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THE EFFECTS OF BODY DIRTINESS SCORES AND TEAT PROFILE ON MILK YIELD AND QUALITY IN HOLSTEIN-FRIESIAN COWS RAISED IN SOME DAIRY CATTLE FARMS IN AYDIN PROVINCE

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The thesis with the title of “The Effects of Body Dirtiness Scores and Teat Profile on Milk Yield and Quality in Holstein-Friesian Cows Raised in Some Dairy Cattle Farms in Aydın Province” prepared by Frederic Ndihokubwayo, Masters’ Student at the Graduate School of Natural and Applied Sciences Program at the Department of Animal Science was accepted by the jury members whose names and titles presented below as a result of thesis defense on July, 22nd 2020.

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I hereby declare that all information and results reported in this thesis have been obtained by my part as a result of truthful experiments and observations carried out by the scientific methods, and that I referenced appropriately and completely all data, thought, result information which do not belong to my part within this study by virtue of scientific ethical codes.

…/…/2020

Signature

Frederic NDIHOKUBWAYO

ÖZET

AYDIN İLİNDE BAZI SÜT SIĞIRI İŞLETMELERİNDE YETİŞTİRİLEN SİYAH-ALACA İNEKLERDE VÜCUT KİRLİLİK PUANLARI İLE MEME BAŞI PROFİLİNİN SÜT VERİM VE KALİTESİ ÜZERİNE ETKİLERİ

Frederic NDIHOKUBWAYO

Yüksek Lisans Tezi, Zootekni

Tez Danışmanı: Prof. Dr. Atakan KOÇ

2020, 62 Sayfa

Bu çalışmanın amacı, Aydın ilinde farklı süt sığırı işletmelerinde yetiştirilen Siyah-Alacaların vücut kirlilik puanları ile meme başı profilinin süt verim ve kalitesi üzerine etkilerini araştırmaktır. Çalışmada, 8 farklı işletmede yetiştirilen toplam 265 baş ineğin sabah süt verimi (SSV, kg) ile 9 işletmedeki 432 ineğin vücut kirlilik puanı (VKP), meme başı puanı (MBP), yağ oranı (YO, %), yağsız kuru madde oranı (YKMO, %) ve somatik hücre sayısı (SHS, hücre/ml) kullanılmıştır. SSV ile ilgili olarak, işletme ve laktasyon dönemi etkileri önemli ($P<0.01$) ve en küçük kareler ortalaması 13.92±0.315 kg olarak hesaplanmıştır. VKP için işletme ve laktasyon sırası ($P<0.01$) etkileri istatistiksel olarak önemli bulunurken, MBP için işletme ($P<0.01$), laktasyon sırası ($P<0.05$) ve laktasyon dönemi ($P<0.01$) ve ortalamaları sırasıyla 3.30±0.048 ve 2.17±0.038 olarak hesaplanmıştır. YO üzerine işletme ve YKMO üzerine işletme, laktasyon sırası, buzağılama mevsimi ve laktasyon dönemi etkileri önemli ($P<0.01$), diğer etkiler önemsizdir ($P>0.05$). YO ve YKMO ortalamaları sırasıyla %3.58±0.039 ve %10.14±0.032 olarak hesaplanmıştır. SHS üzerine işletme, laktasyon sırası ve MBP etkileri önemli ($P<0.01$) ve ortalaması (165.958 hücre/ml) olarak hesaplanmıştır. Çalışma sonunda VKP'nin süt kalitesi üzerine önemli bir etkisi elde edilmemişken, makinalı sağım ve bakım-yönetimin etkisi altında olan MBP'nin işletmelerde azaltılmasının çiğ sütteki SHS düzeyini düşürerek süt kalitesinin artışına katkı sağlayacağı sonucuna varılmıştır.

Anahtar Kelimeler: Süt sığırı, vücut kirlilik puanı, meme başı puanı, inek sütü, somatik hücre sayısı.

ABSTRACT

THE EFFECTS OF BODY DIRTINESS SCORES AND TEAT PROFILE ON MILK YIELD AND QUALITY IN HOLSTEIN-FRIESIAN COWS RAISED IN SOME DAIRY CATTLE FARMS IN AYDIN PROVINCE

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MSc. Thesis, Animal Sciences

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The aim of this study was to determine the effects of body dirtiness score and teat profile on milk yield and quality in Holstein-Friesian dairy cattle raised in some dairy farms in Aydın Province. In this study, a total of 265 Holstein-Friesian (HF) cows raised in 8 different farms were used for morning milk yield (MMY, kg). Besides, 432 HF cows raised in 9 different farms were sampled for the determination of body dirtiness score (BDS), teat score (TS), fat content (FC, %), non-fat dry matter content (NFDMC, %) and somatic cell count (SCC, cell/ml). Regarding MMY, the effects of farm and the lactation stage were statistically significant ($P<0.01$). The overall least square mean (LSM) was 13.92±0.315 kg. The effects of farm, parity on BDS ($P<0.01$) and farm ($P<0.01$), parity ($P<0.05$), lactation stage ($P<0.01$) on TS were statistically significant. The overall LSM of BDS and TS were 3.30±0.048 and 2.17±0.038, respectively. Regarding milk quality, the effects of farm on FC and farm, parity, calving season and lactation stage on NFDMC were found statistically significant ($P<0.01$) and the LSM were 3.58±0.039% and 10.14±0.032%, respectively. Regarding the SCC, the LSM was 165,958 cells/ml. The effects of farm, parity and TS were found statistically significant ($P<0.01$) whereas other effects were not important ($P>0.05$). As a result, BDS having no significant effect on milk quality, reduction of TS, which is under the influence of machine milking and management, can contribute to the increase of milk quality by lowering the SCC level in raw milk.

Key Words: Dairy cattle, body dirtiness score, teat score, cow milk, somatic cell count.

ACKNOWLEDGEMENTS

This study was aimed at determining the effects of body dirtines score and teat profile on milk yield and quality in Holstein-Friesian cows raised in some dairy farms in Aydın province. The milk quality being the major concern of milk producers, processors and milk consumers, this study showed the role played by the control of teat conditions. This study was the first realized about teat scoring in Turkey. That is why the information provided here may help in academic area for researchers who would like to perform similar researches in other cattle breeds or other lactating species such as goats, buffalos and camels.

The accomplishment of this work was the fruit of concentration of efforts of many people. My special thanks go towards my Thesis Supervisor Prof. Dr. Atakan KOÇ who, despite his intensive program, provided all kinds of support, reading, evaluation and necessary corrections of this work; and to all lecturers of the Faculty of Agriculture of Aydın Adnan Menderes University.

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Frederic NDIHOKUBWAYO

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LIST OF ABBREVIATIONS

º C: Degree Celsius

g: Gramme

kg: Kilogram

L: Liter

ml: Milliliter

mm: Millimeter

µl: Micro liter

ADÜ: Aydın Adnan Menderes Üniversitesi

BC: Before Christ

BS: Brown-Swiss

BSE: Bovine Encephalopathy Spongiform

cfu: Colony-forming unit

CMT: California Mastitis Test

BDS: Body dirtiness score (VKP: Vücu kirlilik puanı)

FC: Fat content (YO: Yağ oranı)

HF: Holstein-Friesian

$Log_{10:}$ Ten based logarithm

MB: Montbeliarde

MC: Microorganism content

MMY: Morning milk yield (SSV: Sabah süt verimi)

Mt: Million tones

N: Normal

NFDMC: Non-fat dry matter content (YKMO: Yağsız kuru madde oranı)

PC: Protein content

R: Rough

RH: Red Holstein

S: Smooth

SCC: Somatic cell count (SHS: Somatik hücre sayısı)

TEH: Teat end hyperkeratosis

TL: Türk Lirası

TS: Teat score (MBP: Meme başı puanı)

TSI: Turkish Statistical Institute

USA: United States of America

USD: United States Dollar

VR: Very rough

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1 INTRODUCTION

Cattle is a mammal belonging to the genus *Bos*. It has been domesticated since 10-12 thousand years BC (Butor, 2019) principally for purposes of soil cultivation, meat, milk and skin production. Among those purposes, the soil cultivation has been progressively replaced by tractors all over the world. Actually, beef, milk, skin and manure productions are topical. Regarding milk production, even though there are more than 800 cattle breeds worldwide, dairy cattle breeds are not abundant (Akman et al., 2015).

The increase in world population associated with globalization, both provoked the change of the lifestyle and increase in basic needs especially food from animal source. Generally, local breeds with low production performances being present everywhere, the mankind sought to improve cattle breeds that can produce the maximum of meat and milk. Akman (1985) stated that the genotype of local cattle breeds in terms of beef and milk production is lower but adapted to the local breeding conditions. The local breed is normally resistant to diseases and survives in poor diet while foreign breeds require improved nutrition, intense veterinary care and are not resistant to local diseases. That is why the crossbreeding of local and foreign breeds has then been applied to ameliorate production performances of the local breeds. That crossbreeding has been applied by mating a male of foreign breed and a female of local breed or by practicing artificial insemination.

In Turkey, since the year 1925 when the first foreign breeds (Brown-Swiss and Simmental) were imported, later on Brown-Swiss was crossbred with local Steppy Grey breed in Karacabey Harası (Sönmez et al., 2007), a new genotype was improved, called Karacabey Brown-Swiss (Karacabey Esmeri). After the first introduction of the above foreign cattle breeds, the importation of foreign breeds continued. In 1958, two beef breeds, Aberdeen Angus and Hereford, and two dairy cattle breeds, Holstein-Friesian and Jersey breeds were introduced to the breeders in Turkey. Then, in 1986, the private companies got permission to import foreign breeds but this importation was stopped because of the apparition of Bovine Spongiform Encephalopathy (BSE) disease in 1996. After the year 2000, the importation was re-allowed from the countries that have been declared free from BSE. In addition, during this time, Turkey has also imported cattle sperm for the use of artificial insemination. As a result, the proportion of cattle population resulted in three main groups: Foreign, crossbred and local breeds. This means that among 17.688 million heads, 48.39% are made of foreign breeds, 42.71% crossbred and 8.90% of local breeds (TSI, 2020).

Generally, one of the main reasons of keeping cattle is milk production. By definition, milk is a physiological liquid that is white, opaque, slightly sweet, with a density greater than that of water. It is secreted by epithelial cells of mammary gland under the influence of prolactin hormone in female mammals. Normally, when the word ‘milk’ is said freely, it is related to cow milk. Milk is then the complete food containing nutrients such as animal protein, fat, vitamin, mineral substances, lactose, etc that are necessary for balanced and adequate nutrition.

When considered milk production worldwide, a significant increase in milk production has been observed last decades. In 1970, a total of 391.95 million tones (Mt) milk were produced. The top 5 milk producers were the United States of America (53.07 Mt), Germany (28.18 Mt), France (22.85 Mt), India (20.80 Mt) and Poland (14.96 Mt). In the year 2017, a total worldwide milk production of 827.88 Mt has been registered. The top 5 milk producers were India (176.27 Mt), the United States of America (97.76 Mt), Pakistan (44.29 Mt), China (34.87 Mt) and Brazil (33.74 Mt). According to years, milk productions were 391.95 Mt in 1970, 465.82 Mt in 1980, 542.53 Mt in 1990, 759.31 Mt in 2000, 724.45 Mt in 2010, 801.13 Mt in 2015 and 827.88 Mt in 2017 (FAOSTAT, 2019).

In Turkey, milk production also showed a significant increase last decades. That increase is explained by the increase of the proportion of foreign cattle breeds in the cattle population, amelioration of nutritional conditions followed by the increase in number of dairy cattle recent years. The milk yield per animal passed from 1351 liters in the 1990’s to 3161 liters in the year 2018. However, that value of milk yield still stays lower when compared to the European Union countries whose average is 6000 liters per animal (NMC, 2018). In the year 2000 in Turkey, the total quantity of milk from all sectors (cattle, buffalo, sheep and goats) was 9,790,000 tones. Among that amount, 8,732,000 tones of milk were produced by 5,279,569 cows. In the year 2019, the total milk production passed to 22,960,379 tones. Among them 20,782,374 tones were produced by 6,580,753 of cows (TSI, 2020).

Considering that production, it is seen that milk has a great importance in human nutrition. It is drunk as raw milk or can be transformed into cheese, yoghurt, milk powder, butter, etc. That being so, milk quality has to be considered as the first priority issue for consumers. So many factors influence milk quantity and quality such as animal breed, nutrition, season, lactation stage, parity, milking machine, milking management, milking interval and so on. Those factors are also associated with the feeding system and hygienic conditions of the farm where dairy cows are kept. The milk composition varies according to species. The following table (Table 1.1) shows milk composition of different mammals.

Table 1.1. Milk composition of some species of mammals (percentage per unit of weight) adapted by Forsbäck (2010).

