PAPER

SOME PHYSICOCHEMICAL CHARACTERISTICS OF RAW MILK OF ANATOLIAN BUFFALOES

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ABSTRACT

This research was carried out to determine some constituents and properties of raw milk samples of Anatolian buffaloes. Raw milk samples were collected from the different areas of the Tokat province of Turkey and analyzed for density, acidity, urea, free fatty acids (FFA), citric acid, freezing point (FPD), and pH. Milk samples were collected in February, March, and April 2012. Results of the research showed that the averages of raw milk density, acidity, urea, free fatty acids, citric acid, freezing point degree, and pH were determined as 1029.66 g/cm^3, 8.26 ^{o}SH, 0.047%, 4.78 mmol/10L, 0.13%, -0.56 ^{0}C, and 6.56, respectively. As a result, the effects of lactation number, calving age, village, herd, sampling time, and stage of lactation on the determined parameters were found to be statistically significant (P<0.01).

- Keywords: buffalo milk, density, acidity, urea, free fatty acids, citric acids, freezing point, pH -

INTRODUCTION

Milk is universally recognized as a complete diet owing to its essential components for human nutrition. Therefore, it is considered as one of the most important foods for human beings (SHARİF and MUHAMMED, 2009). Milk quality is as important as the quantity of milk production to the dairy industry. The physical properties and chemical composition of buffalo milk vary according to the animal genotype, and are influenced by several factors such as the lactation stage, parity, calving age, and season. Buffaloes are used more frequently as a draft animal in rural places in Turkey. Also, buffalo milk, as one of the most valuable products, is among the main protein sources for poor or rural breeders and provides a significant income for the rural economy (BORGHESE, 2005; YILMAZ *et al.*, 2011). Buffalo breeding provides 12% of total milk production in the world (AHMAD *et al.*, 2008). The Anatolian Buffalo is the second most important dairy species in Turkey. In recent years, while buffalo population has increased throughout the world, the buffalo population in Turkey has begun to decline (SAHİN *et al.*, 2011). The buffaloes in Turkey are called Anatolian buffalo and they are among the Mediterranean Buffaloes, which are a subgroup of river buffaloes (SOYSAL *et al.*, 2005). The recorded number of Anatolian buffaloes in Turkey was 366,150 in 1991 and decreased to 107,435 in 2012 (ANONYMOUS, 2012). They are mostly bred in North, Middle, West, East, and Southeast Anatolia in Turkey (ATASEVER and ERDEM, 2008). Anatolian buffaloes are particularly bred for milk production and they are slaughtered for meat production after their productive years in Turkey (SEKERDEN, 2001). Anatolian buffaloes are a considerably preferred breed in the different regions of Turkey due to their resistance to diseases and lower feed consumption. Notwithstanding, the genetic structure of buffaloes is principally taken into consideration and the importance of environmental factors remains secondary to many dairy operations in Turkey. The scientific literature concerning the description of the density, acidity, urea, free fatty acids, citric acid, freezing point, and pH, and understanding the effects on these physical components of buffalo milk is limited. Thus, there is limited research on the density, acidity, free fatty acids, citric acids, freezing point, and pH in raw buffalo milk in Turkey.

The aim of this study was to define the density, acidity, urea, free fatty acids (FFA), citric acid, freezing point degree (FPD), and pH, and to identify and quantify environmental factors affecting some milk chemical compositions in Anatolian buffaloes.

MATERIALS AND METHODS

Location of the experiment

This study was carried out in the Tokat province in the mid-Black Sea Region of Turkey. Located between 35° 27' and 37° 39' East longitudes, and 39° 52' and 40° 55' North latitudes. The district has a climate with a transition feature between the Black Sea Maritime climate and the Anatolian Continental climate. The long-term average yearly temperature ranges from 8.1 to 14.2°C. Average relative humidity is between 56 and 73% (MARA, 2011).

