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RESEARCH ARTICLE

Investigation of dairy farms using different milking systems in Balıkesir province in terms of bulk tank milk quality, somatic cell count and total bacteria count

Busra Yaranoglu*[1], Sabiha Sena Ozdemir [2], Hakan Tavsanli [3], Ozlem Varol Avcilar [4], Tevhide Elif Guner [3], Bilge Camliyurt [2], Mustafa Sihlaroglu [2]

[1]Balıkesir University, Veterinary Faculty, Department of Animal Science, Balıkesir, Türkiye
[2]Balıkesir University, Veterinary Faculty, Balıkesir, Türkiye
[3]Balıkesir University, Veterinary Faculty, Department of Food Hygiene and Technology, Balıkesir, Türkiye
[4]Osmaniye Korkut Ata University, Health Sciences Faculty, Department of Nutrition and Dietetics, Osmaniye, Türkiye

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*busrayaranoglu@balikesir.edu.tr

Balıkesir'de farklı sağım sistemleri kullanan sütçü işletmelerin tank süt kalitesi, somatik hücre ve toplam bakteri sayısı bakımından incelenmesi

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Öz

Amaç: Bu çalışmanın amacı farklı sağım sistemlerine sahip işletmelerden elde edilen sütün toplam bakteri ve somatik hücre sayısı yönünden karşılaştırılarak sağım hijyeni, barınak hijyeni ve sürü yönetimi açısından değerlendirilmesi ve kuru madde, yağ, protein ve laktoz içerikleri bakımından kıyaslanarak süt kalite özelliklerinin incelenmesidir.

Gereç ve Yöntem: Çalışma materyalini Balıkesir ve çevresinde Holstein ırkı süt sığırı yetiştiriciliği yapan toplam 45 farklı işletmeden (15 elle sağım, 15 makineli sağım, 15 robotik sağım) alınan tank sütleri oluşturmuştur. Yağ, protein, laktoz, kuru madde, yağsız kuru madde ve somatik hücre sayısını belirlemek için çiğ süt analiz cihazı kullanılmıştır. Toplam bakteri sayısının tespit edilmesi için, Plate Count Agar besi yerlerine dökme plak metodu ile ekim yapılmıştır.

Bulgular: Süt kalite özelliklerinden yağ ($p<0.05$), protein ($p<0.001$), laktoz ($p<0.01$), kuru madde ($p<0.001$) ve yağsız kuru madde değerleri ($p<0.001$) elle sağım yapan işletmelerde en düşük olarak belirlenmiştir. Süt protein oranı en yüksek işletmeler robotik sağım sağım yapan işletmelerdir ($p<0.001$). Elle sağım yapılan işletmeler, somatik hücre sayısı bakımından en yüksek değeri almıştır ($p<0.05$). Toplam bakteri sayısı açısından makineli sağım yapan işletmeler en yüksek değere sahipken ($p<0.001$); robotik ve elle sağım yapan işletmeler daha düşük değerlere sahip olup, aralarında anlamlı bir farklılık bulunmamıştır.

Öneri: Farklı sağım sistemlerinin süt kalite ve hijyen değerleri üzerinde anlamlı etkilerinin bulunduğu anlaşılmıştır. Bu bakımdan sağım robotu kullanımının yaygınlaşması, toplam iş gücü maliyetini düşürmesi ve tank süt kalitesinde iyileşmeler sağlaması bakımından önerilmektedir

Anahtar kelimeler: Elle sağım, inek, robotik sağım, somatik hücre sayısı, süt kalitesi.

Abstract

Aim: The aim of this study is to evaluate the milk obtained from the farms with different milking systems by comparing total bacteria and somatic cell count for evaluating milking hygiene, barn hygiene and herd management and estimate the data by examining milk quality characteristics as dry matter, fat, protein and lactose contents.

Materials and Methods: The study material consisted of tank milk (15 hand milking, 15 conventional machine milking, 15 robotic milking) taken from 45 farms breeding Holstein dairy cattle in and around of Balıkesir. A calibrated raw milk analyzer was used to determine fat, protein, lactose, dry matter, fat-free dry matter and somatic cell count. In order to determine the total bacteria count, Plate Count Agar were inoculated with the cast plate method.