Species	**Water**	**Fat**	**Casein**	**Whey protein**	**Carbohydrates**	**Ash**
Human	87.1	4.5	0.4	0.5	7.1	0.2
Cow (*Bos taurus*)	87.3	3.9	2.6	0.6	4.6	0.7
Zebu (*Bos indicus*)	86.5	4.7	2.6	0.6	4.9	0.7
Sheep	82.0	7.2	3.9	0.7	4.8	0.9
Goat	86.7	4.5	2.6	0.6	4.3	0.8
Camel	86.6	4.5	2.7	0.9	4.5	0.8
Buffalo (*Bubalus bubalis)*	82.5	7.5	3.6	0.7	4.8	0.8
Horse	88.8	1.9	1.3	1.2	6.2	0.5

The feeding system affects the nutritional quality of milk such as milk fat content (FC), protein content, non-fat dry matter content (NFDMC). In parallel, the hygienic conditions of the barns and milking management have effects on the total number of bacteria and somatic cell count (SCC) in the milk. Other factors affecting milk quality are barn conditions, stress, poor cleanliness or high dirtiness score and poor feeding conditions. Some additional factors may be added like some practices that are susceptible to cause total bacteria changes such as storage of milk, milking management and the manner how cows are managed while entering the dry period (Batu, 1978). Additional factors affecting milk quality maybe the presence of antibiotics, disinfectants, pesticides, herbicides and mycotoxins from moldy feeds whose traces are found in the milk. Brown et al. (1986) reported high SCC in milk of fast-milked cows whereas Galton et al. (1982) reported a negative effect of inappropriate milking operations on milk SCC. Milk quality is also determined by its processing characteristics especially in production of high value added market products (e.g: cheese) (Sturaro et al., 2013).

Regarding the health and hygienic conditions of a lactating cow, the udder and teats have to be taken into consideration. In dairy cattle, teat conditions are of great importance as they give an idea about the general health of the lactating cow (Ndihokubwayo et al., 2019). The deficiency in teat conditions result in disease incidence and the common and most assisted disease in this case is mastitis. It is well known that mastitis is the costliest disease causing economic losses in dairy cattle. Mastitis is an inflammation of the mammary gland generally due to microbial (bacteria, virus and fungus) origin factors. The entrance gate of those harmful microorganisms is the teat canal. The disruption of the natural form of the teat canal and teat end profile facilitates the entrance of microorganisms into the udder, leading to mastitis and milk quality deterioration.

So many factors cause the teat profile deterioration such as milking machines errors (Baştan, 2010), high vacuum, increased milk yield, prolonged milking time (Mundan et al., 2015), dirtiness of the barn condition, inproper bedding, etc. Milking machines sometimes continue milking despite the end of the milk flow. All those factors are accused to cause deficiency in teat conditions and result in teat end hyperkeratosis (TEH). The formation of cracks at the teat end provokes sphincter cellular degeneration and harmful microorganisms may develop in those cracks. Those microorganisms enter the udder via teat canal and cause subclinical or clinical mastitis. That is why the idea came to the mind that the degree of teat condition may affect the milk quality.

The overall objective of this study was to determine the effect of the body dirtiness scores and teat profile on milk quantity and quality in HF dairy cows raised in some farms in the province of Aydın, South-West of Turkey. That overall objective was processed in three steps. The first step was the determination of the BDS and TS. The second step was the determination of MMY, FC, NFDMC and SCC. The last the step was the determination of BDS and TS effects on MMY, FC, NFDMC and SCC in HF cows.

2 LITERATURE REVIEW

In lactating dairy cows, teat condition here expressed by the teat end hyperkeratosis (TEH) is of great importance in dairy herd management. The TEH is formed progressively during the whole lactation period. There is formation of cracks at the teat end that vary between 1-4 mm of diameter and constitute a suitable area for the development of microorganisms. Those microorganisms, normally present in the environment, due to the low quality of hygienic conditions, are attached to the udder and the teats and develop in the cracks formed as a result of resistance response of the teat end to the high vacuum of milking machines and other factors. Those microorganisms enter into the udder via the teat canal and are likely to cause mastitis.

In addition, another indicator of hygienic conditions of the cows in a herd is the body dirtiness score (BDS) that demonstrates the quality of the environment in the area where the herd is managed. The degree of dirtiness of a dairy cattle in a farm has been used ever since for the evaluation of the quality of the environment, fact that may affect the animal health and hence the quality of dairy output.

This study was carried out in HF dairy cattle. Its characteristics and performances are presented below. Also, studies related to BDS, TS, MMY, FC, NFDMC and SCC are summarized in this section.

2.1 Holstein-Friesian breed

Holstein-Friesian (HF) breed has been selected for its high dairy performances. HF breed, *Bos Taurus Primigenius* originates from Friesian Region of the Netherlands (Kumlu, 1999). It is known as a best dairy breed all over the world. As chief characteristics, HF is of large size, black and white spotted. HF calf weighs approximately 40 kg at birth. At adulthood, bulls can reach up to 1000 kg whereas cows reach 600 kg or more of body weight. Because of their high performance, HF cattle necessites very specialized breeding conditions, high genetic selection, very careful feeding and suitable health and hygienic conditions. Once kept in suitable conditions, milk production can even reach more than 10000 kg per lactation. HF is one of the first dairy breeds kept in Turkey. It is also stated as the most dominant breed in Aegean Region (Yilmaz, 2010). In Aydın, HF constitutes alone more than 55% of the total number of heads kept in this province (local and foreign breeds combined).

2.2 Teats

Teats are the part of the udder ensuring communication between the mammary gland and the external environment. They are located on the lower part of the udder. Generally, anterior teats are longer than the posterior ones. With the length varying between 3-12 cm and 2-3 cm of diameter (Boudry, 2005), teats canalize milk from the udder to the exterior while calves are suckling or during milking by milking machines or by human’s hands. The conformation of the teats differs from one cow to another. They are of three principal shapes: Cylindrical, Funnel-shaped and Pear-shaped teats. However, shapes of the teat are not the interest of this study.

The parts of a teat are teat skin, teat end and teat canal. Those components sometimes undergo short-term, medium to long term changes that are induced by various factors: milking management, milking machine-induced, environmental and infectious-induced changes. Long term changes result in TEH. Hyperkeratosis can likely develop very rapidly in case of harsh environmental conditions or when the weather is particularly windy or very cold (Anonymous, 2020).

2.3 Body dirtiness score

Another factor that is independent from the cow level but could be affecting milk quality is the body dirtiness score (BDS). The BDS is the result of the quality of the environment where dairy cows are raised. While the cows scored 1-2 are the dream in intensive and semi-intensive farming system, BDS 4 to 5 indicate a harsh or non-appreciated hygienically environment for dairy cows and are the scores characteristic of intensive farming systems. Environmental matter such as bedding materials, soil, manure and various organic matter constitute the current sources of coliform bacteria causing infections in the udder via the cow’s teats. However, not so many studies are available about BDS in dairy cows, some study cases are summarized below.

Trajcev et al. (2003) conducted a study with the objective of determining udder, hind legs cleanliness on clinical mastitis incidence in lactating dairy cattle in the Republic of Macedonia and the longitudinal observations were conducted during one year observations. In this study, a total of 1031 HF lactating cows of three different farms were used for hygienic scoring three times an year in all seasons. It was found 45.86% as percentage of the annual incidence risk of clinical mastitis on the entire population level and mean hygiene scores were 1.87; 2.13 and 2.04 respectively for udders, hind legs and tail. The colony count average resulted in 5908.29 cfu/ml bacteria at the rises of front and rear papilla mamma. There was a high statistical significant interdependence between farm management, period of the year and hygiene score but the hygiene score was not significantly linked with clinical mastitis in dairy cows. However, the influence of the farm management, lactation period and the period of the year on total colony count of bacteria was statistically significant ($p<0,01$).

In their study constituted of 11 dairy farms, Barbari and Ferrari (2006) compared the hygienic conditions of lactating cows sheltered in loose housing systems with various lying areas. To realize the study, they scored the cleanliness of five different anatomical parts of cow's body: back sacro-ischiatic part, back side of the udder, front side of the udder, legs and feet. They obtained the best hygienic conditions in cubicle cowsheds using 3.3 kg of straw per cow and 2 kg of sawdust per cow. Therefore, researchers concluded that acceptable hygienic conditions can be assured by using cubicles that are equipped with synthetic mattress without bedding. Nonetheless, cow's cleanliness can be better ameliorated using bedding in that kind of cowsheds (Barbari and Ferrari, 2006).

O'Driscoll et al. (2008) conducted a study aimed at comparing cow's dirtiness scores during winter housing period and udder's health during both winter period and following lactation and for spring-calving cows resulting from three woodchip out-wintering pad designs and indoor cubicle housing during two years. Results showed that dry cows stocked at $12m^2$/cow in the out-wintering pad showed less chance to have udder health problems in subsequent lactation. Then, the cleaning of the shelter and provision of clean woodchips are the management factors helping to keep cows clean in the out-wintering pad design.

The effect of two housing system (free-tall & tie stall) on cow's cleanliness and its effect on milk SCC in lactating cows was determined. It was found that the Log_{10}SCC increased from 11.54 to 12.37 of average according to increased udder dirtiness. Once analyzed the effect of overall cleanliness of the cow's body and parts on milk SCC classes, clean cows (71.52%) produced the highest milk quality with less than 200000 cells/ml in the milk. It was observed that the incidence of subclinical and clinical mastitis was increased with decreased cleanliness of the udder especially for cows sheltered in free-stall barn. Regarding clinical mastitis in cows, the proportion was varying from 2.51% (in clean cows) to 14.29% (in dirty cows) (Neja et al., 2016).

2.4 Teat end hyperkeratosis in lactating cows

In this study, the teat end hyperkeratosis (TEH) level has been evaluated as TS. It is defined as a roughness, thickness, fronds, cracks and rings that are formed at the teat end. Blowey and Edmondson (1995) said that TEH evolves as a result of degeneration of the keratin layer that has a physical barrier against the pathogens that cause infection in the udder (Blowey and Edmondson, 1995). Baştan (2010) stated that hyperkeratosis formation may be due to functional errors of milking machines. The excessive vacuum of milking machines is associated with pulsation error after milking run outs. While assisting to milking, it can be observed the milking machine scenario where machines do not stop milking despite the stop of milk flow or milking that last longer (Mundan et al., 2015), all those factors are accused to cause TEH in lactating dairy cows. The advanced TEH expressing the deformation of the teat end may provoke the accumulation of microbes that develop in the cracks and, via the teat canal, colonize the udder and evolves into mastitis or into other complications. This may result in increase of SCC and reduce the yield and quality of milk.

The farm management factors such as barn type, barn care, regular changing of litter, manure's removal and milking machine control may be taken into account to reduce TEH formation. Those factors may also help to reduce mastitis which usually occurs in case of teat located on low udder base that let the small space to the barn floor, causing easy teat contamination and traumas (Emre, 2009). Make sure the causes of TEH are various including the genetic factors.

On cow level, factors that cause TEH are:

Cow's age: The TEH is not frequent in heifers (cows of young age, before calving) but it is common in cows especially milked by milking machines (Sieber and Farnsworth, 1981; Shearn and Hillerton, 1996; Neijenhuis et al., 2000). With increased age, the height of the udder base decreases, sphincter muscles are relaxed and therefore, TEH is high and the cow is very sensible to mastitis (Izgür, 1984).

Lactation Number: As SCC increases at a rate of 31.3% at fifth and above lactations (Emre, 2009), TEH also increases with the parity.

Lactation Period: The highest point of TEH is reached at the peak lactation and decreases at the end of lactation.

Environmental conditions: The TEH is likely to occur when the weather is very hot or very cold or in harsh environmental conditions.

2.5 Inspection time morning milk yield in HF

Studies related to inspection time MMY are summarized in this section.

In a study, 45 HF and 55 MB dairy cows raised together in 10 different dairy cattle farms in Aydın Province were used. The averages were 13.20±0.529 kg and 10.99±0.462 kg, respectively as results of inspection time morning milkings. It was found that the effect of breed on MMY was statically significant ($P<0.01$) (Koç, 2007a).

Koç (2007b) conducted a study in three different farms accounting 67 HF and 16 BS lactating cows in the province of Aydın. Inspection time milk yield averages were 8.92±0.188 kg and 7.09±0.367 kg, respectively. In this study, breed, farm, milking time, lactation month, lactation number, NFDMC and milk SCC effects were reported statistically significant.

Koç and Kızılkaya (2009) conducted a study about inspection time milk yield in HF dairy cows. In that study, milk samples from 95 heads HF cows were harvested and effects that influence inspection time milk yield have been studied. It was found that farm, lactation month, lactation number, milking time and milk SCC effects were significant. It was reported a low milk yield in cows at first lactation (8.92±0.183 kg) and morning milk yield average was higher (10.58±0.204 kg) when compared to evening milk yield average (8.99±0197 kg).

In another study, 114 heads HF and 108 heads MB lactating cows raised together in 19 different farms in Aydın Province were used. Milk samples were harvested in the morning winter and summer. In this study, the effect of breed on inspection time morning milk yield was reported statistically significant ($P<0.05$). The averages milk yield were 7.69±0.397 kg and 9.39±0.237 kg (Koç, 2011).