Sample collecting

Anatolian buffaloes, raised in different villages of Tokat, were examined between February to April 2012. More than 636 samples were collected. Lactating buffaloes were grouped into three lactation stages (1^{st}, 2^{nd}, 3^{rd} month (1: early); 4^{th}, 5^{th}, 6^{th} month (2: mid); and 7^{th}, 8^{th} and 9^{th} month (3: late) and a total of seven parity groups (1- ≥7 parities). Sampling times were evaluated in three subgroups (February, March, and April). Buffaloes are typically milked once in the morning before being moved to pasture. Therefore, raw milk samples (about 50 mL) were obtained from each animal during the morning milking in plastic sterile bottles containing (one tablet) of 2-bromium-2-nitroprophane-1,3 diol (Bronopol) and kept cold until analyzed.

Methods of analysis

FOSS Milko Scan TM 120 (calibrated with appropriate buffalo standard, Foss electric, Denmark) was used to determine density, acidity, free fatty acids, citric acid, and freezing point in raw milk samples. It is founded on well-identified IR-technology utilized in other FOSS Milko Scans, and compatible with IDF (International Dairy Federation) principles and AOAC (Association of Official Analytical Chemists) formal procedures.

The pH was measured using a digital pH-meter (HI 8314, Hanna Instruments, Italy), standardized with pH 4 and 7 buffers.

Statistical analysis

In the study, stage of lactation, parity, farm, and season were evaluated as independent variables. All statistical analyses were conducted using the SPSS statistical package program (SPSS 17.1). The data were examined by analysis of variance (ANOVA).

The model was as follows:

$$Y_{ijklmn} = \mu + a_i + b_j + c_k + d_l + f_m + e_{ijklmn}$$

Table 1 - Descriptive statistics of some physicochemical characteristics of Anatolian buffaloes milk.

	N	Mean	SE	Minimum	Maximum
Density (g/cm³)	636	1029.66	0.306	1028	1033
Urea (%)	609	0.047	0.001	0.036	0.057
Acidity (°SH)	636	8.26	0.153	5.96	9.94
Free fatty acids (mmol/10 L)	304	4.78	0.375	3.22	6.35
Citric Acid (%)	636	0.13	0.002	0.11	0.15
Freezing Point Degree (°C)	636	-0.56	0.007	-0.46	-0.66
pH	328	6.56	0.008	6.01	7.00

Where:

Y_{ijklmn}: Observation value for various physicochemical characteristics
μ: Population mean
a_i: Effect of the parity (k: 1, 2, ...7)
b_j: Effect of villages (j: 1, 2,....12)
c_k: Effect of the calving ages (I =3, 4, 5, ...9)
d_l: Effect of sampling time (February, March, April)
f_m: Effect of the stage of lactation (Early, Mid, Late)
e_{ijklmn}: Random residual effect

RESULTS AND DISCUSSION

The means of density, acidity, urea, free fatty acids, citric acids, freezing point degree, and pH values were determined to be 1029.66 g/cm³, 8.26 °SH, 0.047%, 4.78 mmol/10L, 0.13%, -0.56 °C, and 6.56, respectively. Descriptive statistics of the variables studied in this study are presented in Table 1.

The results obtained from the preliminary analysis of the means of various chemical characteristics for lactation number, village, calving age, sampling time, and stage of lactation are presented in Figs. 1, 2, 3, 4, and 5, respectively. The density and pH of all the raw milk samples were found to be 1029.66±0.306 g/cm³ and 6.56±0.008, respectively. Small variations were found for the two parameters in all the milk samples. The density is mainly due to the water content present in the sample, and pH is the parameter that determines the sample alkalinity and acidity. Furthermore, density is a measure that provides information about the purity of the raw milk. The pH range found in the current study was similar to the findings in previous investigations (6.38±0.60 to 6.77±0.88; 6.59±0.59 to 6.93±0.57; 6.58 to 6.95; 6.62 to 6.64; 6.45 to 6.61) (REHMAN and SALARIA, 2005; IMRAN *et al.*, 2008; BRAUN and PREUSS, 2008; SAMEEN *et al.*, 2010; YANG *et al.*, 2013). Furthermore, this pH value (6.65) was lower than those reported by GHAFOOR *et al.* 1985, Han *et al.* (2007), BRAUN and PREUSS (2008), and ENB *et al.* (2009). Additionally, MÉNARD *et al.* (2010) reported that buffalo milk pH was 6.74. The current research produced results that support the findings of a great deal of the previous work in this field. The density and pH of buffalo milk were reported to be 1033 g/cm³ and 6.75, respectively, by MAHMOOD and USMAN (2010). KANWAL *et al.* (2004) stated that buffalo milk pH, acidity, and densi-