Results: Milk quality characteristics as fat ($p<0.05$), protein ($p<0.001$), lactose ($p<0.01$), dry matter ($p<0.001$) and fat-free dry matter ($p<0.001$) were determined to be the lowest in hand milking enterprises. The enterprises with the highest ratio of milk protein were robotic milking ($p<0.001$). Hand milking farms had the highest value for somatic cell count ($p<0.05$). For total bacterial count machine milking enterprises had the highest value ($p<0.001$) robotic and hand milking enterprises had lower values and no significant difference was found between them..

Conclusion: It was understood that different milking systems had significant effects on milk quality and hygiene values. In this respect, it is recommended that use of milking robots become widespread, reducing the total labor cost and providing improvements in tank milk quality.

Keywords: Cow, hand milking, milk quality, robotic milking, somatic cell count.

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Introduction

Milk and dairy products are important food sources by animal origin and constitute a source of healty life for people (OECD-FAO 2022). Dairy cattle breeding has an important place and a large amount of contribution in total milk production (Sarıalioğlu and Laçin 2020). The total cattle presence in Türkiye in 2021 was reported as 17,850,543 heads, sheep as 45,177,690 heads, goat as 12,341,514 and buffaloe as 185,574. In 2021, 23,200,306 tons of raw milk was produced in Türkiye and 92% of this amount (21,370,116 tons) came from cattle, 5% (1,143,762 tons) from sheep, 3% (622,785 tons) from goat and % 0,2 (63,643 tons) from buffaloes (TUIK 2021).

Innovations in industry and technology and animal welfare-based improvements in the agricultural sector have brought higher amount of production quantity and reduced the labor. Breeders have to follow the new technology in order to increase production and competition (Gökçe et al 2020). From this point of view, the first reflections of technology started with milking systems. Firstly, machine milking started in hand-milking enterprises, followed by a significant increase in the number of animals at the farm level, and separate sections were created for milking, and after milking, milk was stored in tanks through pipes. Today, many enterprises using robotic milking systems, which are the latest in milking technology, have succeeded in minimizing the use of labor (Alıç and Yener 2006, De Koning 2010).

Compared to conventional machine milking, robotic milking is a completely automatic process based on computer management, which increases the milk yield per cow by providing a significant increase in milking frequency, affects the economic, technical and social aspects of farming, changes animal physiology, health status. At the same time, since it is a voluntary milking system, it contributes to welfare in herd management (Hogenboom et al 2019). Moreover, it has provided advantages for farmers such as reduced labor, better social life and more efficient use of skilled labor. Manual labor involved in milking is largely replaced by management and control activities. Robotic milking also makes animal breeding more attractive for young breeders.

Today, milk is an important nutrient for humans (Baştan 2010). Quality milk production is necessary in order to benefit from the nutritional properties of milk. In addition to composition, cooling and storing the raw milk at +4 ^{0}C within 2 hours after milking in order to prevent microorganism growth is an important parameter that shows quality in production (Kılıç et al 2020).

The quality characteristics that can be detected in milk are fat, protein, dry matter, non-fat dry matter, lactose, freezing point, somatic cell count and total bacterial count. Hygiene problems experienced in milk obtained by hand milking due to the inability to clean and empty the udder properly, lack of cooling and storage tanks are important disadvantages related to manual milking (Gülsoy 2014). Although robotic milking uses the same milking principles as conventional milking, there are also differences. Robotic milking systems are in continuous use for 24 hours. Visual control is not possible during milking. Cows visit the system voluntarily, that can affect the quality of milk produced by causing changes in milking frequency (De Koning 2010).

The aim of this study is to evaluate the milk obtained from farms with different milking systems (hand milking, conventional machine milking, robotic milking) in terms of milking hygiene, barn hygiene and herd management by comparing them in terms of total bacteria and somatic cell counts and also evaluate of the data obtained by examining the milk quality characteristics by comparing them in terms of dry matter, fat, protein, non-fat dry matter and lactose contents.

Material and Methods

Material

The study material consisted of tank milk samples taken from Holstein dairy cattle breeding enterprises with different milking systems. The groups were determined as a total of 45 different enterprises, including 15 hand milking enterprises, 15 using a conventional machine milking enterprises and 15 enterprises with a robotic milking system from Balıkesir and the surrounding provinces. The number of dairy animals in the enterprises varied. Animals were fed with appropriate rations to meet their physiological needs. The brands of robotic milking systems were Lelly and De Laval. There were several brands of conventional machine milking and hand milking systems. Ideal pressure to be applied during milking were 280-380 mm/hg, and optimum pulsation ratio was 60:40 for cows. Hand milking and conventional machine milking enterprises, milkings were performed every 12 hours twice a day as morning and evening milkings. The bulk tank was cooled down the milk to +4^{0}C for conventional machine milking and robotic milking enterprises. For hand milking enterprises there were no cooling system and the milk was collected by local cooperatives. In the study only morning milking milk samples included in the study because laboratory analyzes were made in fresh samples for getting reliable results.

