics Committee (Approval no: 2020/23).

Animal Material

The presented study was carried out in a commercial dairy farm which is free from herd diseases (brucellosis and tuberculosis) and had 11.5 tons milk yield per lactation. Preventive medicine and vaccination programs are followed, and milking is done 3 times a day with a computerized milking system. Animals included in the presented study consisted of 80 multiparous Holstein cows which gave at least one birth and under the age of five with body condition score ranging between 2,5 – 3 over 5 scale. All cows were housed in similar conditions and fed by the appropriate nutrition program for the period and received the same dry period treatment. Clinical examinations were performed to evaluate general condition and udder health of the animals. Animals who had signs like fever, weight loss, lethargy and loss of appetite considered as sick and excluded from the study. All udders of the cows were examined visually and by palpation for common mastitis signs like redness, pain, swelling and heat. Cows included in the study were observed closely before, during and after birth. Animals who had difficult birth were excluded from the study. In addition, physical examination of colostrum was performed and, samples who had flakey, clotty and abnormal colostrum were excluded from the study.

Sample Collection

Delivery rooms were under 24-h observation, and after delivery single milking machines were provided and within 1 h after the birth first colostrum samples were collected. The following milking were performed every 12 h. Within the scope of the study, colostrum samples were collected from 7 milking for 3 days. All collected samples were stored at -20ºC until analyses performed.

Analyses

Colostrum volumes were obtained by manually measuring the colostrum milked into separate chambers with single milking machines at each milking. Colostrum volume measurement was made with measuring cups. Liters were measured with 10-liter containers adjusted to 250 mL precision, and the mL measurement giving the fraction was measured with 1 liter measuring tapes with 100 mL precision. The results obtained were recorded as multiples of 250 mL and were standardized by rounding up or down.

Analyses were performed using a commercial enzyme linked immunosorbent assay (ELISA) kit (Bovine Immunoglobulin ELISA kit, Bio-X Diagnostics, Rochefort, Belgium). According to commercial kit test procedure colostrum samples were diluted 1/1000 and analyses were performed according to the kit manual. The mass of IgG was calculated by the results obtained data from ELISA method used. The results obtained in mg/dL were converted to g/L units, and the mass was obtained by multiplying the volume and density.

RESULTS

The average colostrum volume at the 1st, 2nd 3rd, 4th, 5th, 6th and 7th were measured as 5.42 L, 6.73 L, 8.55 L, 9.26 L, 8.44 L, 9 L, 10.01 L respectively. The average total colostrum produced by cows in the first 3 days period was calculated as 57.41L. The average colostrum IgG concentration were calculated as 90.81 mg/mL, 68.67 mg/mL, 58.40 mg/mL, 37.33 mg/mL, 15.22 mg/mL, 10.7 0mg/mL, 5.9 mg/mL respectively for each milking. Total colostrum IgG concentration was calculated as 36.29 mg/mL. At each milking, average IgG mass were measured as 492.19 g, 462.15 g, 499.32 g, 345.67 g, 128.45 g, 96.3 g, and 59.05 g respectively. Total colostral IgG mass obtained in the first 7 milking were calculated as 2083.09 g (*Table 1*).

Table 1. Average volume, IgG density and IgG mass of the milk obtained in the first 7 milking separately for each milking

Milking	1	2	3	4	5	6	7	Total
Average Volumes (Liters)	5.42	6.73	8.55	9.26	8.44	9.00	10.01	57.41
Average IgG Concentrations (g/L)	90.81	68.67	58.40	37.33	15.22	10.70	5.90	36.28
Average IgG mass (Gram)	492.19	462.15	499.32	345.67	128.45	96.30	59.05	2083.09

DISCUSSION

In the presented study, the average colostrum volume obtained at the first milking was calculated as 5.42L. The volume of colostrum obtained at the first milking for Holstein cattle was reported as 6.4L (Kehoe et al. 2011) and 9.5 L(Quigley et al. 2013) at different studies. Different studies show that average colostrum weight at the first milking for Holstein cow is between 5.9 kg and 6.7 kg (Soufleri et al. 2019, Conneely et al. 2013, Fischer-Tlustos et al. 2020). Colostrum density in Holstein cattle is 1.056 g/cm^3 (Sobczuk-Szul et al. 2013). Considering that the colostrum density is very close to 1 g/cm^3, it is possible to compare the studies in which colostrum is evaluated by mass and volume. In the presented study, at the first milking, colostrum amount measured were lower than the results of (Quigley et al. 2013), but similar to those of other researchers' results. (Soufleri et al. 2019, Conneely et al. 2013, Fischer-Tlustos et al. 2020).