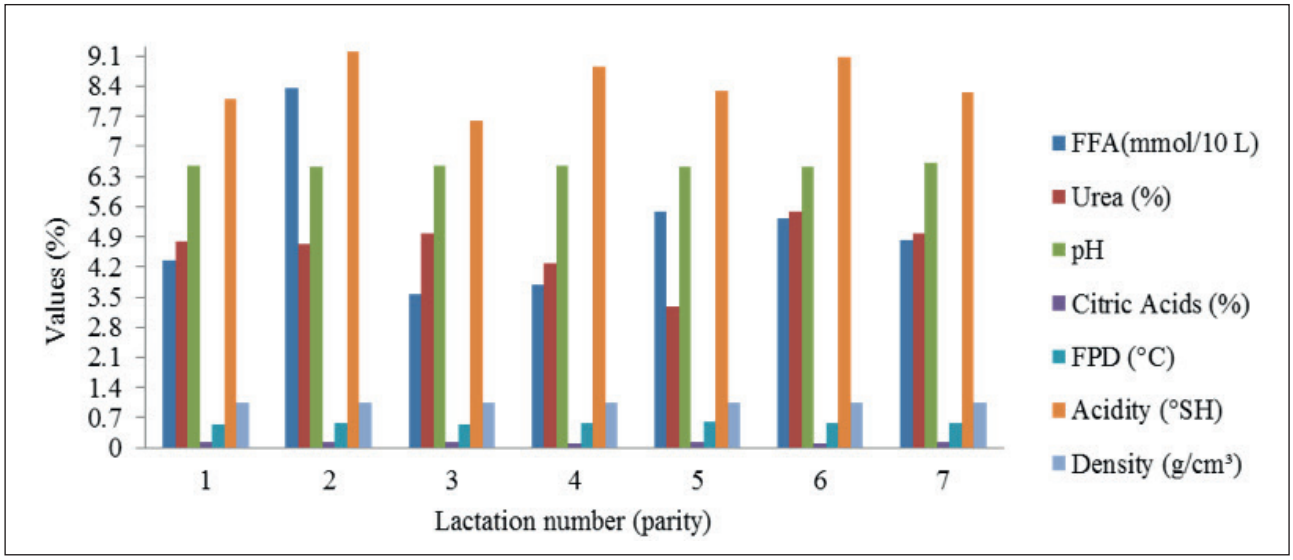

Fig. 1 - Chemical composition of buffalo milk according to parity.