2.6 Milk quality traits

Milk has been used as food alternative and complete food since ancient times. That being so, milk quality has always been a problem hunting societies all over the world. The transformation of good quality milk gives also the good yield of products such as yoghurt, cheese, butter, oil, etc. For example, increased number of SCC in the milk results in decrease of lactose, caseins and the rate of fat content (Eyduran et al., 2005).

By the way, milk quality is related to feeding and hygienic quality. On one hand, the feeding quality of milk refers to the rate of milk FC, NFDMC, PC, etc. On the other hand, hygienic qualities of milk are related to total microorganism contents (MC) and SCC. Apart from that, other indicators of milk quality traits are the traces of antibiotics, disinfectants, pesticides, herbicides and mycotoxins from moldy feeds that can be found in milk. However, this study didn't deal with all those milk quality traits, it dealt with milk FC, NFDMC and SCC.

2.6.1 Milk fat content (FC)

The milk FC is an indicator of milk quality. The percentage of FC in raw milk varies between 2.4 and 5.5%. In HF, the mean percentage is 3.6%. The rate of FC in cow milk normally shows significant variation according to cow breed (Baştan, 2010).

Factors affecting milk FC are various such as:

Individuality: Milk FC depends on genetic and inheritance potentials for a given cow.

Cow breed: Milk FC from some breeds are higher than others (3.6% in HF, 3.8% in Ayrshire, 4.6% in Guernsey and 4.8% in Jersey)

Lactation stage: Milk FC is lower during the first two months of lactation and becomes higher in the following months. Milk FC level is said to be decreased to the lowest point between 25 and 50 days after calving but the peak is reached at 250 days when milk production is beginning to decrease.

Cow age: The older is the cow the lower becomes milk FC. Milk fat is said to fall about 0.2% every year from 1st to 5th and + parities. That decrease is likely a result of high production associated with more udder infections.

Feeding: Nutrition constitutes a great factor influencing milk FC and the whole milk composition. Scientists suggested that the great key to get normal milk FC is to feed cows with a ration constituted of 35% of forage or forage quantity reaching 1.5% of body weight.

Other factors: Milk FC can vary due to mechanical errors such as cooling problems in the bulk tank, sampling problems and over agitation in the pipeline. When the milk is harvested from the udder before milking, the fat content is lower, it increases progressively with the milking. This explains the fact that FC in milk is affected by udder emptying during milking process (Tancin et al., 2007; Nielsen et al., 2005; Svennersten et al., 1991; Johansson et al., 1952). At the contrary, the degree of udder filling contributes to the increased FC rate in the milk (Weiss et al., 2002). Note that studies that investigate milk FC in cows with mastitis are not in agreement.

2.6.2 Non-fat dry matter content (NFDMC) in the milk

The rate of NFDMC in the milk is another factor indicating milk quality. Normally, the highest rate of milk constituent is water that occupies 902-905 g/L. The total rate of dry matter in the milk occupies only about 125-130 g/L including fat content (FC). The rate of NFDMC, expressing milk content in dry elements, has the value of around 90g/L (ULB, 2017). What is more, the rate of NFDMC depends on various factors such as cow breed, milking time, lactation month, parity, farm managerial conditions, etc. Available studies about NFDMC in the milk were reviewed in this section.

The results of morning milk samples analysis obtained from a study realized by Koç (2007a) in 10 dairy farms located in the province of Aydın constituted of 45 HF and 55 MB cows showed that NFDMC were respectively 9.98±0.99% and 10.26±0.087%. Those averages were found statistically significant ($P<0.01$) regarding milk NFDMC between breeds.

The similar study realized by Koç (2007b) in 3 dairy farms constituted of 67 HF and 16 BS cow breeds of Aydın province showed that milk NFDMC were 9.61±0.048% and 10.12±0.093%, respectively. The averages were found statistically significant ($P<0.05$) regarding the breed, milking time, farm conditions and lactation month.

Another study conducted in 4 dairy farms of Aydın province during 2003-2005 years by Koç (2008a) in milk samples from 110 HF lactating cows resulted in 9.78±0.024 % NFDMC. Those averages were found statistically significant ($P<0.05$) regarding farm conditions, month, farm-year interaction effects; and statistically not important ($P>0.05$) regarding the year and farm-season interaction effects.

In another study, a dairy farm constituted of only RH breeds was taken. During that study, 53 heads were taken for morning and evening milk samples during winter; and 49 heads for morning milking and 48 heads for evening milking samples during the summer. NFDMC were analyzed and 8.94±0.067% were found for primiparous. Those values were reported statistically not important regarding parity and month effects (Yılmaz, 2010).

In Aydın province, 19 mixed Montbeliarde (MB) and HF dairy farms were used by Koç (2011) in a study aimed at determining NFDMC in milk. During that study, milk samples from 108 heads MB and 114 heads HF were harvested during morning milkings in winter and summer. The averages for MB and HF were 8.35±0.047% and 8.23±0.067% NFDMC, respectively. Those values were reported statistically significant ($P>0.05$) regarding farm group, season, lactation period and breed x farm group interaction effect. The average NFDMC for both breeds were 8.38±0.066% at the first lactation.

In a study aimed at determining the effect of SCC and some environmental factors on milk yield and milk components conducted within 4 years (2009-2012), RH lactating cows were used. During this study, 129 heads were targeted for 449 morning milk samples and 442 evening milk samples 2 times an year during winter and summer. The results for milk NFDMC morning and evening were respectively 8.58±0.038% and 8.60±0.038%. Those averages were statistically significant ($P<0.05$) regarding the season, parity and milk SCC. The average milk

NFDMC was 8.78±0.044% and it was reported very high for primiparous than pluriparous (Koç, 2015).

Another study aimed at determining the reproductive characteristics, milk yield and milk quality in HF and RH dairy cows raised in a private dairy cattle farm in the Province of Aydın was performed. In that study, 14 HF and 83 RH lactating cows at first lactation were used. The overall mean NFDMC was 9.79±0.036%. The effect of lactation month on milk NFDMC was statistically significant ($P<0.05$). However, breed, interaction breed x lactation month was not significant (Gürses, 2019).

2.6.3 Somatic cells in the milk

The milk contains different types of somatic cells. In a healthy udder, it was said that 75-85% are made of leukocytes and the 15-25% that remain are made of epithelial cells and 98-99% of somatic cells are white blood cells. On one hand, epithelial cells are found in alveoli, tissues known as units that produce milk. The role of epithelial cells is to immediately synthesize milk after birth within the first 3 days and are regularly significantly renewed. On the other hand, it seems impossible to find a milk sample not containing somatic cells (Blowey and Edmondson, 1997). Normally, white blood cells are present in the lymph centers. In case of inflammation or injury, somatic cells pass to the blood and directly to the milk as a result of defense resistance mechanism. In general, milk SCC is an indicator of udder's health.

The elevated number of SCC in the milk is associated with mastitis or other factors such as age, parity, season, etc. Lactating cows with milk samples accounting from 250000 cells/ml are said to be with subclinical mastitis. In Turkey, the Turkish Food Codex criteria allows the amount of SCC of 500000 cells/ml in raw milk.

Generally, a great number of factors affects SCC in the milk such as:

Age: The high SCC is observed in milk samples of old cows. When the age is increased, deformations in the udder tissue occurs, causing sensitivity of the udder tissue and the probability of contamination by pathogen microorganisms is increased. Thus, it results in the increase of mastitis incidence in lactating cows (Göncü and Özkütük, 2002). With age, the occurrence of Streptococcus agalactiae, one of the bacteria responsible for mastitis, is increased in lactating cows (Emre, 2009).

Breed: Some breeds have high milk SCC than others: It is said that SCC is lower in Ayshire than HF. Koç (2004; 2006a; 2007b; 2011) also reported higher SCC in HF, Brown-Swiss and Montbeliarde cows.

Lactation number: Göncü and Özkütük (2002) confirmed that an increase in SCC is observed according to the increase in lactation number. It is said to be below 100000 cells/ml at the first lactation (Harmon, 1994). It was shown that mastitis rate increase correspondently to parity by averages of 8.6%, 30%, 42%, 44%, 52% and 56% between the first and sixth and upper lactation numbers, respectively (Izgür, 1984).

Lactation stage: The number of epithelial cells, together with somatic cells, is significantly increased at the beginning and at the end of lactation.

Season and region: This is due to temperature and humidity. Cows that started their lactations in the summer have high SCC and have the high risk to get mastitis (Rupp and Boichard, 2000). Schultz et al. (1994) confirmed that calving season give almost similar results in all breeds of cows, but cows that gave birth in summer have highest SCC averages. However, Topaloğlu and Güneş (2005) found an insignificant effect of seasonal factor on milk SCC ($P > 0.05$).

2.6.4 Studies related to milk SCC

Schalm et al. (1971) conducted a study aimed at explaining the change of SCC in milk during the day. They also investigated about the amount of milk yield and the effects of the cells in the alveoli to the transition. Normally, leukocyte and epithelial cells cannot move due to the pressure caused by the accumulation of milk in the alveoli as milking time approaches. It is observed a pressure drop in the alveoli formed due to the removal of milk with the onset of milking. Those leukocyte and epithelial cells remain free in the milk. According to that reason, those researchers concluded that milk samples taken within a few hours after milking contain a high number of somatic cells.

Paape et al. (1973) conducted a study with the purpose of examining the relationship between heat stress, blood leukocytes and erythrocytes and SCC in milk. During the experiment, cows were kept at 21°C and 32°C daytime with 65% of humidity, at 21°C and 32°C night in a period of 2 and 4 weeks. It was found that heat stress has no effect on milk SCC but fluctuating temperatures significantly increase the number of leukocytes and erythrocytes.

In a study, 2 groups of lactating cows were used to compare SCC variation with age. For that purpose, a group of young cows of 2 years old or more and a group of old cows of 6 years and more were used. It was found that the average value of SCC in milk was increased from 166000 cells/ml to 507000 cells/ml, respectively (Ng-Kwai-Hang et al., 1984).

The study aimed at determining the variation of milk SCC was performed at Kansas State University. It was found that SCC was generally lower in earlier lactating cows (50 days) than in later lactation (300 days), those two extremes were higher than in the middle of lactation. It was then reported that milk SCC increased in early and late lactation periods, it also increased with increasing parity (Dunham and Smith, 1985).

In a study aimed at comparing SCC in milk at different parities, 3 groups were used such as 1-2nd, 3-4th and 5th and plus parities. It was found that milk sample from the group of cows at 5th lactation had a significantly high SCC average than other groups whereas the 3-4th group had SCC slightly higher than the 1-2rd group (Göncü & Özkütük, 2002).

In a study conducted by Koç (2004), 41 heads HF and 9 heads Brown-Swiss raised in 3 different farms in Aydın province were used. The results of SCC in milk samples were 534668 and 267116 cells/ml respectively. The effect of breeds ($P<0.05$) and milking time ($P<0.01$) were both significant whereas effects of farm and lactation month were reported to be not significant ($P>0.05$)

Between the years 1994-2003 in England, the average of SCC was calculated from milk yield records in HF. The average value was 138000±4,313 cells/ml. It was found that farm effect, lactation number, season and calving year effects were statistically significant ($P<0.05$) (Topaloğlu and Güneş, 2005).

Koç (2006a) realized a study about SCC in milk samples from 3 dairy farms in the province of Aydın. The results were ranging between 25119 cells/ml and 511872 cells/ml. The calculated overall average was 422669 cells/ml.

Koç (2006b) conducted a study about milk SCC of 95 HF cows raised in four different farms between the years 2003-2005 in the province of Aydın. As result, the effects of farm, lactation month, parity, milking time and daily milk yield on SCC were found statistically significant ($P<0.05$). The average of SCC with farm effect ranged from 319448 cells/ml to 497279 cells/ml. In the first month of lactation, the average milk SCC was higher (605899 cells/ml) while the lowest value was found in primiparoud (345303 cells/ml). The average milk SCC increased at the second parity (390122 cells/ml) and an average of 490456 cells/ml was found at the third and plus parities. Therefore, the average milk SCC from morning milk samples was 390122 cells/ml. That average was lower when compared to 418890 cells/ml found during evening milk samples. It was also reported a negative relationship between daily milk yield and milk SCC.

The results of a study conducted in Aydın province on 55 Montbeliarde and 45 HF cows raised in 10 different farms showed that milk SCC averages of morning and evening milk samples were 218524 cells/ml and 344112 cells/ml respectively. Those values were found statistically significant regarding SCC between breeds (Koç, 2007a).

In a study conducted by Koç (2007b), milk samples from 67 HF and 16 Brown-Suiss (BS) dairy cows raised in 3 different farms in Aydın were used for milk SCC analysis. The averages of SCC in HF and BS were 491813 cells/ml and 312464 cells/ml, respectively. On one hand, those results were found statistically significant regarding the breed, milking time, lactation month and milking time x milk yield effects. On the other hand, the farm effect on SCC was found not significant. The milk SCC during the first lactation was found lower when compared to advanced parities.

