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Monitoring Tool for Assessing Metabolic Disorders in Individual Cows

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Abstract
The objective of this study is to determine whether milk lactose and milk fat concentration could be used as an easy monitoring tool for assessing energy status of dairy cows. Data collected from four farms (A, B, C, and D) located in Balıkesir were used in this study. Feed samples were collected from each farm and proximate analysis was carried out. Milk samples were collected from individual cows on each farm and milk constituents were measured. The effect of milk lactose level on ration and on the percentage of milk fat was found to be significant in the study (P<0.01). It can be estimated according to the proportion of milk fat and milk lactose that 18% of the 2392 animals on four farms were ketosis and that 23% of 554 animals which were in early lactation period were ketosis and that 13% of 972 animals in late lactation period were ketosis.
Keywords: *Milk lactose, milk fat, ketosis, ration, dairy cows*

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I. Introduction

Lactose, known as milk sugar, is a single-molecule disaccharide to each molecule of which glucose and galactose are bonded, and is the main carbohydrate source of animal origin in human nutrition. The lactose content of milk is around 4.8-5.2%, and although its concentration in milk is quite stable, it may vary significantly depending on the breed of the animal (Ptak et al., 2012). Lactose is the major carbohydrate of milk, and since it provides osmolarity, the density of milk depends on its lactose content (Ling et al., 1961). It is known that there is a close relationship between milk yield and the total amount of lactose produced by the cow. Lactose acts as the main osmolyte in milk and thus the effect that increases lactose synthesis enables the milk to contain more liquid and thus the higher the lactose synthesis, the higher the milk yield. It has been reported that it will occur (Kronfel, 1982). In the study conducted by Miglior et al. (2007), it was reported that there was a high correlation (R = 0.979) between lactose yield and milk yield in dairy cattle. The level of liquid secretion in milk significantly affects the fat and protein content of milk, and mostly the rate of lactose synthesis determines the water secretion rate, because lactose is the most important factor responsible for milk osmality (Zhao and Keating 2007). However, the increase in milk lactose level leaves all of the milk components (milk protein and other milk solids) unchanged, so although milk yield increases, the concentration of milk components decreases relatively. This relationship generally shows that milk volume is determined by lactose and that when a high level of milk secretion is reached in high-yielding dairy cattle, the amount of fat and protein synthesized cannot adapt to the increased amount of lactose synthesis (Mirzaei-Aghsaghali and Fathi, 2012).

In recent years, a large number of studies have been conducted to determine the relationship between lactose content and reproductive performance. In the study conducted by Francisco et al. (2003), they reported that the lactose percentage was a good predictor of postpartum ovulation on the first and second days. It has been reported that a decrease in lactose concentration of 0.1-0.3% is a sign of increasing subclinical mastitis (Staufenbiel, 2003). Buckley et al., (2003) associated the increasing lactose percentage with the pregnancy rate, and therefore it was reported that the milk lactose percentage could be a useful indicator of the animal's reproductive performance. Reksen et al., (2002) reported that the higher lactose percentage in the first 8 weeks' postpartum period was related to the early luteal response in second parity cows. It has been reported that the milk fat/milk lactose ratio is an indicator of subclinical and clinical ketosis and is the most informative parameter in estimating energy balance (Steen et al., 1996; Reist et al., 2002; Manzenreiter et al., 2013).

Considering that variations in milk components will provide useful clues for improving milk composition, controlling the health of animals and the suitability of herd management programs, many studies have been carried out in recent years on the chemical composition of milk and the factors affecting the composition of milk. Forsback et al., (2010) investigated daily variations in milk yield and milk total protein, whey protein, casein, fat, lactose and somatic cell counts of 10 cows for 21 days. The results of the research showed that 4 cows had healthy mammary tissue and the daily variations in milk composition of these cows were not significant, but different milk components showed daily variation at different levels and the least variation was in lactose (0.9%) and the highest variation was in the milk fat level (7.7%). Since lactose is the main osmotic regulator in milk and therefore the most stable component in milk, variations in the percentage of lactose have been attributed to the clinical and subclinical sign of mastitis and the possible risk of disease in udder health.

II. Materials and Methods

In the study, milk samples were taken individually from cows every 30 days for 8 months, during the morning milking on the control or test day. In individual milk samples, milk protein, milk fat, milk urea nitrogen, milk lactose level, milk dry matter percentage and the number of somatic cells in milk were determined. Milk analyses were performed with the Bently FTS/FCM COMBI 400 (Bentley Nexgen 400) model NIR device located in the Raw Milk Analysis Laboratory of the Breeding Cattle Breeders Association in Balıkesir province. Regarding the reproductive performance of the cows on the control day, information on calving date, insemination date, insemination number, information on the insemination date when pregnancy was confirmed, and milk yield, number of lactations, number of days in lactation were collected from the records of the farm.