Method

The samples were taken from the stored tanks with sterile syringes after they were thoroughly mixed. For the total bacterial count, average of 10 ml of raw milk was taken into sterile tubes. For milk composition analysis and somatic cell

count, average of 30 ml of raw milk samples was taken into sterile tubes and a protective tablet was added into each tube. All samples taken were studied fresh, and the cold chain was maintained at +4 ^{0}C until they were delivered to the laboratory. After samples were taken, they were reached to the laboratory approximately in 1 hour.

In the chemical content analysis of raw milk, a Bentley Combi (FTS 600, USA) branded raw milk analyzer calibrated for cow's milk was used to determine fat, protein, lactose, dry matter, non-fat dry matter and somatic cell count. Before entering analyzer the milk samples temperature was increased at 40^{0}C

In order to determine the total bacteria count, Plate Count Agar (PCA) was inoculated with the cast plate method. Each sample was incubated at 37 ^{0}C for 24-48 hours and colony counts were made in petri dishes.

Statistical analysis

IBM SPSS 25 package program was used in the analysis of the data. After determining the suitability of the data for normal distribution, General Lineer Model (GLM) was used to determine whether there was a significant difference between the variables, and Duncan's test was used to compare significant groups. The lactation stage of animals in the enterprises and the ration mixture were different. The mean values of different enterprize groups were taken and to eleminate the effect of the enterprise it was added in to the statistical madel as a covariate. Analyses were considered as significant at ($p<0.05$).

Results

In the study, fat, protein, lactose, dry matter and non-fat dry matter data obtained from the analyzes made on raw milk from 15 hand milking enterprises, 15 conventional machine milking enterprises and 15 robotic milking enterprises were given in Table 1; somatic cell count and total bacterial count data were given in Table 2.

Milk fat percentage for hand milking group was 3.58% as the lowest among the milking enterprises ($p<0.05$). The highest protein percentage was 3.37% as robotic milking group and the lowest was hand milking group (3.04%) ($p<0.001$). While hand milking enterprises had the lowest lactose (4.56%), dry matter(11.66%) and fat free dry matter value (6.93%), conventional machine and robotic milking systems had the highest values (4.80%, 12.54%, 8.48% ; 4.83%, 12.60%, 8.64%) ($p<0.01$; $p<0.001$).

Table 1. Fat, protein, lactose, dry matter and fat-free dry matter values of cow's milk obtained from different milking systems (Mean±SEM)

	Hand Milking (n=15)	Machine Milking (n=15)	Robotic Milking (n=15)	p
Fat (%)	3.58±0.12^a	3.99±0.14^b	3.95±0.10^b	*
Protein (%)	3.04±0.06^a	3.23±0.01^b	3.37±0.03^c	***
Lactose (%)	4.56±0.09^a	4.80±0.03^b	4.83±0.02^b	**
Dry Matter (%)	11.66±0.24^a	12.54±0.12^b	12.60±0.13^b	***
Fat-free Dry Matter (%)	6.93±0.40^a	8.48±0.05^b	8.64±0.06^b	***

The difference among means carrying different letters in the same line is statistically significant *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

Table 2. Somatic cell count and total bacteria count from cow milk obtained from different milking systems (Mean±SEM)

	Hand Milking (n=15)	Machine Milking (n=15)	Robotic Milking (n=15)	p
Somatic Cell Count (10^3× cell/ml)	615.33±191.00^a	382.40±176.62^b	312.20±51.65^b	*
Total Bacteria Count (log kob/ml)	5.56±0.25^a	6.76±0.25^b	5.10±0.95^a	***

The difference among means carrying different letters in the same line is statistically significant *: $p<0.05$, ***: $p<0.001$.