Koç (2008a) conducted another study in 110 heads HF cows of four different dairy farms located in Aydın province around 2003-2005. The average of SCC in milk samples was 512861 cells/ml. He found that the farm and lactation month effects on SCC were statistically significant. He concluded that the high SCC average found during the summer are due to the heat stress during that period.

The results of a study of 88 heads HF cows managed in Mediterranean climate conditions raised in four different farms in Aydın province showed that farm effect, lactation month, parity and milking time on milk SCC were found statistically significant ($P<0.05$). The SCC average of milk samples from cows at first lactation was 404296 cells/ml and was the lowest value. The highest average was found at the 3rd parity + and was 555393 cells/ml. Regarding lactation months, the highest average (607295 cells/ml) was found in cows at first lactation while the lowest average (387525 cells/ml) was found in cows at the second lactation (Koç, 2008b).

The results of a study showed that SCC in the milk of cows that calved during the winter by morning and evening milking respectively were 138325 cells/ml and 133265 cells/ml lower than the averages obtained for the summer, control season being the winter. Those differences were found to be statistically significant ($P<0.01$) (Koç, 2009).

Koç et al. (2009) conducted a study aimed at determining factors affecting milk quality in dairy cattle farms in Aydın province. In this study, the results from 36 farms' milk sample analysis were 743019 cells/ml of average for SCC and 849181 cfu of average colonies for total microorganism counts. It was stated that the training level of the landlord, the employment status and the good care of the milking machines had a significant impact on SCC averages.

In a study, a farm constituted of Red-Holstein (RH) lactating cows was used. During that study, milk samples from 53 heads morning and evening during winter, 49 heads morning and 48 heads evening in the summer were analyzed. Regarding milk SCC, 63753 cells/ml of average was found. The calving season, lactation month and interaction of calving season x inspection time effects were found statistically significant ($P<0.05$). Regarding parity, 47687 cells/ml in primiparous was found lower compared to advanced parities (Yılmaz, 2010).

With the same interest, a similar study was conducted by Koç (2011) in the province of Aydın, Turkey. In that study, during summer and winter, only morning milk samples of 119 HF dairy cows and 108 MB dairy cows spread over 19 different farms were analyzed for milk SCC determination. As results, milk SCC averages were found to be 199022 cells/ml and 138644 cells/ml summer and winter respectively. Regarding SCC, breed, parity, interaction between lactation period and breed x season effects were found statistically significant ($P<0.05$). The average of SCC at the first lactation (112331 cells/ml) was found lower compared to advanced parities.

A study aimed at determining the relationship between milk SCC and some linear type traits of primiparous HF cows and managerial characteristics of intensive dairy farm in Çukurova region was performed. The study was carried out on 88 first lactating cows from 3 different farms in Çukurova region and Test-day records of SCC, milk yield and linear type traits were performed. The results showed that the parity and months of the year group were statistically significant ($P<0.01$) regarding SCC averages whereas differences between SCC averages and linear type traits of the farms were reported not significant. It was also reported a significant negative correlation between hind udder height and milk SCC (Gökçe, 2011).

Another study was conducted in RH dairy breeds raised in Aydın. The study was aimed at determining the effect of SCC and some environmental factors on milk yield and milk components. Within the years 2009-2019, milk samples were taken twice a year during winter and summer seasons. Among 129 lactating cows, 449 milk samples morning and 442 milk samples evening were harvested for milk SCC. The averages were found to be 91833 cells/ml and 100462 cells/ml morning and evening, respectively. Thus, regarding SCC, season, parity and lactation month effects were found significant ($P<0.05$). According to the parity, the average of SCC in milk samples from primiparous (54702 cells/ml) was found very lower when compared to pluriparous (Koç, 2015).

Gürses (2019) conducted a study aimed at determining the reproductive characteristics, milk yield and milk quality in HF and RH dairy cows raised in a private dairy cattle farm in the rovince of Aydın. In that study, 14 HF and 83 RH lactating cows at first lactation were used. An overall mean milk SCC of 38815 cells/ml in both breeds was found. It was found that the effect of lactation month on milk SCC was statistically significant ($P<0.001$) whereas the interaction of breed x lactation month effect was not significant ($P>0.05$).

2.7 Relationship between teat profile, udder and milk quality

Researchers reported a close relationship between teat length and mastitis. Cows with long teats were found with high mastitis incidence while applied the California Mastitis Test (CMT) than the shorter ones and that relationship was reported not statistically significant (Alaçam et al., 1983).

Hamoen (1994) confirmed that the teat length in cows has a negative effect on ease of milking. The researcher explained the fact that very long teats being closer to the ground favorites easier physical injuries. That is why during the selection of breeding cows, the preferable teats maybe shorter than 6.5 cm and such teats are reported to be resistant to mastitis (Izgür, 1984).

In a study aimed at examining the relationship between various udder characteristics, milk yield, SCC and milking per minute in HF, it was shown that milk SCC is related to teat shape and milk yield per minute. The same researchers also showed that milk SCC was related to the height of the udder from the ground, teat shape, milk yield, lesions and teat diameter. It was concluded that cows with low milk SCC maybe selected by analyzing the height of the udder and teat’s placement, facts that help combatting mastitis and milking difficulties, resulting in increasing of milk yield (Seykora and McDaniel, 1985).

As for teats and SCC, Seykora and McDaniel (1985) reported that milk SCC was decreased in cows with elevated height between posterior and anterior teats and the ground. The results of a study realized by Slettbakk (1992) showed that milk SCC was higher in cows with short teats. The similar issue was confirmed by Rogers and Hargrove (1993) who reported that closer teat location decrease SCC and mastitis risk (Rogers, 1996; 1997). They all confirmed that the selection for more closed/narrow teat placements could be more effective in maintaining udder’s health.

Van Dorp et al. (1998) investigated the relationship between anterior teat length and mastitis. The results showed that there was a low phenotypical and genetically moderate relationship. Similarly, Kuczaj (2003) found positive phenotypic correlation between the diameters of the anterior and posterior teats and SCC at the level of 0.27 and 0.28, respectively. He also found a negative phenotypic relationship (-0.30) between posterior teats’ height from the ground and SCC. The researcher concluded that the decreased height of posterior teats above the ground was corresponding to the increased SCC in the milk.

Another study aimed at determining the relationship between the udder and teat shape and effects of parity, lactation period and subclinical mastitis in HF dairy cows was realized in İzmir province, Turkey. During this study, data of 887 HF cows from 21 breeding cattle farms were analyzed. Udder and teat shapes were scored. The results of that study showed that the effect of udder's form, teat shape and parity on the possibility of having subclinical mastitis was statistically significant ($P<0.01$). The effect of teat placement and lactation period was found not statistically significant (Uzmay et al., 2003).

In the same mean of interest, a similar study was realized by Juozaitiene et al. (2006). The study was aimed at investigating the relationship between milk SCC, milk yield, udder and teat characteristics in 2012 head HF cows. As scoring method, they used 1 to 9 scoring system for six different udder characteristics. They found 6.04 ± 0.01, 7.17 ± 0.01, 5.22 ± 0.01, 7.23 ± 0.011, 4.81 ± 0.01 and 5.50 ± 0.01 of average values for the front teat connection, posterior teat height, teat depth, teat center ligament, teat placement and teat length, respectively. It was found that the effect of udder and teat characteristics on milk SCC was statistically significant ($P < 0.001$). Those researchers advised that the selection based on udder and teat features in reducing milk SCC may improve milk quality output.

2.8 Relationship between TEH, SCC and mastitis

As stated before, TEH is expressed as the adaptation of the organism and results in formation of a ring of 2-4 mm of diameter. Consequently, the hyperkeratosis cause protective mechanism disrupts in the teats, that result in the interruption of the protective mechanisms of the teats and make the udder sensitive to mastitis.

The TEH is scored differently according to the preference of the researcher. If the caliber of the scoring system is 1 to 4, teats scored 1-2 guarantee a healthy udder, if one says so, he means that the resulted milk will be of good quality with low SCC. The score 3-4 expresses the imminent mastitis incidence because of the estimated high SCC in that case. The increase of TEH is said to correlate with the increase of mastitis risks, those risks continue to increase during the whole lactation period (Michel et al., 1974). During the fourth month corresponding to the high milk yield, it is said that the observed increase of TEH (Francis, 1984) has a relationship with the increased number of SCC.

However, the list of previous studies about TEH is not so long. So few related studies are summarized below.

A study whose objective was the examination of changes in teat-end hyperkeratosis in a herd that transitioned from a standard pulsation milking to individual quarter pulsation milking systems was performed. The results of the study revealed that individual quarter pulsation milking system may decrease over milking and reduce teat-end hyperkeratosis in HF lactating dairy cows. Researchers suggested that decreasing the incidence and severity of TEH may decrease mastitis incidence. Afterwards, the system of individual quarter pulsation milking may be very beneficial for both dairy producers and lactating dairy cattle (Sterett et al., 2012).

Bemba et al. (2018) realized a study aimed at assessing the hyperkeratosis severity in teats of dairy cows by using dielectrically measurement. During that study, a total of 241 teats of lactating dairy cows were used to survey the occurrence of TEH. By using the Spearman rank correlation coefficient, it was found a negative correlation between dielectrically constant and hyperkeratosis score ($r_s = -0.55$ to -0.36). As results found by the regression analysis, the dielectrically constant values between teat ends without hyperkeratosis (≤ 2) and with hyperkeratosis (≥ 3) were significantly different. It was concluded that the non-invasive measurement of dielectrically constant constitutes a promising assessment method of the occurrence and severity of hyperkeratosis.

A group of researchers from Portugal performed a study aimed at evaluating the teat end, level of hyperkeratosis and callosity in lactating dairy cattle. In that study, 43 farms were sampled and a total of 11828 teats of 2957 dairy cows were used. It was found that hyperkeratosis increased with parity ($P<0.01$), for the period of 61-180 days of lactation ($P<0.01$), over-milking ($P<0.01$), cows with high incidence of mastitis ($P<0.01$) and more steps but without kicks during milking ($P<0.05$). They concluded by the results that hyperkeratosis may be be monitored for preventing and controlling the teat end hyperkeratosis pathology, fact that ensures the udder health and improving the welfare of lactating cows (Cerqueira et al., 2018).

Juozaitiene et al. (2019) conducted a study with the objective of assessing different levels of TEH in dairy cows and determining the relationship between teat thermographic characteristics, mastitis and milk SCC. To realize the study, a sample of 230 Lithuanian HF were taken and a total of 920 teats were evaluated regarding teat end assessment and thermographic characteristics before evening milking. Cow’s teats were grouped in four groups according to the level of TEH: N (No ring; Group 1) and S (Smooth or slightly rough ring; Group 2) groups were given to healthier teats. In addition, R (Rough ring; Group 3) and VR (Very Rough ring; Group 4) groups (P<0.001) were taken as not healthier teats. Thermographic analysis at the teat sinuses showed lower teat temperature (0.93-1.32 $^{\circ}$C) in group 1 than group 2 and 3 (P<0.01). Researchers reported a significant positive correlation between teat's temperature and milk SCC when evaluated the hyperkeratosis scores N, S, and R. The results of the study demonstrated a significant connection between different TEH levels and teat temperature, fact that indicates the high risk to mastitis.

2.9 Relationship between milk yield, SCC and mastitis

McDonald (1979) calculated an annual loss of 770 kg milk per lactation from a cow with infected lobe. It was confirmed a negative relationship between SCC and milk yield. If SCC is increased, there is a loss of 0.92 kg/day at the first lactation. That value passes to 1.52 kg/day in multiple parities. The researcher calculated an average milk loss of 1.17 kg/day in a herd (Munro et al., 1984; Barlett et al., 1989). Seykora and McDaniel (1985) estimated at 386 kg milk yield loss due to mastitis in the USA.

Keown (1987), when SCC reached 200000 cells/ml, every increase of 100000 cells/ml causes 2.5% of milk yield loss in dairy cows. Harmon (1994) said that milk sample from a healthy udder lobe has SCC generally less than 200000 cells/ml. To add more, he said that this value is expected to go below 100000 cells/ml in primiparous. He concluded that even in a healthy udder lobe, milk SCC may be varying dependently to physiological and environmental conditions.

Cassell (1994), in a study aimed at SCC usage in herd management, explained that in the case of SCC-based selection, the incidence of clinical mastitis rate in the herd will be decreased by 20-25%. Thus, the milk yield will be decreased by 2% during the whole lactation.

The results of a study showed that the cow that caught mastitis lost approximately 231 kg of milk than a healthy cow per lactation (Fırat and Akar, 1995).

In a review, ~0.70 was reported as the mean genetic correlation found between milk SCC and mastitis (Mrode and Swanson, 1996).