From the data obtained from the farms, the chemical composition of milk was taken as the dependent variable and the effect of the independent variables on the dependent variables was calculated in accordance with the Proc Mixed processes of the SAS Statistics Package Program (SAS, 1996).

III. DISCUSSION AND CONCLUSION

In the study, the effect of ration and milk fat percentage on milk lactose percentage was found to be significant (P<0.01). In the study, the differences between the farms were significant and the average milk lactose percentage was found to be 4.78%, 4.50%, 4.80%, 4.69%, respectively (Table 1). It has been reported that the risk of mastitis is high when the milk lactose content is below 4.5% (Babnik et al., 2002). Although low milk lactose percentage is an indicator of metabolic and functional irregularities in the breast tissue, it has been reported that these metabolic irregularities may result in breast inflammation (Zadnik and Jazbec, 1993). Accordingly, milk lactose values for animals on the farms where the research was conducted show that the risk of mastitis is low. Lactose is produced from glucose or glycogen in the breast wall. During lactation, the need for glucose in the breast is met by both active and passive transport pathways and is independent of the concentration of glucose and insulin in the blood (Zhao et al., 1999). The rate of lactose synthesis in the epithelial cells of the breast tissue serves as the main factor affecting milk volume, and the main precursor of lactose secreted from the epithelial cells of the mammary gland is glucose. The glucose needed for the synthesis of milk lactose is largely obtained from probionate and amino acids through gluconeogenesis. A breast wall that secretes lactose cannot synthesize glucose from other precursors due to the absence of glucose 6 phosphate and depends on blood for its glucose needs (Neville et al., 1983). It has been reported that blood glucose concentration affects the milk lactose synthesis rate and thus milk volume in an osmic manner, and a negative relationship between milk production and blood glucose concentration and a low blood glucose level in genetically high-yielding dairy cattle have been reported (Mirzaei-Aghsaghali et al. 2012). Therefore, optimizing the intake of digestible dry matter is an important issue in increasing the amount of glucose precursors and therefore the amount of milk synthesized.

Table 1. The Effect of the farm on milk lactose ($\bar{X} \pm Sx$)

Farm No	N	Milk lactose	Minimum	Maximum
1. farm average	360	4.78 ± 0.132^{B}	4.46	5.23
2. farm average	166	4.50 ± 0.652^{D}	3.11	5.22
3. farm average	540	4.80 ± 0.212^{A}	3.60	5.28
4. farm average	149	4.69 ± 0.270^{C}	3.42	5.24
General average	1215	4.74 ± 0.320	3.11	5.28

A,B,C,D: P<0.01

It was reported by Hanus et al., (2013) that ketosis is a lack of energy and means an insufficient level of glucose in the blood. Negative energy balance, which occurs due to inadequate feeding of cows despite high milk yield in the early lactation period, may be the possible cause of reproductive disorders such as abomasum displacement, mastitis and non-ejaculation, which reduce milk yield and threaten milk quality in the postpartum period. Some of these negative health problems are caused by suppression of the immune system. Monitoring the symptoms of subclinical ketosis is important for improving milk quality, herd health and reproduction, and preventing economic losses on the farm. The meta-analysis conducted for the early diagnosis of ketosis showed that the energy metabolism of dairy cows can be monitored using milk components and ratios (milk fat/milk protein; milk fat/milk lactose) as an easy and advantageous method, unlike blood and urea, to control the daily nutrition and health status of dairy cattle. has been reported (Hanus et al., 2013). It has been reported that the first two weeks following birth in the cow is very important as the most appropriate sampling time for the reliability estimation of the indicator threshold of ketosis in milk (Hanus et al., 2013). The results of the research conducted by Hanus et al., (2013) are the result of a meta-analysis of 2-4 day milk fat/milk protein and milk fat/lactose ratios (1.27 and 0.82, respectively) obtained from samples taken on risky days in the early lactation period instead of monthly milk records. It has been reported to be a successful indicator for the diagnosis of ketosis. In this study, the average milk fat/milk lactose ratio of animals in the 1st, 2nd, 3rd, 4th and 5th lactation was found to be 0.61, 0.75, 0.64, 0.64 and 0.65, respectively (Table 2). The effect of the number of lactations on the milk fat/milk lactose ratio on the test day was not found to be statistically significant. The milk fat/lactose ratio was found to be low in the 4th week after birth (0.84) in cows in the second parity and was associated with a delay in luteal functions (Reksen et al., 2002). According to the research findings, in the current study, the milk fat/milk lactose ratio in the second lactation cows was found to be higher than the others, although it was not statistically significant. In the study, milk fat/milk lactose ratio was affected by the percentage of milk solids, milk fat percentage and milk lactose percentage at the $P<0.01$ level, and the number of days in lactation affected the $P<0.05$ level.