Somatic cell count was determined as the highest with 615.33×103 cells/ml for hand milking enterprises, 382.40×103 cells/ml for conventional machine milking enterprises and 312.20×103 cells/ml for robotic milking enterprises ($p<0.05$). Total bacterial count was obtained as the highest with 6.76 kob/ml in the milk of conventional machine milking system, 5.56 kob/ml in the milk of hand-milking system, and 5.10 kob/ml in the milk of robotic system ($p<0.001$).

Discussion

The milking process applied in dairy farms is a time-consuming, difficult and demanding activity that takes approximately 25-35% of the annual labor of the enterprises (De Koning 2010). Today, the rapid increase in the movement from small family enterprises with a small number of animals to large intensive enterprises with an increase in the number of animals for dairy cattle breeding resulting increasing labor and make it necessary to use technology in dairy cattle enterprises. Investing in new technologies is one of the main ways to improve farm-level production and thus increase productivity (Heikkila and Myyra 2014).

Hand milking processes are applied in enterprises where the number of animals to be milked is low. Farms using this technique are very few today. With the technological developments and the increase in the number of animals have made machine milking compulsory in order to use the labor more efficiently, milk more cows per unit of time and obtain higher quality of milk (Alıç and Yener 2006, Akçapınar and Özbeyaz 2021).

In enterprises with high animal capacity, the milk milked in the milking departments and reaches the cooling tank through pipes. Compared to conventional milking, robotic milking system provides a significant increase in milking frequency, rise in milk yield, change milk quality in terms of certain parameters, affects the economic, technical and especially social aspects of farming. In addition changes in animal physiology, health and welfare in a fully automated process based on computer management. In particular it is an important system that offers modifications in herd management and allows voluntary milking of dairy cattle (Jacops and Siegford 2012, Hogenboom et al 2019).

Considering the current situation of animal husbandry in Turkey, it is known that the number of large-scale enterprises is quite low compared to small and medium-sized enterprises. In this respect, it is very difficult for small and medium-sized enterprises to meet the high amount of robotic system installation costs. On the other hand, it would be advantageous to prefer this system, especially for large-scale enterprises to be established, since the robotic system installation costs can pay for itself in a few years.

Quality parameters of milk produced in dairy farms are very important for enterprises. In this study, the effects of different milking systems on milk quality parameters were investigated comperatively. The fat ratio determined in the study was found to be the lowest in hand milking enterprises, and it was found to be similar in conventional machine milking and robotic milking enterprises ($p<0.05$). When the protein ratio was evaluated, the lowest enterprises were hand milking followed by machine milking and robotic milking ($p<0.001$). In terms of milk lactose, dry matter and non-fat dry matter values, enterprises of machine and robotic milking had highest values and the hand-milking enterprises were determined to be lower ($p<0.01$; $p<0.001$).

Hand milking enterprises in the study had low number of animals. At the same time, the productivity and genetic capacities of the animals were thought to be lower compared to robotic and conventional farms. In this respect, it is expected that the milk of hand milking enterprises will have lower rates in terms of fat, protein, lactose, dry matter and non-fatty dry matter values compared to the milk obtained from robotic and conventional milking enterprises.

The milk fat is related with feeding and genetic capacity of animal but also remaining milk in the breast affects the ratio. The fat level of the last milk remaining in the breast was higher than the first milk taken from the breast (Forsbasc et al 2010). Because of hand milking takes a long time, oxytocin activity decreased towards the end of milking. Fat globules accumulated in the upper part of the udder lobe. As the duration of milking increased, the effect of oxytocin decreased, so these fat globules remained in the udder and cannot be taken out by milking. At the same time due to the higher pressure in machine and robotic milking systems, it was easier to remove fat globules outside (Forsbasc et al 2010, Walter et al 2019).

In some studies, when milk samples obtained from automatic milking and conventional machine milking at different herd sizes, different periods and different stages of lactation were compared. While some of them were stated that the milking system didn't significantly affect the fat, fat-free dry matter, protein, casein and lactose values (Abeni et al 2005, Janstova et al 2011, Innocente and Biasutti 2013, De Marchi et al 2017); some researchers found that robotic milking enterprises had higher fat and protein content compared to conventional milking systems (Klungel et al 2000, Tousova et al 2014). With the transition conventional milking to robotic milking system, Salovuou et al (2005) found an increase in fat ratio in milk, Tousava et al (2014) determined an increase in milk fat and protein; Klungel et al (2000), Everitt et al (2002) and Kolenda et al (2021) found a decrease in milk fat and protein ratio.