Researchers estimated at 40-60 kg of monthly milk yield loss for a cow with mastitis. Once calculated per lactation period, milk yield loss is estimated at 350-750 kg, it means that the total loss is generally estimated at 10% of milk yield. Even when mastitis treatment has been applied in 3 lobes (understand that one lobe is untreated for experience purpose), milk yield loss was 350 kg in cows during the 2nd and 3rd parities (Hortet and Seegers, 1998).

Analyzing the relationship between SCC and milk yield, enterprises that analyzed tank milk stated that milk with 100000 cells/ml showed a milk loss of 32%, milk loss of 15% in enterprises with 800000 cells/ml and the one with 500000 cells/ml had 7.5% of milk loss (Anonymous, 2015). In that case, the previous situation corresponds to the loss of 4.5 kg/day for a dairy cow that produces 30 kg/day of milk (Hortet and Seegers, 1998).

Emmanuelson et al. (1988) conducted a study aimed at determining genetic correlation between SCC and mastitis. In that study, it was found a correlation equaling to 0.60. By concluding, they said that a great importance may be given to the use of breeding bulls in order to reduce mastitis incidences in farming enterprises.

Rupp and Boichard (2000) confirmed that generally, cows that have milk samples with low SCC are said to be least risky to catch clinical mastitis. They added that cows at second lactation have the highest risk to develop clinical mastitis, so are cows starting their lactation during the summer. Göncü (2000) added that cows with high milk yield are likely to experience mammary inflammation, thus an increase in SCC.

Yalçın et al. (2000) confirmed, in a study, that cow level milk SCC influenced the different milk yield losses in lactating dairy cows. In their study, it was shown that milk yield loss was 0.6 kg/day per cow for cows with 403000 cells/ml milk SCC. Milk yield losses were varying between 3.8 and 6.8 kg/day per cow for cows with 1,097,000 and 1,900,000 cells/ml of milk SCC, respectively. Generally, the average milk yield loss per day due to the progressive increase in SCC was evaluated at 1.53 kg per cow.

Harmon (2001) added that milk with SCC above 200000 cells/ml may be taken as an indicator of subclinical mastitis. In Tunisia, the annual loss in cow milk yield due to mastitis is estimated at 524 kg (Mtaallah et al., 2002).

Haas (2003) observed higher milk SCC during first few weeks of lactation after calving when compared to the typical lactation curve. He also observed that 50% of clinical mastitis incidence were observed in the first two months of lactation.

Juozaitiene et al. (2006) and Tekeli (2010) observed a significant increase in milk SCC (5 to 20% of rate) that was associated with abnormalities in udder health, the decrease in milk quality and milk production losses.

A study showed that a cow that had 400000 cells/ml SCC in milk experienced a loss of 1.2 liter, that value goes to 3.3 liters milk loss for cows with 500000 cells/ml SCC. In case of 1,500,000 cells/ml SCC, milk loss is expected to reach 14.6 liters and the loss can pass up to 30% of milk per cow in case of 5,000,000 cells/ml SCC (Anonymous, 2007).

Kesenkaş (2008), while evaluating economic annual losses caused by mastitis incidence in the Republic of Turkey, found a value estimated at 41.5 million TL per year. In a study realized in HF during the years 1999-2009 by Atasever and Erdem (2009), it was shown that the decrease of milk yield triggered a loss of 217.8 USD.

Kvapilik et al. (2014) conducted a study aiming to determine the relationship between milk SCC and milk production loss in lactating dairy cows. Data analysis showed a correlation of 0.775 ($P<0.01$). Those researchers reported that an increase/decrease of 100000 cells/ml milk SCC resulted in milk yield decrease/increase of 2% with the regression coefficient b=1.82. Due to mastitis, the relationship between SCC and lower milk production got a correlation of 0.832($P<0.01$). They also observed a reduction of 51 kg average milk yield loss/cow per lactation due to the increase of 100000 cells/ml milk SCC and the regression coefficient was b =0.511.

2.10 Relationship between milk FC, NFDMC and SCC

So many factors are linked to milk quality such as cow breed, parity, lactation month and period, milking time, season, milking management, barn conditions, environment, feeding conditions, etc. Animal scientists determined the relationship between milk SCC and other milk quality traits. Some researchers confirmed lower milk FC during mastitis (corresponding to high SCC) whereas others report higher (Ma et al., 2000; Munro et al., 1984; Kitchen, 1981; Ali and Shook, 1980) but it was reported the changes in milk FC, physical properties and fat composition during mastitis (Santos et al., 2003; Ma et al., 2000; Munro et al., 1984; Kitchen, 1981). It was confirmed that neutrophils are the major cell types that are present in the milk of cows with mastitis while macrophages are the predominant cell types in healthy cow milk.

During mastitis, it is well known that the number of somatic cells increase. What is more, the proportion of different types of cells changes in the milk during mastitis (Sordillo et al., 1997; Saad & Östensson, 1990; Paape & Tucker, 1966) even though increased SCC is not always linked with mastitis. Example, it has been found the increased SCC in milk harvested after a single prolonged milking time interval (Lakic et al., 2009; Fox & Schultz, 1985) or in relationship with pasture turnout (Wredle et al., 2008; Coulon et al., 1996).

Generally, it is reported that SCC in milk from uninfected udder is normally below 200000 cells/ml. However, those values are expected to be below 100000 cells/ml in milk of primiparous. Schultz et al. (1990) confirmed that SCC and milk yield increase with parity in Jersey, Guernsey and HF dairy cows whereas FC and proteins decrease. They showed that milk SCC was lower at the beginning of lactation but tended to grow higher at the end of lactation and in advanced parities.

It was observed milk yield loss during mastitis, fact that corresponds to elevated number of SCC in the milk. It was reported that the loss of milk yield equaling to 3-22 kg during mastitis was corresponding to 1.5-7.5% of milk fat loss (Hortet and Seegers, 1998).

In some countries, milk quality characteristics are taken into account in the regulation of the market price of the raw milk. In the USA and European countries, quality traits such as non-fat dry matter ratio, total milk dry matter ratio, protein and fat content are considered. In addition, milk powder, butter and cheese formation constitute a great importance in determination of raw milk prices at the market (Filik et al., 2011).

In a study realized by Ayaşan et al. (2011), the effect of SCC on milk composition was determined. During that study, milk samples from 30 HF dairy cows were analyzed. The results showed that milk samples with high SCC had higher FC than the ones with low SCC whereas milk NFDMC was lower in group with high SCC.

In a study, the effect of milk SCC on milk yield and milk composition in first and second lactation HF dairy cows was investigated. During that study, individual milk samples were harvested monthly from June 2009 to March 2010 from 30 primiparus cows and 49 cows in second parity were used. The results of that study showed that milk SCC effect was significant regarding milk yield, milk lactose, milk protein ($P<0.01$), total solids and Urea-N in the milk ($P<0.05$). Nonetheless, the effect of milk SCC on milk FC was found not statistically significant (Mahmut et al., 2015).

3 MATERIAL AND METHOD

This study was carried out on HF dairy cows raised in the Province of Aydın, Turkey. Milk samples were analyzed in Animal Breeding Laboratory of Aydın Adnan Menderes University, Faculty of Agriculture.

In fact, the BDS was performed by analyzing the degree of cleanliness or dirtiness of the udder and the hind legs from the hoof till the tarsal joint and the TS was determined by scoring the TEH

Milk samples were collected during morning milking time from lactating HF cows raised in different farms of Aydın province from October 2019 till February 2020. The rate of milk FC was determined using Gerber method. The rate of NFDMC in the milk was determined using a portable refractometer. The SCC in the milk was determined by using Direct Microscopic Somatic Cell Count Method.

3.1 Animal Material

Animal material of this study was composed of HF dairy cows being at different parities and different ages. All the animals used in this study were raised in Aydın province and the farms were almost in similar conditions. Aydın is a province having mediterranean climate conditions. For inspection time MMY, milk samples were harvested from 265 lactating HF cows raised in 8 farms located in Çakmar, Cincin, Hacı Hamzalar Village and Çine counties. The total number of HF heads used in this study was 432 for the determination of TS, BDS, FC, NFDMC and SCC, all of them raised in 9 farms in different villages such as Çakmar, Cincin, Hacı Hamzalar Village, Efeler and Çine counties. Farms were visited during morning milking time.

3.2 Milk sampling

All the lactating cows were milked by milking machines. Samples were taken individually from every cow; bulk tank milk samples were not collected in this study. During this process, some farms had individual milk yield measuring apparatuses installed in their milking system with milk measurement caliber. In that case, milk samples were taken directly from those apparatuses. Here, milk yield was read directly on the caliber. There were some farms where milk yield was registered electronically in their milking machine system whereas others were not possessing milk yield measurement system. In that case, milk samples were taken by installing removable individual milk yield apparatus (Figure 3.1).

Regarding milk sampling, samples were harvested in a sampling cups of 100 ml each. Cows were milked and a quantity of 25-50 ml of milk sample was harvested individually from each cow and the cow's name or the earring number was registered on the cup of each cup and on the paper. After that, milk samples were kept in a cold chain and were directly brought to the Animal Breeding Laboratory of ADU Faculty of Agriculture, Department of Animal Science. Without storage and respecting the cold chain, milk samples were directly analyzed regarding milk quality facts such as FC, NFDMC and SCC individually in every milk sample and values were registered in an Excel software page.

Figure 3.1. Removable individual milk yield apparatus from private animal breeders of Aydın.

3.3 Determination of the BDS

The BDS demonstrates the quality of the environment and the degree of hygienic conditions of the farm. It affects the udder's health by the way they ensure the survival of microorganisms and thus affect the milk quality. According to some authors, the BDS is determined by scoring the dirtiness observed from tarsal joint till the toenail at the hind legs. That must be associated with the dirtiness observed at the udder. According to others, in some countries that scoring is realized by evaluating the part from the hip joint till the hoof of a cow.

During this study, BDS was determined by grading the degree of cleanliness at the udder and the hind legs from the hoof till the tarsal joint (Figure 3.3). The scoring caliber was 1-5 depending on how the cow was very clean or very dirty, respectively. The score 1 was registered for cows with very clean udder and hind leg. The score 2 for clean cows, score 3 for unclean cows, score 4 for dirty cows and score 5 for very dirty cows as it can be seen on the image below (Figure 3.3). However, it has been impossible to find very clean cows that were scored 1.

BDS 1	**BDS 2**	**BDS 3**	**BDS 4**	**BDS 5**
Very clean	Clean	Not clean	Dirty	Very dirty

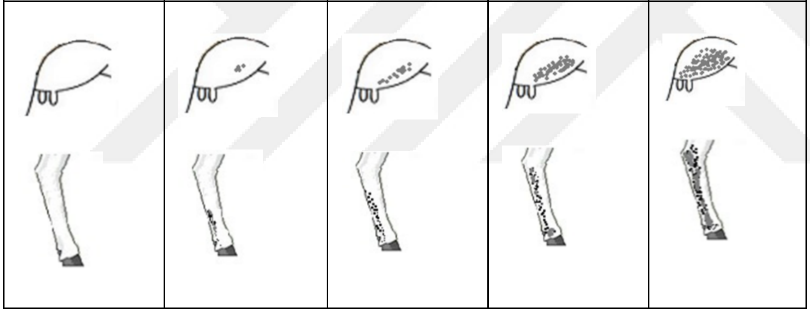

Figure 3.2. Scale of BDS in dairy in cattle (Source: Adapted from Tarım ve Orman Bakanlığı, 2019)

BDS 2 **BDS 3** **BDS 4** **BDS 5**

Figure 3.3. Different level of BDS in HF dairy cows in some farms of Aydın province (Source: Author).

3.4 Evaluation of the TS

During this study, the TEH or TS was scored after milking. As it is well known, teat condition is directly and immediately evaluated within 30 seconds after the cluster removal and before the application of disinfectants. In this study, the TS was determined after milking and were registered on a paper correspondingly to the cow's name or the earring number. Only one score of TEH was registered for 4 teats of every lactating cow. Practically, teats were scored as follows: Score 1 for N (No ring), score 2 for S (Smooth ring), score 3 for R (Rough ring) and score 4 for VR (Very Rough ring) as it can be seen in table 3.1. and Figure 3.4.

Table 3.1. Scoring system for teat end hyperkeratosis (Mein et al., 2001).

Score	Description	Illustration
N	**No ring** The teat-end is smooth with a small, even orifice. This is a typical status for many teats soon after the start of lactation	
S	**Smooth or Slightly rough ring** A raised ring encircles the orifice. The surface of the ring is smooth or it may feel slightly rough but no fronds of old keratin are evident.	
R	**Rough ring** A raised, roughened ring with isolated fronds or mounds of old keratin extending 1 - 3 mm from the orifice.	
VR	**Very Rough ring** A raised ring with rough fronds or mounds of old keratin extending 4 mm or more from the orifice. The rim of the ring is rough and cracked, often giving the teat-end a "flowered" appearance.	