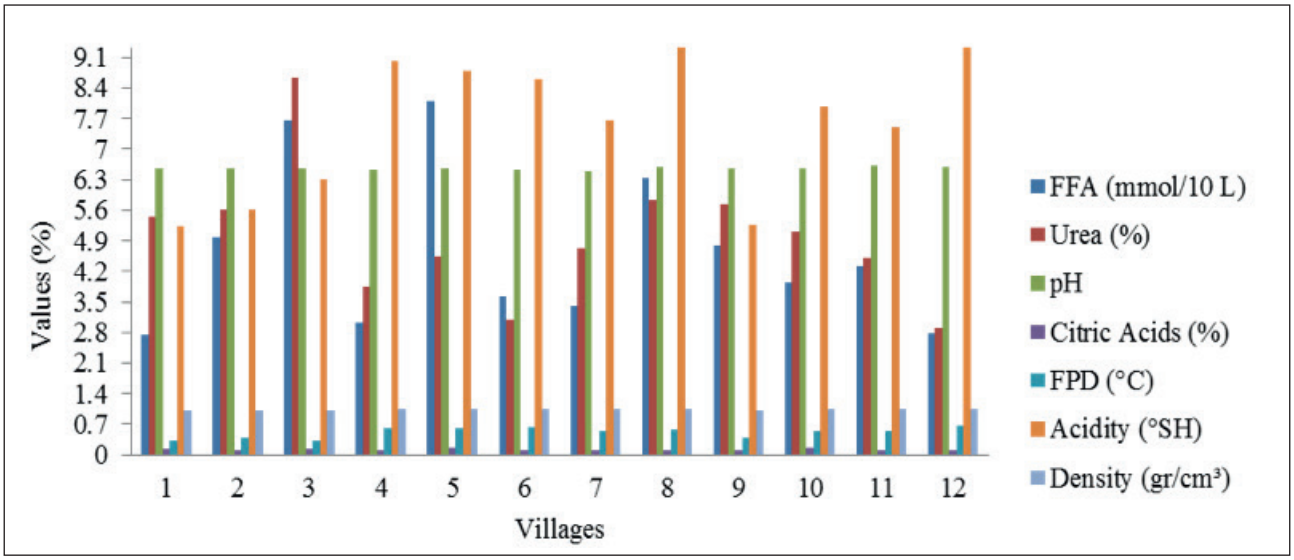

Fig. 2 - Chemical composition of buffalo milk according to villages.

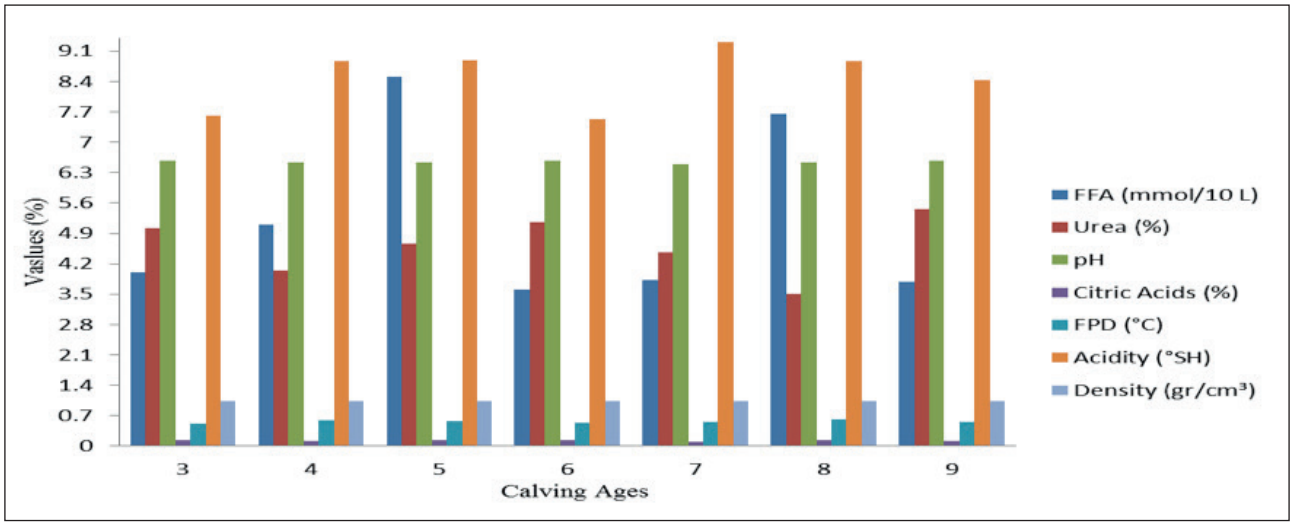

Fig. 3 - Chemical composition of buffalo milk according to calving ages.