In terms of somatic cell count, hand milking enterprises had the highest values, while machine milking and robotic milking enterprises had lower values ($p<0.05$). There was no statistically significant difference in terms of machine and robotic milking systems. The reasons of such an increase in somatic cell count could be the inability to ensure the cleanliness of the udder completely, insufficient level of hygiene in the milking environment and open cups the milk was collected into during milking. The increase in the somatic cell count is directly related to milking hygiene and udder health. When many parameters such as type of milking system, private milking parlor, maintenance frequency and cleaning routine of the milking system, washing and drying the teats before milking, teat dipping practices before and after milking performed correctly, udder health problems will be reduced and decrease of somatic cell count will be observed (Başţan 2010).

The robotic milking causes an important decrease in somatic cell count and a positive improvement in udder health compared with hand milking and conventional machine milking system. However, no matter what type of milking system is used, failure to control, maintain regularly and not paying attention to cleaning routines can lead to the growth of microorganisms in the system. It is inevitable that disorders such as irregularities in the vacuum/ pulsation ratios lead to nipple damage and increase in the rate of intramammary infection (Köker and Erdem 2016). Rasmussen et al (2002) reported an increase in somatic cell count and a deterioration in breast health in the transition from the conventional system to the robotic system but after the adaptation period, the number of somatic cells decreased. The most criticized point in robotic milking is the inability to visually control of the animals in terms of udder hygiene. The system cannot distinguish how clean or dirty the teat is at the start of milking. In this respect, although the system ensures the cleaning of the teat, problems caused by nipple contamination can be observed in the robotic system (Jacobs and Siegford 2012). The possibility of cross contamination can be observed at a higher rate in robotic milking systems due to the lack of visual control. In conventional milking systems, animals with suspected mastitis are milked last; In robotic milking, since milking is on a voluntary basis, it is important that the individual follow-up of the animals is done well and the system does not allow milking of these animals (Bockhahn and Terry 2022a, 2022b).

In the presented study, while the total bacteria in the milk obtained from the conventional machine milking enterprises was the highest; the values determined from hand milking and robotic milking enterprises were lower ($p<0.001$). There was no significant differences between the robotic and hand milking enterprises for total bacteria ($p>0.05$). The highest level of total bacteria in enterprises with conventional machine milking may be caused by a contamination at any point of the milking system, cross-contaminations during milking, problems that may occur during the cleaning of the system, residual milk in the pipelines of the milking system or contamination in the tank milk due to the fact that animals with suspected mastitis were not milked separately (Aytekin and Boztepe 2004, Patır et al 2010).

In order to reduce the total bacteria count, it is necessary to focus on critical measures and practices such as arranging the barn and the environment, correct management of the milking process, maintenance and cleaning of milking equipment. Also, cleaning of teats, teat dipping before/after milking and dry period management are important for total bacteria count (Tosun and Acar 2019).

Conclusion

As a result, it was understood that different milking systems had a significant effect on fat, protein, lactose, dry matter, non-fat dry matter, somatic cell count and total bacterial count. Fat, protein, lactose, dry matter and non-fat dry matter values were found to be the lowest in hand milking enterprises. The total bacterial count was found to be the highest in conventional machine milking systems. Somatic cell count was found to be the lowest in milk obtained by robotic milking systems.

The study has shown that there is a need for region-based improvements in quality of milk production. In order to overcome these problems, all dairy cattle breeders should pay attention for quality and hygienic production. For this purpose, it can be recommended to switch to the use of machine milking or milking robots in order to reduce the workload of enterprises with a large number of animals, to carry out the necessary controls for each animal regularly and continue hygienic milking procedures in accordance with the standards as much as possible. It should not be forgotten that the robotic milking system is only a milking machine. In the success of this system, the importance of the technically trained workforce, the need for attention and the good functioning of other sub-systems are important

Conflict of Interest

The authors did not report any conflict of interest or financial support.

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Author Contributions

Motivation / Concept: BY; Design: BY; Control/Supervision: BY, OVA, HT; Data Collection and / or Processing: SSO, BY, BC, MS; Analysis and / or Interpretation: SSO, HT, TEG; Literature Review: SSO, OVA, TEG, BC, MS; Writing the Article: BY; Critical Review: BY, HT, OVA.

Ethical Approval

Balıkesir University Experimental Research and Application Center, Animal Experiments Ethics Committee 03/06/2021, 2021/5-2 Number Ethics Committee Decision