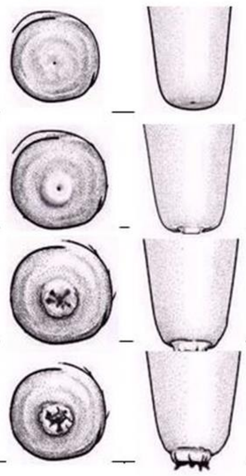

Figure 3.4. Different TS in HF dairy cows raised in some farms of Aydın Province (Source: Author).

3.5 Determination of milk fat content (FC)

To determine milk FC, the Gerber method (EAS 164:2006) was used in this study. The steps were processed as follows:

- 10 ml H_2SO_4 (d=1.82) was placed in the Gerber milk butyrometer
- 11 ml of milk sample was slowly poured drop by drop as titration practice
- 1 ml of amyl alcohol was added
- Distilled water was added to complete the space till the throat line.

The mouth of the butyrometer was closed with a rubber, homogenized and placed in the centrifuge apparatus for centrifugation within 5 minutes. Under the caliber of 8% of milk Gerber butyrometer, the percentage of milk FC was read and registered.

3.6 Determination of NFDMC

In this study, milk NFDMC was determined using portable refractometer with the caliber 20% BRİX (Brand: ATC Refractometer 0-20% BRIX). To ensure homogenization, milk was mixed and almost 5 ml of milk was poured on the caliber's face of the refractometer at the side of the oblique prism, the transparent cover was adjusted and the covered prism was faced to the light. The NFDMC in milk was read by holding the eyepiece section of the refractometer parallel to the eye and the value in percentage was registered in Excel Software.

3.7 Somatic cell counting method

The used method for SCC in this study was the Direct Microscopic Somatic Cell Count method (N.M.C, 1968). By using a micropipette, 10 µl of milk were taken and spread on a strip area of $1cm^2$ on a slide. This act is applied on three strips of a slide. Slides were kept until the spread milk is dry and cells fixed on the slide surface. Once dried, cells were colored by methylene blue colorant. Almost 30 min were spent until they become dry and slides were washed with water to take out the excess of colorant. At that time, slides were ready to be placed under microscope for milk somatic cell counting. Somatic cell counting was processed as follows: Each strip was taken under microscope field view and 10 fields were considered. The average of somatic cells from those ten fields was calculated and registered.

Practically, milk SCC were calculated using general formulas for microscopes. The diameter of the field view of the microscope (in millimeters) was found by dividing the number written on the eyepiece of the microscope (here 20) by the magnification number of the lens (100X).

Diameter of the Field View = 20/100 = 0.2, the unit is millimeter (mm).

Surface of the Field View = $3.14*(0.2/2)^2$ = 0.0314, the unit is the square millimeter (mm^2).

For 100 mm^2 ($1cm^2$), the number of fields to be seen are 100/0.0314 = 3184.71338 fields. Remember that only 10 microliter (µl) of milk were spread on the strip of 100mm^2 of a slide and colored by Methylene Blue colorant. This means that the number of somatic sells found in 10µl have to be multiplied by 100 in order to obtain the total number of SCC found in 1ml of milk sample. Hereby, the factor will be 3184.71338 x 100 = 318471.338 and the unit is expressed in cells/ml.

Example: Suppose that the average of SCC counted in ten fields equals to 1. The total SCC in the milk will be 1*318471.338 cells/ml = 318471 cells/ml. All SCC values were converted to Log_{10} base to ensure uniformity and homogeneity of the variance.

3.8 Statistical analysis

During this study, TS, BDS, milk FC (%), milk NFDMC (%) and SCC (cells/ml) data were recorded in the Excel software and statistical analysis was done with the SAS (1999) package program. Comparison of subgroups was made according to Tukey ($P <0.05$).

The following statistical model was used in the analysis of TS, BDS, FC (%), NFDMC (%), SCC and morning milk yield (MMY):

$$Y_{ijklmno} = \mu + a_i + b_j + c_k + d_l + f_m + g_n + e_{ijklmno} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$Y_{ijklmno}$: observation of the properties emphasized, μ: general average of the traits, a_i: effects of farm (i=1, 2, 3, …, 9), b_j: parity effect (j= 1, 2, 3, 4 and 5+), c_k: calving season effect (k= winter, spring, summer, autumn), d_l: lactation stage effect (l = 1, 2, 3, 4. For this effect, the groups were determined by considering the period of 100 days: 1 for 1-100 days, 2 for 100-200 days, 3 for 200-300 and 4 for 300 and more days), f_m: TS effect (m=1, 2, 3 and 4, this factor is used for the analysis of FC, NFDMC, MMY and SCC), g_n: BDS effect (n = 1-2, 3, 4 and 5, this factor is used for the analysis of FC, NFDMC, MMY and SCC), $e_{ijklmno}$: refers to random error.

4 RESULTS AND DISCUSSION

In this study, whose aim was to determine the effects of body dirtiness score and teat profile on milk yield and quality in HF dairy cows, the effects of the farm, parity, lactation stage (LacStage) and calving season (CalSeason) effects on the BDS and TS on one hand, and the effect of parity, LacStage, BDS and TS on milk quality traits such as MMY, FC, NFDMC and SCC on the other hand, are presented and discussed in this section.

4.1 Body dirtiness score and teat score

The least-square means of BDS, TS, Farm, parity, CalSeason, and LacStage are presented in Table 4.1. and changes in averages BDS and TS are presented on Figure 4.1.

For the BDS, the overall LSM was found to be 3.30±0.048 (Table 4.1.). The effect of farm and parity were found statistically significant ($P<0.01$) whereas the CalSeason and LacStage were not important ($P>0.05$).

According to farm effect, the cleanest farm was Farm 4 (2.10±0.252) whereas the dirtiest farm was Farm 9 (4.64±0.165). However, other farms showed similarities and BDS average were ranging between 2.10±0.252 and 4.64±0.165 of average (Figure 4.1). Regarding the parity, primiparous were less dirtier (3.08±0.093) and those at the 3rd lactation were dirtier (3.52±0.129) and changes can be observed on Figure 4.2. The cleaning of the shelter and provision of clean woodchips are the management factors helping to keep cows clean (O’Driscoll et al., 2008) even though it has been impossible to find a farm that is managed in such conditions in Aydın province.

For the TS, the overall least-square mean of all animals was found to be 2.17±0.038. The effect of farm ($P<0.01$), parity ($P<0.05$) and LacStage ($P<0.01$) were found statistically significant. However, the CalSeason was not significant ($P>0.05$).

As it can be observed in the Table 4.1., regarding the farm effect, the lowest average was for the Farm 2 (1.80±0.312) whereas the highest score was found in the Farm 9 (2.70±0.140). Other TS averages were ranging between 1.80±0.312

and 2.70±0.140. The low average TS found in Farm 2 means that the lactating cows of that farm were healthier when compared to other farms. As for high TS found in Farm 9, this means that lactating cows of this farm were less healthier when compared to other farms used in this study. On the farm level, according to literature, the average value of TS depends on farm conditions, high vacuum of milking machines and farm management.

The lowest average TS regarding parity was found in primiparous (1.92±0.079). The score increased with parity unless for the third parity where it decreased when compared to the second parity (2.16±0.084 vs 2.04±0.109, respectively). The TS continued to increase with advanced parities and the highest score was found in 5th and + parities (2.24±0.123). These results correspond to the expected results and also correspond to the confirmation of Emre (2009) who stated that the TS increases with parity as it can be observed on Figure 4.2. The TS also increases with parity (Shearn and Hillerton, 1996; Neijenhuis et al., 2001).

For the LacStage, the lowest value of TS was 1.86±0.111 for the 1st LacStage whereas the highest TS (2.39±0.111) was found for the 3rd stage. This is similar to the theories stating that the highest point of TS is reached at the peak lactation and decreases at the end of lactation (Shearn and Hillerton, 1996; Neijenhuis et al., 2001). If the Table 4.1 is analyzed, the highest averages are observed at the 2nd and 3rd LacStage (2.24±0.102 and 2.39±0.111 respectively), points that correspond to the peak lactation. Francis (1984) stated also that the increased TS is observed during the fourth month. However, the TS did not increase progressively with the LacStage.

For both BDS and TS, only the farm ($P<0.01$) and parity ($P<0.01$ for TS and $P<0.05$ for BDS) effects were statistically significant. This means that the farm management has a great importance on the degree of the BDS and TS. On the farm level, the degree of TS is due to the milking machine system, vacuum of the machines and the electricity current to which milking machines are mounted. On cow level, the genetic, cow's age (Sieber and Farnsworth, 1981; Shearn and Hillerton, 1996; Neijenhuis et al., 2001) and the parity (Emre, 2009) are likely to cause the level of TS. It is well shown that the TS increased with parity even though for parity, the average decreased in 3rd lactation and continued to increase with other advanced parities (Emre, 2009).

Table 4.1. Least-square means and standard errors for BDS and TS in HF cows.

Factors	N	TS Mean	BDS Mean
Farm		**	**
1	25	2.32±0.158^{ABab}	2.90±0.187^{ABCabd}
2	6	1.80±0.312^{ABab}	3.81±0.370^{ACDace}
3	38	1.87±0.127^{Aa}	2.84±0.151^{ABab}
4	13	1.95±0.213^{ABab}	2.10±0.252^{Bb}
5	27	2.03±0.150^{ABa}	3.69±0.177^{Cc}
6	104	2.11±0.082^{Aa}	3.26±0.097^{ACac}
7	19	2.05±0.179^{ABab}	3.50±0.212^{ACac}
8	167	2.23±0.070^{ABa}	3.49±0.083^{Ccd}
9	33	2.70±0.140^{Bb}	4.64±0.165^{De}
Parity		*	*
1	171	1.92±0.079	3.08±0.093^{a}
2	107	2.16±0.084	3.25±0.099^{ab}
3	62	2.04±0.109	3.52±0.129^{b}
4	44	2.22±0.124	3.49±0.147^{ab}
5+	48	2.24±0.123	3.46±0.146^{ab}
CalSeason		**NS**	**NS**
1	88	2.23±0.102	3.11±0.121
2	57	1.90±0.141	3.52±0.167
3	133	2.08±0.096	3.45±0.113
4	154	2.26±0.083	3.35±0.098
LacStage		**	**NS**
1	93	1.86±0.111^{Aa}	3.53±0.132
2	134	2.24±0.102^{ABbc}	3.26±0.121
3	81	2.39±0.111^{Bb}	3.24±0.131
4	62	1.90±0.119^{ABac}	3.42±0.141
5	62	2.19±0.114^{ABab}	3.34±0.135
Overall	432	2.17±0.038	3.30±0.048

NS: non significance, *: P<0.05, **: P<0.01, A,B,C,D: different letter shows significant differences between the groups for P<0.01, a,b,c,d,e: different letter shows significant differences between the groups for P<0.05.

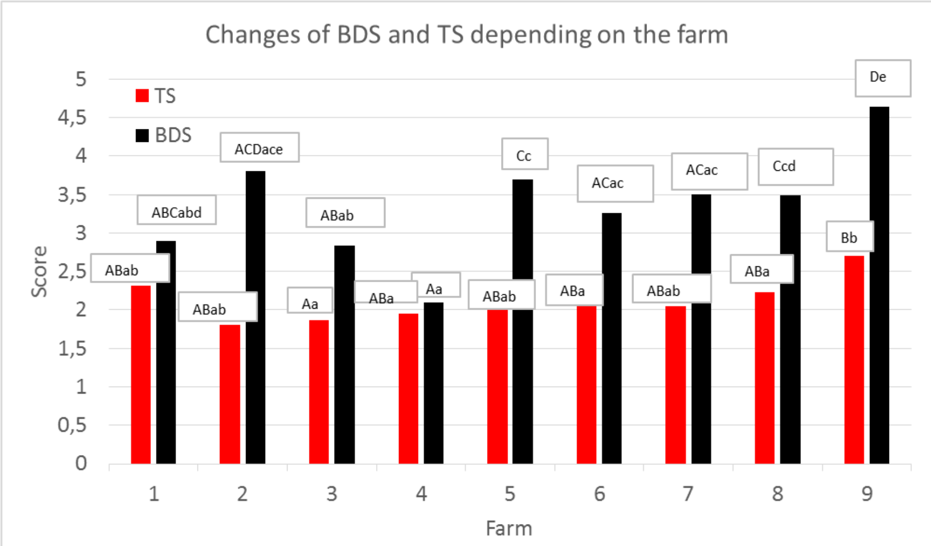

Figure 4.1. Changes of BDS and TS depending on farm effect. A,B,C,D: different letter shows significant differences between the groups for P<0.01, a,b,c,d,e: different letter shows significant differences between the groups for P<0.05.