Table 2. The effect of number of lactations on milk fat/milk lactose ratio ($\bar{X}\pm Sx$)

LS	N	Milk fat/milk lactose ratio	Minimum	Maximum
1	270	0.61±0.311	0.20	2.90
2	635	0.75±0.228	0.17	1.74
3	183	0.64±0.282	0.20	2.67
4	69	0.64±0.332	0.20	2.21
5	18	0.65±0.294	0.21	1.45

Table 3. Estimation of ketosis risk on farms according to milk fat/milk lactose ratio

Lactation period	Milk parameter	Observation	Percentage	Metabolic status
1. farm	Milk fat/Milk lactose	N	%	Energy balance
Early lactation 0-100 day	>0.9	117	51	Ketosis
Mid-lactation 100-200 day	>0.9	256	45	Ketosis
Late lactation 200-300 day	>0.9	338	27	Ketosis
2. farm	Milk fat/Milk lactose	N	%	
Early lactation 0-100 day	>0.9	76	33	Ketosis
Mid-lactation 100-200 day	>0.9	141	9	Ketosis
Late lactation 200-300 day	>0.9	99	2	Ketosis
3. farm	Milk fat/Milk lactose	N	%	
Early lactation 0-100 day	>0.9	279	12	Ketosis
Mid-lactation 100-200 day	>0.9	367	10	Ketosis
Late lactation 200-300 day	>0.9	430	1	Ketosis
4. farm	Milk fat/Milk lactose	N	%	
Early lactation 0-100 day	>0.9	82	10	Ketosis
Mid-lactation 100-200 day	>0.9	102	22	Ketosis
Late lactation 200-300 day	>0.9	105	25	Ketosis
4 Overall total of the farm	Milk fat/Milk lactose	N	%	
Early lactation 0-100 day	>0.9	554	23	Ketosis
Mid-lactation 100-200 day	>0.9	866	21	Ketosis
Late lactation 200-300 day	>0.9	972	13	Ketosis
Overall Total		2392	18	Ketosis

Table 4. The effect of the farm on milk fat/milk lactose ratio ($\bar{X} \pm Sx$)

Farm No	N	milk fat/milk lactose ratio	Minimum	Maximum
1. farm average	359	0.81±0.185	0.17	1.21
2. farm average	141	0.76±0.176	0.22	1.74
3. farm average	536	0.59±0.295	0.20	2.90
4. farm average	139	0.73±0.291	0.260	1.69
Overall average	1175	0.69±0.272	0.17	2.90

According to the milk fat/milk lactose ratio, it can be predicted that 18% of a total of 2392 animals in 4 farms were in ketosis, 23% of 554 animals in the early lactation stage were in ketosis, 21% of 866 animals in the mid-lactation stage were in ketosis and 13% of 972 animals in the late lactation stage were in ketosis (Table 3). Manzenreiter et al. (2010) reported that the usability of the milk fat/milk lactose ratio in diagnosing ketosis was 66.7% correct when compared to the control group, but the correct diagnosis rate was 60.9% in diagnoses made with the milk fat/milk protein ratio. It has been reported that the milk fat/milk lactose ratio is more reliable in diagnosing subclinical and clinical ketosis compared to the milk fat/milk protein ratio (Steen et al., 1996; Reist et al., 2002; Manzenreiter et al., 2010). In the study, it was estimated that 26% of 2788 animals were in ketosis based on the milk fat/milk protein ratio, and 18% of 2392 animals were estimated to be in ketosis based on the milk fat/milk lactose ratio. In the study conducted by Manzenreiter et al. (2010), 37.5% of the milk fat/milk lactose ratio was found to be over 0.9 as a false positive value. This can lead to the conclusion that the predictive values obtained in the study may be slightly higher than the actual diagnostic values. In the research, the average milk fat/milk lactose ratio for the farms was found to be 0.81, 0.76, 0.59 and 0.73, respectively (Table 4). For the farms where the research was conducted, the effect of the chemical composition of milk on the service period and the number of inseminations was not found to be statistically significant. In the research, the average milk fat yield for the farms was calculated as 1.31, 1.09, 1.07 and 1.21, respectively, and the effect of milk fat percentage and milk yield on milk fat yield was found to be significant ($P<0.01$).

IV. Conclusion

According to the research results, it can be estimated that 18% of 2392 animals were in ketosis, and this value may be slightly higher than the actual diagnostic values. Using milk lactose and milk fat concentrations to evaluate the energy status of dairy cattle can provide an estimate of the negative energy balance, especially in the early lactation period, and can be used as a tool for precautions to be taken. In order to reduce the severity of negative energy balance and ensure the efficient functioning of the immune system, it is important that animals receive sufficient and balanced nutrients and that feed consumption at the beginning of lactation be peaked as early as possible. According to the results obtained in this study, evaluation of milk lactose and milk fat parameters may provide important clues about the determination of the current situation and the precautions to be taken.

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