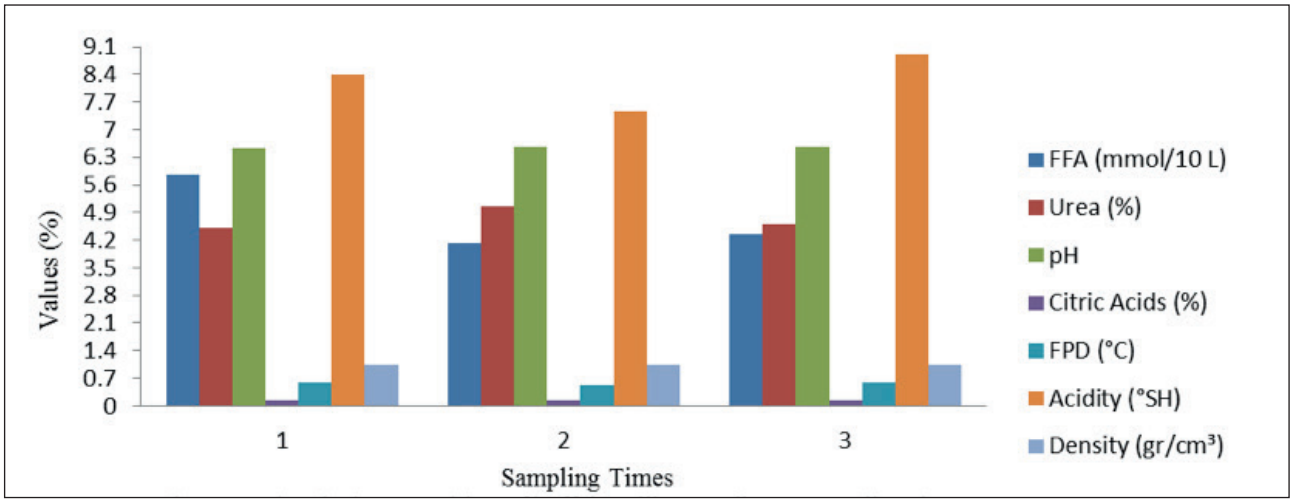

Fig. 4 - Chemical composition of buffalo milk according to sampling times.

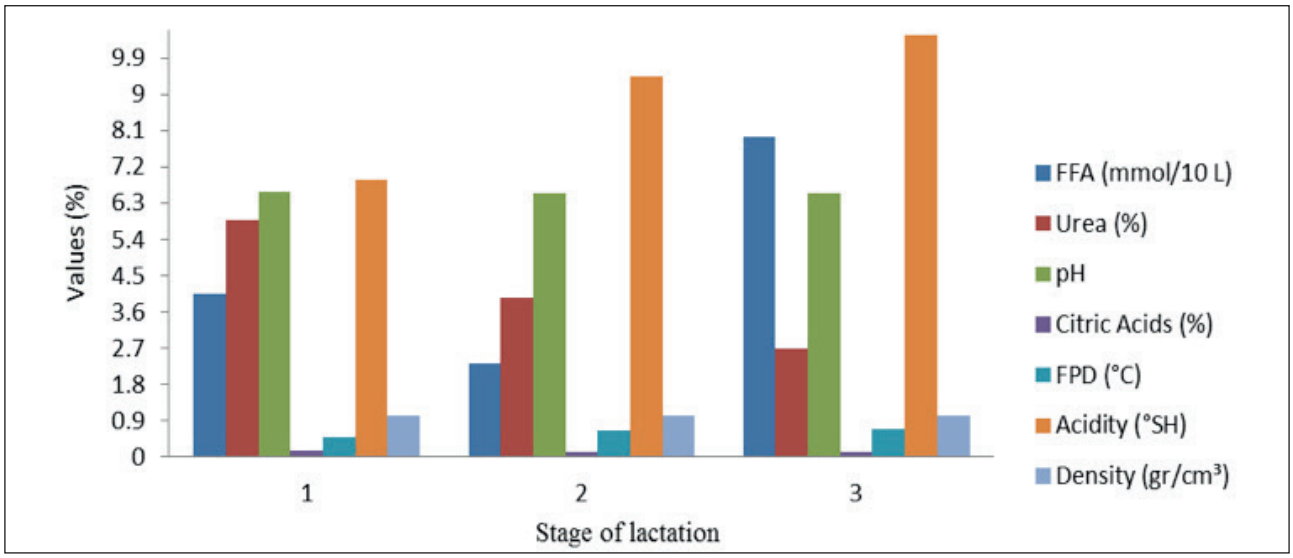

Fig. 5 - Chemical composition of buffalo milk according to stage of lactation.