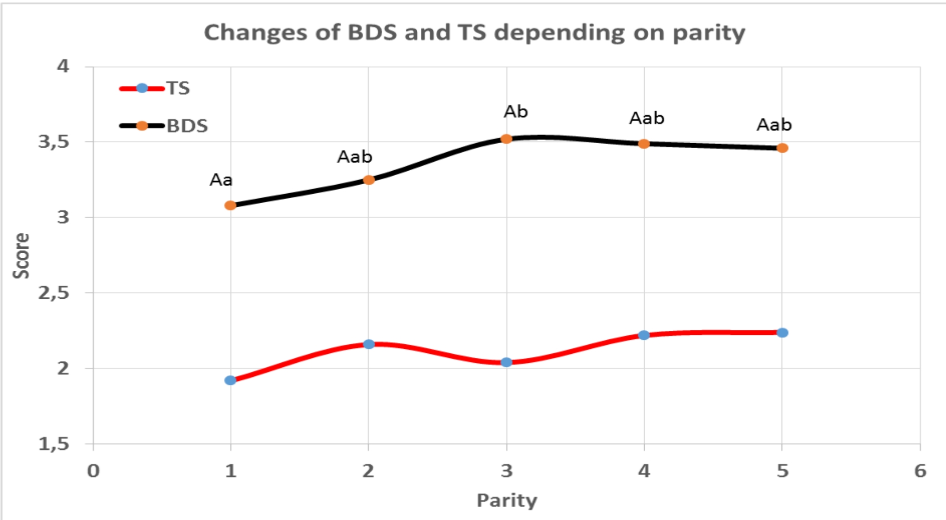

Figure 4.2. Parity and evolution of BDS and TS in HF dairy cattle. A,B: different letter shows significant differences between the groups for P<0.01, a,b: different letter shows significant differences between the groups for P<0.05.

4.2 Morning milk yield (MMY)

In this study, 8 farms all counting 265 lactating HF heads were used for inspection time MMY analysis. Factors such farm, parity, CalSeason, LacStage, BDS and TS effects are also presented in Table 4.2 and variations between farms are observed on Figure 4.3. Regarding all factors, the LSM was 13.92±0.315 kg at the inspection time. Farm and LacStage effects on MMY were found statistically significant (P<0.01). However, other effects such as parity, CalSeason, BDS and TS effects were not significant (P>0.05).

The highest MMY average was found in Farm 9 (No data for Farm 8 in the Table 4.2) and the average was 17.27±0.917 kg. The MMY of farm 9 was statistically (P<0.01) different from Farm 1, 3 and 5. The lowest average was found in Farm 5 (7.67±0.920 kg). When analyzed the lactation stage, the highest MMY was obtained from the first LacStage and this mean was different from 4th and 5th LacStage means (P<0.01) (Figure 4.4).

In this study, the average inspection time MMY found (13.92±0.315 kg) was similar than the result of Koç (2007a) who found 13.20±0.529 kg of average inspection time milk yield in HF. However, the average found here was higher than Koç (2007b) with 8.92±0.188 kg of average, Koç and Kızıkaya (2009) with 8.92±0.183 kg of average and Koç (2011) with 7.69±0.397 kg of average. The fact that milk yield was higher at the beginning of lactation and lower in advanced LacStage corresponds to the theories as it is well known that milk yield increase progressively till the peak lactation and decrease also progressively till the dry period.

4.3 FC and NFDMC in the milk

The least-square means for FC, NFDMC and Farms, parity, CalSeason, LacStage, BDS and TS effects are presented in the Table 4.2. and different changes are presented on Figure 4.3.

The overall means when considered all factors for milk FC and NFDMC were 3.58±0.039% and 10.14±0.032%, respectively. On one other hand, only farm effect on FC was found statistically significant (P<0.01), other factors such as parity, CalSeason, LacStage, TS and BDS effects were not significant (P>0.05). On the other hand, the farm, parity, CalSeason and LacStage effects on milk

NFDMC were found statistically significant (P<0.01) while the BDS and TS effects on NFDMC were not significant (P>0.05). When considered the farm effect, the lowest averages was found in Farm 6 (3.04±0.095%) regarding milk FC and in Farm 9 (9.48±0.098%) regarding milk NFDMC and. That being so, the highest FC average was found in Farm 2 (4.21±0.318) and the highest NFDMC average was found in Farm 7 (10.90±0.117).

Unless farm effect, other effects were not significant on milk FC. In this study, variability of milk FC may be explained by feeding system and farm management as it is confirmed by literature suggesting that the great key to get normal milk FC is to feed cows with a ration constituted of 35% of forage or forage quantity reaching 1.5% of body weight.

Milk NFDMC were higher in first 3 parities but decreased from 4th and 5th and + parities (Figure 4.5). This can be shown by the following means respectively in 1, 2, 3, 4, 5 and + parities: 10.40±0.059, 10.36±0.058, 10.39±0.074, 10.01±0.082 and 10.15±0.082 %, respectively.

According to CalSeason effect on NFDMC, averages were higher in the 1st CalSeason or winter (10.48±0.071%), decreased in the 2nd CalSeason or spring (10.07±0.094%), increased with the following season to reach 10.33±0.057% average in autumn. At 100 day intervals for LacStage, the milk NFDMC was higher in the middle of lactation (3rd LacStage) with 10.46±0.075 of average. Other averages were ranging between 10.11±0.077 and 10.46±0.075 % milk NFDMC. However, statistical analysis showed that there is no significant effect (P>0.05) of BDS and TS on both FC and NFDMC in the milk.

The significance of farm and parity effects on milk NFDMC found in this study corresponds to the theories. The overall average NFDMC value found in this study was similar to that found in a study of morning milk samples (9.98±0.99%) from 45 HF raised in some farms of Aydın Province (Koç, 2007a). However, that overall average was higher than those resulted from HF lactating dairy breeds by Koç (2007b) with 9.61±0.048% of average in HF, Koç (2008a) with 9.78±0.024 % of average in HF, Koç (2011) with 8.23±0.067% in HF. It was also higher than Koç (2015) with 8.78±0.044% in RH. For farm effect, the lowest and highest averages found respectively in Farm 9 (9.48±0.098%) and Farm 7 (10.90±0.117%) encumber the averages found in Koç (2007a), Koç (2007b) and Koç (2008a).

When the parity is taken into account, in this study, milk NFDMC decreased with the parity as it can be observed on Figure 4.5.

4.4 Milk somatic cell count

The LSM for Log_{10}SCC and farms, parity, CalSeason, LacStage, TS and BDS effects are presented in the Table 4.2. and change in averages are presented on Figure 4.3.

In this study, the effect of farm, parity and the TS being found statistically significant ($P<0.01$), CalSeason, LacStage and BDS were not significant ($P>0.05$). The Log_{10}SCC average was found to be 5.22±0.024. Once taken backward, it becomes 165958 cells/ml.

The farm effect on milk SCC between farms being statistically significant ($P<0.01$), the lowest average milk SCC was found in Farm 4 (5.21±0.137≈162181cells/ml) while the highest average was found in Farm 3 (5.79±0.081≈616595 cells/ml). Note that the farm with lower milk SCC is said to be healthy. Some farms used in this study had similarities and Log_{10}SCC averages were ranging between 5.21±0.137 and 5.79±0.081 (Table 4.2).

As for parity, the low average Log_{10}SCC is observed in primiparous (5.25±0.054). As it can be observed in Table 4.2, the Log_{10}SCC increased progressively with the parity. In this case, it was higher in cows at 4th and 5th and + parities (5.55±0.076) even though little decrease has been remarked at 3rd parity (5.30±0.068) when compared to the 2nd parity (Figure 4.5). This situation corresponds to expected results and the increase of milk SCC normally corresponds to the decrease in milk yield and the prevalence of subclinical or clinical mastitis. The increased SCC corresponding to the parity that was found in this study is similar to the confirmation of Göncü and Özkütük (2002) who confirmed an increase in SCC according to the parity and thus, the increase of mastitis incidence (Izgür, 1984). Topaloğlu and Güneş (2005) also found a significant ($P<0.05$) effect of the parity on the value of milk SCC in HF dairy cows.

As it was shown by the statistical analysis the CalSeason, lactation stage and BDS on SCC were not important.

In this study, the SCC increased with TS, having a significant effect on milk SCC. Cows scored 1 and 2 are said to be very healthy and Log_{10}SCC values were 5.25±0.061 and 5.24±0.042, respectively. Log_{10}SCC averages were higher in cows with TS 3 and 4 and the highest average value was found to be 5.62±0.096 in cows scored 4 (Figure 4.6). These results correspond to expected results and sustain the aim of this study.

In this study, the progressive increase of milk SCC with parity corresponds to the confirmation of Göncü & Özkütük (2002) and Yılmaz (2010) who found in their studies low somatic cells in 1st and 2nd parities and higher milk SCC in 5th and + parities.

As for the BDS and SCC, the BDS has an effect on total colony counting but not the SCC as it was concluded in a study by Trajcev et al. (2003) whose aim was the determination of the udder and hind legs' cleanliness on clinical mastitis incidence in lactating cows. Even though the BDS effect on total colony count of bacteria was found to be very significant ($p<0,01$), the BDS effect on SCC was not significant and this insignificancy corresponds to the results of this study.

To add more, the increased TS may have the relationship with teat temperature and thus the increase of milk SCC. This statement was concluded in a study conducted by Juozaitiene et al. (2019). They reported a significant positive correlation between teat's temperature and milk SCC when evaluated the hyperkeratosis scores N (no ring), S (smooth ring), and R (rough ring) and it was demonstrated a significant connection between different TEH levels and teat temperature, fact that indicates the high risk to mastitis. Consequently, the fluctuating temperatures significantly increase the number of leukocytes and erythrocytes (Paape et al., 1973).

The lowest average milk SCC found in this study was higher than averages found in the study of Koç (2009) whose aim was to compare SCC in the milk of cows that calved during the winter by morning and evening milking (133265 cells/ml). It was also higher than the results of Topaloğlu and Güneş (2005) who found 138000 cells/ml in their study, also higher than Yılmaz (2010) with 63753 cells/ml in Red-Holstein. It was once again higher than Gürses (2019) with 38815 cells/ml of average in HF and RH, Koç (2015) with 91833 cells/ml and 100462 cells/ml morning and evening, respectively.

All averages found in this study were lower than the averages resulted in studies by Koç et al. (2009) with 743019 cells/ml of average. In this study, it was found a high significance of the TS level on SCC. In his study, Francis (1984) found an increased TEH in cows during the fourth month of lactation and there was a relationship with an increased number of milk SCC. It was also confirmed by Michel et al. (1974) who stated that the increased TEH correlates with the increased risks of mastitis incidence. All those statement sustain the aim of this study.

In this study, the overall average milk SCC (165958 cells/ml) was similar to the mean average found by Ng-Kwai-Hang et al. (1984) who performed a study aimed at comparing the variation of milk SCC with age in two groups of lactating dairy cows (166000 cells/ml). Also, it can be confirmed that the overall mean milk SCC found in this study was similar to the results of Koç (2011) in HF and MB cows in summer and winter seasons. He found 199022 cells/ml and 138644 cells/ml respectively in summer and winter whose average in both seasons was 168833 cells/ml.

Table 4.2. Least-square means and standard errors of MMY (kg), FC (%), NFDMC(%) and $Log_{10}SCC$ in HF dairy cows