In this study, colostrum IgG concentrations of the first 7 milkings (0 - 72 h period, 12 h intervals) were evaluated as, 90.81 mg/mL, 68.67 mg/mL, 58.40 mg/mL, 37.33mg/mL, 15.22 mg/mL, 10.70 mg/mL and5.9 mg/mL respectively. Researchers reported IgG concentrations in the colostrum of Simmental cattle as 62.82 mg/mL, 41.18 mg/mL and 17.33 mg/mL on days 0, 1 and 3, respectively (Erkılıç and Erdoğan 2019). In a different study with Holstein cows, starting from the first milking, 94.1 mg/mL, 39.3 mg/mL at the 2nd milking, 13.9 mg/mL at the 3rd milking, 6.1 mg/mL at the 4th milking, 3.4 mg/mL at the 5th milking, 2.6 mg/mL in 6th milking (Fischer-Tlustos et al. 2020). Although the first milking colostrums of this study were higher than Erkılıç and Erdoğan (2019), the 3rd day measurements were found to be lower, and the IgG decrease was faster. Although it is very similar to the first milking density of Fischer-Tlustos et al. (2020), the decrease in IgG density in the present study was slower. It is thought that the difference between these studies may be due to the different breeds, which is known to have a direct effect on colostrum quality (Kara et al. 2020).

Colostrum quality in cattle varies between 1-200 mg/mL (Gökçe and Erdoğan 2013). Considering the colostrum studies in Holstein cattle, the colostrum IgG densities obtained in the first milking varies. Different researchers reported between 79.51 mg/mL and 117.45 mg/mL (Genc and Coban 2017, Kara and Ceylan 2021, Aydogdu and Guzelbektes 2018). At the first milking, IgG density of the present study is 90.81 mg/mL which is compatible with previous studies.

The density of the colostrum is the highest at first milking which is compatible with the definition (Wilms et al. 2022). In addition to this, where the IgG density decreases by more than 50% compared to the previous milking was 5th milking and IgG concentration reaches down to mature milk composition at 7th milking. Secretion at mammary gland 48 h after birth is called as colostrum, 48 – 72 h as transitional milk and after 72 h called as mature milk (Erdem and Atasever 2005). In this context, decrease in IgG concentration in 7 milking are compatible with previous studies.

The colostral IgG mass was obtained by multiplying the colostrum volume obtained for each milking with its density. Kehoe et al. (2011) found the IgG mass obtained in the first milking between 532.8 g and 690 g for cows in different lactations and

revealed that the colostral IgG mass increased with increasing lactation number. In the present study, 492.19 g of IgG was obtained in the first milking. Average colostrum volumes were quite similar in the two studies. However, in another study (Morin et al. 2010) that the amount of colostrum was higher than the present study, but the IgG density and mass were reported lower. Even though all 3 compared studies were conducted on Holstein cows, the results obtained may differ considerably.

A similar study was conducted by Fischer-Tlustos et al. (2020) as obtaining colostrum amount and concentration. They reported IgG masses as 555.19 g, 302.61 g, 134.83 g, 75.03 g, 47.26 g, 34.84 g in first 6 milking respectively and 1149.76 g in total. In the present study it was evaluated as 492.19 g, 462.15 g, 499.32 g, 345.67 g, 128.45 g, 96.3 g respectively in same order and 2024.04 g totally. The colostral IgG mass obtained in the first 6 milking was found to be 76.04% more than the Fischer-Tlustos et al. (2020)reported. It was thought that this difference is because the colostrum IgG density decreases very rapidly in the second and subsequent milking in the mentioned study(Fischer-Tlustos et al. 2020), whereas it decreases very slowly in the first 4 milking in the present study.

In this study, it is aimed to calculate the IgG mass produced by the Holstein cows which is one of the most common dairy cattle in the world, in one lactation to understand how much of this produced colostrum amount can be used except of calf feeding and which milking can be used as raw materials to obtain colostrum derived products. Colostrum has an indispensable place in the lives of calves born without an immune system (Gökçe and Erdoğan 2013). It is recommended to give colostrum up to 10-12% of their body weight within the first 4 h of birth (Godden et al. 2019). When the birth weight of the Holstein calves in the study is taken as reference, an average of 40 kg and 4 L colostrum need arise (Godden et al. 2019, Uzmay et al. 2011). If this 4 L need will be met from the first milking since it is required in the first 4 h, it is seen in the presented study that the average colostrum volume obtained at the first milking is 5.42 L and only 1.42 L of colostrum has increased since the first milking. In the following feedings, 2-2.5 L colostrum is fed every 12 h (Güngör 2006). In the light of this knowledge, according to the data obtained in the present study, 4.23 L, 6.05 L, 7.76 L, 5.94 L, 6.5L and 7.51 L of colostrum and trans-milk is available for industrial use other than calve feeding respectively in the following milking. These excess colostrum and trans-milk could be used in colostrum replacement feeds, or it can be used as a source for obtaining other molecules due to its rich composition. For instance, bovine colostrum contains 5-10 times more IgG than blood sera. In addition to this, bovine colostrum has a content of 40 times more intense than human colostrum (Şahal et al. 2018). Various components other than Ig from colostrum can also be purified and used by using various biotechnological methods (Sacerdote et al. 2013, Mussano et al. 2014).

CONCLUSIONS

In conclusion, enough colostrum and IgG are produced in the first 3 days in Holstein cows for calf feeding. In addition to this, there is huge opportunity that excessive amount of IgG and colostrum could be processed for other by-products.

Conflict of Interest: The authors declared that there is no conflict of interest.

Author Contribution Rates: The authors declared that they contributed equally to the article.

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