ty were 6.64, 0.133, and 1020 g/cm^3, respectively. HAQUE *et al.* (2012) declared that buffalo milk pH was 6.70. Furthermore, AHMAD *et al.* (2005) reported that buffalo milk pH and density were 6.58 and 1032 gr/cm^3, respectively. The density value was lower than the findings of some previous research results (PADGHAN *et al.*, 2008; BRAUN and PREUSS, 2008). HAN *et al.* (2007) declared that buffalo milk pH was 6.53 for Murrah breed, and 6.39 for Nili Rawi breed. Buffalo milk densities were 1034, 1032, 1032, and 1033 gr/cm^3, for winter, spring, summer, and autumn seasons, respectively (AURELIA *et al.*, 2009). The mean pH (6.56 ± 0.008) of Anatolian buffalo milk was similar to the values reported by HAN *et al.* (2007), SEKERDEN and AVSAR (2008), PADGHAN *et al.* (2008), and GÜRLER *et al.* (2013), but higher than those of AURELIA *et al.* (2009) and COROIAN *et al.* (2013). Turkish Food Regulations report that the density of raw buffalo milk is 1028 g/cm^3 (ANONYMOUS, 2000). The present results are similar to this standard. This value (1029±0.306 g/cm^3) is lower than findings of FRANCISCIS *et al.* (1988) and similar to the results of ZAMAN *et al.* (2007). In addition, Ahmad *et al.* (2008) reported that buffalo milk pH was 6.81. The results of the present research are consistent with those of KHAN *et al.* (2007), who found that the density and pH were 1032 g/cm^3 and 6.37 for swamp buffaloes, respectively, and 1032 g/cm^3 and 6.57, respectively, for water buffaloes. The average pH of milk samples collected from swamp and water buffalo were within the normal range.

In this study, the mean value of the milk urea content was 0.047%. This result similar to AYASAN *et al.* (2011), who reported that milk urea content was 0.04% for Holstein cattle in Turkey. Milk urea content was determined to be 3.78 mg/100 mL of Anatolian buffaloes by SEKERDEN and AVSAR (2008), who claimed that milk urea content only affected feeding levels. In addition, the level of the feeding regime has also been reported to have an effect on milk urea content by ABREU (2008).

In this study, the mean value of the milk urea content was 0.047%. This result similar to AYASAN *et al.* (2011), who reported that milk urea content was 0.04% for Holstein cattle in Turkey. Milk urea content was determined to be 3.78 mg/100 mL of Anatolian buffaloes by SEKERDEN and AVSAR (2008), who claimed that milk urea content only affected feeding levels. In addition, the level of the feeding regime has also been reported to have an effect on milk urea content by ABREU (2008).

The protein/energy ratio of animal feed had an effect on milk urea concentration (BAKER *et al.*, 1995; AYASAN, 2009). Milk urea levels may change depending on a number of factors.

Milk composition, breed, season, time of feeding, somatic cell count, feeding regime, feeding method, and water and dry matter consumption are among the most important of these factors (NOUROZI *et al.*, 2010; ROY *et al.*, 2011). These findings further support the results of the study of ROY *et al.* (2005), who reported that feeding regimes had a significant effect on raw milk urea concentration.

Furthermore, the same researchers revealed that this effect might be due to the difference in the quality and type of protein between the diets and the feeding strategy of the research. The composition of milk free fatty acids is dependent on various factors, such as stage of lactation, genetic variation, breed, calving age, animal health, and feed composition (GARNSWORTHY *et al.*, 2006; QURESHI *et al.*, 2010).