Factor	**n**	**$Log_{10}SCC$**	**NFDM**	**FC**	**MMY**	
					n	**Mean**
Farm		**	**	**		**
1	25	5.65±0.096^{ABabd}	10.85±0.104^{ABa}	3.97±0.164^{Aa}	25	12.39±0.944^{Aa}
2	6	5.46±0.188 ^{ABCabc}	10.05±0.203^{ACDbde}	4.21±0.318^{ABa}	6	13.85±1.782^{ABCac}
3	38		10.88±0.087^{Ba}	3.60±0.137^{Aa}	38	12.86±0.819^{Aa}
4	13	5.79±0.081^{Aa}	10.63±0.148^{ABab}	3.37±0.232^{ABab}	13	11.59±1.356^{ABCab}
5	27	5.21±0.137^{BCbc}	9.71±0.100^{CDde}	3.63±0.157^{ABa}	27	7.67±0.920^{Bb}
6	104	5.25±0.093^{BCc}	10.04±0.061^{Cd}	3.04±0.095^{Bb}	104	15.18±0.628^{ACac}
7	19	5.35±0.056^{BCcd}	10.90±0.117^{Ba}	3.61±0.183^{ABab}	19	13.18±1.044^{ACa}
8	167	5.31±0.108^{BCcd}	9.85±0.050^{Cd}	3.73±0.078^{Aa}	-	-
9	33	5.25±0.046^{Cc}	9.48±0.098^{De}	3.67±0.153^{ABa}	33	17.27±0.917^{Cc}
		5.37±0.090 ^{ABCcd}				
Parity		**	**	NS		NS
1	171	5.25±0.054^{Aa}	10.40±0.059^{Aa}	3.77±0.092	88	12.16±0.668
2	107	5.38±0.054^{ABab}	10.36±0.058^{Aac}	3.64±0.091	71	13.04±0.625
3	62	5.30±0.068^{ABac}	10.39±0.074^{Aac}	3.81±0.016	39	13.79±0.815
4	44	5.55±0.076^{Bb}	10.01±0.082^{Bb}	3.52±0.129	33	13.16±0.849
5+	48	5.54±0.076^{Bbc}	10.15±0.082^{ABbc}	3.50±0.129	34	12.84±0.868
CalSeason		NS	**	NS		NS
1	88	5.42±0.065	10.48±0.071^{Aa}	3.77±0.111	62	12.34±0.760
2	57	5.36±0.087	10.07±0.094^{Bb}	3.47±0.148	27	12.87±1.101
3	133	5.40±0.061	10.19±0.066^{Bb}	3.62±0.103	86	14.29±0.779
4	154	5.42±0.053	10.33±0.057^{Bb}	3.73±0.089	90	12.48±0.643
LacStage		NS	**	NS		**
1	93	5.36±0.071	10.11±0.077^{Aa}	3.70±0.121	61	15.62±0.878^{Aa}
2	134	5.39±0.064	10.21±0.069^{ABab}	3.52±0.109	74	12.89±0.834^{ABab}
3	81	5.43±0.069	10.46±0.075^{Bb}	3.73±0.118	42	13.22±0.801^{ABab}
4	62	5.36±0.075	10.20±081^{ABab}	3.61±0.126	52	11.45±0.847^{Bb}
5	62	5.48±0.070	10.35±0.076^{ABb}	3.68±0.120	36	11.45±0.887^{Bb}
TS		**	NS	NS		NS
1	75	5.25±0.061^{Aa}	10.25±0.066	3.66±0.103	48	12.80±0.702
2	234	5.24±0.042^{Aa}	10.27±0.046	3.63±0.072	145	13.19±0.464
3	97	5.50±0.057^{Bb}	10.31±0.062	3.57±0.097	60	13.86±0.664
4	26	5.62±0.096^{Bb}	10.23±0.103	3.74±0.162	12	12.14±1.301
BDS		NS	NS	NS		NS
1-2	106	5.34±0.059	10.16±0.064	3.60±0.100	75	12.95±0.687
3	153	5.36±0.054	10.25±0.059	3.73±0.39	82	12.18±0.666
4	110	5.48±0.057	10.24±0.062	3.60±0.96	69	13.06±0.664
5	63	5.44±0.070	10.32±0.076	3.66±0.118	39	13.79±0.862
Overall	**432**	**5.22±0.024**	**10.14±0.032**	**3.58±0.039**	**265**	**13.92±0.315**

NS: non significance, *: P<0.05, **: P<0.01, A,B,C,D: different letter shows significant differences between the groups for P<0.01, a,b,c,d,e: different letter shows significant differences between the groups for P<0.05.

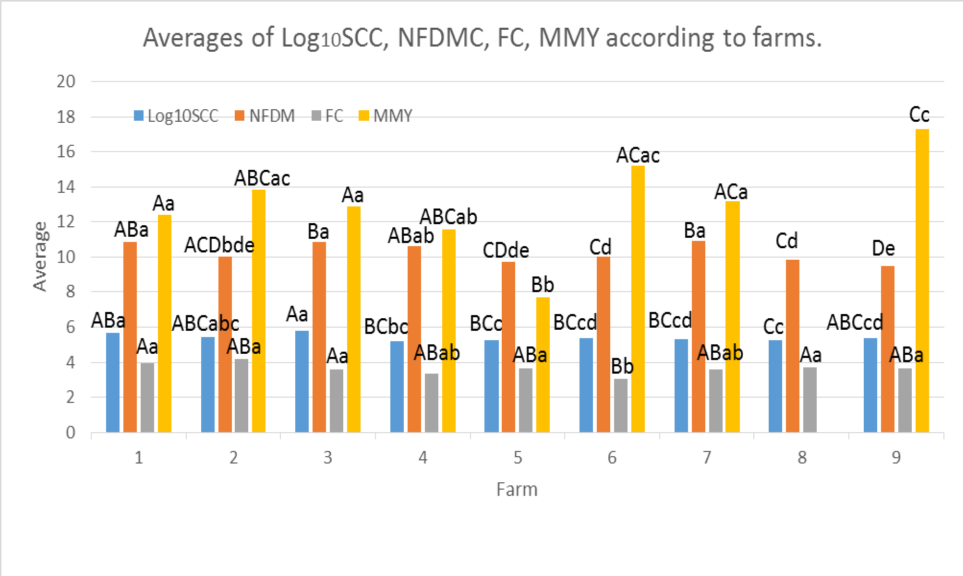

Figure 4.3. Different averages Log10SCC, NFDMC, FC and MMY in different farms. A,B,C,D: different letter shows significant differences between the groups for P<0.01; a,b,c,d,e: different letter shows significant differences between the groups for P<0.05.

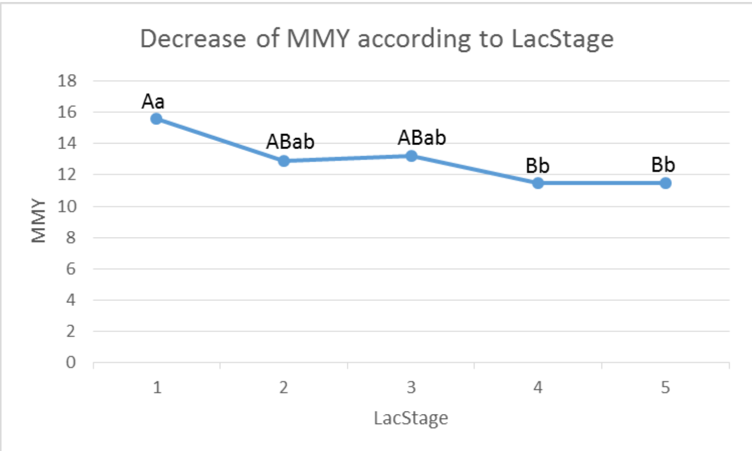

Figure 4.4 Decrease of MMY according to LacStage. A,B: different letter shows significant differences between the groups for P<0.01, a,b: different letter shows significant differences between the groups for P<0.05.

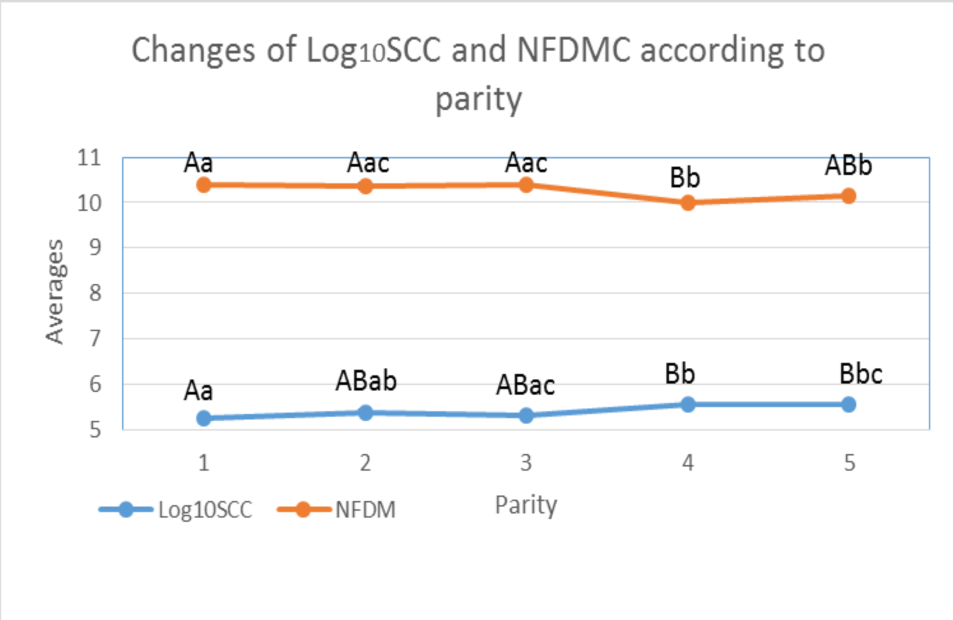

Figure 4.5 Changes of NFDMC and $Log_{10}SCC$ according to the patity. A,B: different letter shows significant differences between the groups for P<0.01; a,b,c: different letter shows significant differences between the groups for P<0.05.

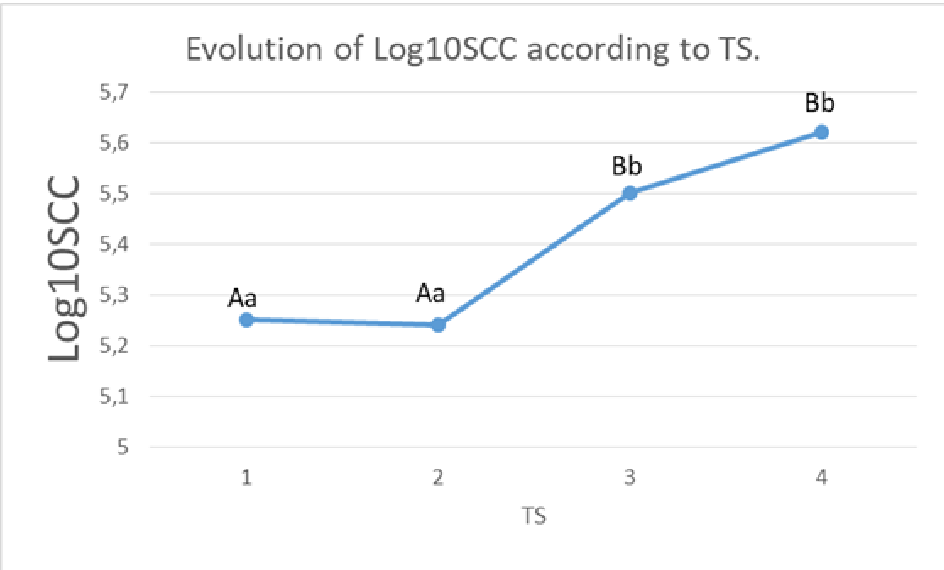

Figure 4.6 Evolution of $Log_{10}SCC$ according to TS. A,B: different letter shows significant differences between the groups for P<0.01, a,b: different letter shows significant differences between the groups for P<0.05.

CONCLUSIONS

This study was carried out on HF dairy cows raised in different dairy farms in Aydın province. In this study, a total of 265 lactating cows in 8 farms were used for inspection time MMY and a total of 432 lactating cows in 9 farms were sampled for BDS, TS, SCC, NFDMC and FC. On one hand, the effects of farm, parity, LacStage, CalSeason on BDS and TS were determined. On the other hand, effects of farm, parity, LacStage, CalSeason, BDS and TS on MMY, FC, NFDMC and SCC were determined in this study.

In this study, it was shown that farm, parity and LacStage effects had a significant effect on the TS. As for the BDS, only the farm and the parity had a significant effect on the body dirtiness of the cow. This means that the farm management and hygienic conditions in the farm have to be considered in order to attenuate both the level of BDS and TS.

As far as milk quality is concerned, it was remarked that among all milk quality traits, only milk SCC was significantly affected by the TS. The BDS did not show any significant effect on milk yield and quality of HF cows. In this study, it was seen that milk SCC increased with the TS. It means that SCC was lower in TS 1&2 and was higher in TS 3&4.

In addition, as the the teat conditions give an information about the general health of the lactating cow, evaluation of the TS level may help to assess the quality of milk without proceeding to laboratory analysis. The TS caused by environmental and farm conditions, genetic issues, high vacuum of milking machines, machine error during milk pulsation, over milking; farm conditions and milking machines have to be controlled and over milking has to be avoided. That can help to reach milk of good quality having low SCC and reduce mastitis incidences in a farm.

In this study, the MMY was higher in cows at the begining of first LacStage and decreased progressively with advanced lactation stage. The FC varied only according to farm management. The FC may be improved by nutrition management conditions such as feeding animals with suitable ratio forage/concentrates.

In addition to the effect of TS on milk SCC, the farm and parity have also the significant effect. As for TS, it was observed that milk SCC also increase progressively with the parity. This may also give an idea about the quality of milk according to the parity of cow. Milk SCC is low in primiparous and high in multiparous and this corresponds to the literature. At the contrary, the NFDMC in the milk was found to decrease significantly with the parity and was also significantly varying with CalSeason and LacStage.

As a result, the scoring of the teat end hyperkeratosis helps in controlling milk quality regarding SCC. The value of TS may be used to identify the emerging problem that may occur in lactating cows especially in estimating the level of SCC that can help to early identify and prevent subclinical and clinical mastitis. The higher TS may also reveal status of milking machines especially the high vacuum.

As recommendations, there must be applied a routine teat condition control and scoring two or three times with a lactation. On a dairy cattle farm, the teat scoring may also be done suddenly in case of stuff change, milking system modification or new parlour. For milking machines, the general status of the equipment may be regularly controlled such as teat cups, current on which milking machines are mounted and vacuum of milking machines. That control may be applied after every 3 of 6 months. Farmers may avoid over milking and may take care of the cows entering the dry period. The milk quality being the major concern of milk producers and milk consumers, this study showed the role played by the control of teat conditions. As the current study was the first done in Turkey, information provided here may help in academic area for researchers who would like to perform similar studies in other cattle breeds or other lactating species.

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