In the present study, milk free fatty acid content was found to be 4.78 mmol/10L. Similar results were obtained by some researchers (HOFI *et al.*, 1977; BERI *et al.*, 1984; TALPUR *et*

al., 2007). On the other hand similar results were obtained for Holstein cattle by FILIK *et al.* (2011) and AYAŞAN *et al.*, (2012). Sharma *et al.* (2000) reported that milk fatty acid content was 0.58±0.01, 0.65±0.02, and 0.84±0.07 according to buffalo during lactation stages (early, mid, and late stages, respectively).

The freezing point of raw milk is an important feature to determine the amount of water added (AYDIN *et al.*, 2010). In this experiment, the average freezing point was determined as -0.56°C in milk samples. Similarly ROSENMAN and GARRY (2010) reported that the buffalo milk freezing point was -0.52°C. The freezing point of buffalo milk in Germany ranged from -0.55° to -0.51°C (BRAUN and PREUSS, 2008); FILIK *et al.* (2011) and AYAŞAN *et al.* (2012) reported that the freezing point of Holstein cattle milk is -0.51° and -0.52°C.

In this study, milk citric acid content was determined to be 0.13%. According to FILIK *et al.* (2011), the milk citric acid content of Turkish Holstein cattle was found as 0.11%. This value is in agreement with findings of AYAŞAN *et al.* (2012) for Holstein cattle in Turkey.

The degree of acidity is a good indicator of whether or not it was held under appropriate conditions from the time of milking until it is processed (UNAL and BESLER, 2006). The mean acidity percentage of the buffalo milk was 8.26±0.153 °SH. It has been explained in the Turkish Food Regulations that the acidity of raw buffalo milk is not higher than average 8 °SH (0.14-0.22 %). It can be seen from Table 1 that this is similar to the normal value. The values of the acidity in buffalo milk were in accordance with the findings REHMAN and SALARIA (2005), PADGHAN *et al.* (2008), and COROIAN *et al.* (2013). This value is similar the study of BOVERA *et al.* (2002), who determined that buffalo milk acidity ranged from 8.37 to 8.81 °SH. It was reported by SEKERDEN and AVSAR (2008) that the acidity percentage of buffalo milk was 0.17%. These results are in agreement with HAQUE *et al.* (2012), who reported that buffalo milk acidity was 0.21. EL AGAMY *et al.* (1998) found that the mean value of acidity for buffalo milk was 0.18. It is clear that the pH values had an opposing trend from acidity percentages. The results of the present study are in agreement with those of KHAN *et al.* (2007), who found that the acidity percentage was 0.16% for swamp buffaloes, 0.15% for water buffaloes, and 0.16% for the overall mean. The results of the present investigation are in agreement with the findings of various researchers (ENB *et al.*, 2009; SAMEEN *et al.*, 2010). Acidity values found in buffalo milk were lower than the findings of Mahmoud and Usman (2010). The first acidity in milk is due to the amount of casein phosphate, citrate, and carbon dioxide. However, later, the bacterial activity increases and lactic acid is formed, and thus the acidity of the milk increases. Extra acidity in milk is not desirable. However, in this study the acidity percentage of all samples from the above breeds were within the normal range.

The analyses indicated that the effects of parity, calving ages, villages, stage of lactation, and sampling time of all traits were statistically significant ($P<0.05$). However, ZAMAN *et al.* (2007) reported that the stage of lactation and parity of buffalo milk density was insignificant.

The some physicochemical compositions of Tokat Anatolian buffalo raw milk determined in this study were in agreement with other research results. It was determined that the density, acidity, urea, free fatty acids, citric acids, freezing point, and pH content of Anatolian buffalo milk were affected by various environmental factors. Additionally, the quality and chemical compositions of the milk are of great importance to the dairy sector and human health because milk composition is related to milk products.

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