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# THE EFFECT OF SOME ENVIRONMENTAL FACTORS ON MILK COMPOSITION OF ANATOLIAN BUFFALOES

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***Abstract***

*The aim of this study was to determine the composition of raw milk from Anatolian water buffaloes raised under different village conditions in the Tokat province of Northern Turkey. The study materials included 600 milk samples from 120 water buffaloes raised at different farms in 12 separate villages of the Erbaa, Turhal, and Pazar counties in the Tokat Province. The dry matter, nonfat dry matter (or solid non fat), fat, protein, lactose, and casein content of the milk samples were determined. The study results demonstrated that the mean dry matter, nonfat dry matter, fat, protein, lactose, and casein content of the raw milk samples were 16.99±0.108%, 10.88±0.036%, 5.98±0.107%, 4.85±0.043%, 5.17±0,021%, and 3.61±0.036%, respectively. The study data were evaluated according to the water buffaloes' lactation stage, parity, and season by using the SPSS statistical program. It was concluded that the sampling time, parity, village conditions, stage of lactation and calving age had a significant effect ($p<0.05$) on the dry matter, nonfat dry matter, fat, protein, lactose, and casein content of raw milk from the Anatolian water buffalo.*

***Key words:*** *Dry matter, Fat, Protein, Lactose, Casein.*

## INRODUCTION

Milk represents an important article in the human diet (Sharif and Muhammed, 2009). Water buffalos are the second most common source of milk source in many countries, and the raising of water buffaloes accounts for nearly 12% of the total worldwide milk production. In the production of dairy products, the quality (and hence the composition) of milk is as important as the quantity produced. Milk composition depends not only on the genotype of the animal, but is also affected by various factors such as lactation stage, parity, calving age, and season. The fat, lactose, protein, and dry matter content of water buffalo milk are higher than that of cow milk. Ahmad et al. (2008) reported mean fat, protein, and dry matter content values of 7.0%, 4.35%, and 17.45%, respectively, for water buffalo milk, while Ariota et al. (2007), reported protein and fat content values of 8.71% and 3.86%, respectively. Previous studies determined that the feeding regime Waldner et al. (2002), lactation period Sethi et al. 1994), Sekerden et al. (1999a), and season Sekerden et al. (1999b) also affected the fat, protein, and dry matter content of water buffalo milk during dairy production. Furthermore, Foltys et al. (1995) reported that the protein and fat content of water buffalo milk was lower in summer in comparison to the winter months.

In addition to the production of milk, buffaloes are also commonly used as draft animals in rural areas of developing countries. Buffalo milk and meat products constitute an important source of protein for low-income farmers, and also serve as a significant source of income for rural economies Borghese (2005), Yılmaz et al. (2011). The water buffalo population, as well as water buffalo milk production, has gradually decreased in Turkey over the past two decades

Sahin et al. (2011). The number of Anatolian water buffaloes in Turkey was 366,150 in 1991, and 117,591 in 2013 (TÜİK, 2014). There are two general types of water buffalo, which are the swamp water buffalo and the river water buffalo. The river water buffalo is the type that is more suitable for milk production. Water buffaloes in Turkey are known as Anatolian water buffaloes, which are considered as part of the Mediterranean water buffalo breed; the Mediterranean water buffalo, on the other hand, represents a subgroup of the river water buffalo Soysal et al. (2005). Anatolian water buffaloes are raised in most rural areas of Turkey, especially in the Northern, Central, Western, Eastern and Southeastern regions of the country Atasever and Erdem (2008). Anatolian water buffaloes are mainly raised for their milk, and also slaughtered for their meat after their productive age passes Sekerden (2001). Due to their resistance to diseases and relatively lower feed consumption, the Anatolian water buffalo represents a preferred breed in the different regions of Turkey. However, when considering milk quality, dairy operations in Turkey generally take into consideration the genetic background of the water buffaloes, while overlooking the importance and effects of environmental factors in milk production.

In this context, the aim of this study was to determine the effects of village conditions, parity, calving age, sampling time and lactation stage on the milk composition of Anatolian water buffaloes.

## MATERIALS AND METHODS

### Location of the Experiment

This study was conducted in the Tokat province within the Middle Black Sea Region of Turkey. The Tokat province is located between 35° 27' and 37° 39' East longitudes, and 39° 52' and 40° 55' North latitudes. The province has a transitional climate, with characteristics intermediate between the Black Sea oceanic climate and the Anatolian continental climate. The long-term average yearly temperature ranges between 8.1°C and 14.2°C. Average relative moisture varies between 56% and 73% (MARA, 2015).

### Sample Collection

A total of 120 Anatolian water buffaloes raised at different farms in 12 separate villages of the Turhal, Pazar and Erba counties in the Tokat Province were evaluated between Data collection started in February 2012 as for as May 2014. Sample collection was performed between February 2012 as for as May 2014, and 600 samples were collected. Lactating water buffaloes were allocated to one of the following three lactation stage groups: the day 30±15, 60±15 and 90±15 group, which was considered as the early (assigned a value of 1); the day 120±15, 150±15 and 180±15 group, which was considered as the middle group (assigned a value of 2); and the 210±15, 240±15 and 270±15 day group, which was considered as the late group (assigned a value of 3). The water buffaloes were also divided into groups depending on their number of parity. As such, water buffaloes with the same number of parity were allocated to the same group, while all water buffaloes with more than seven parities were included into the group with seven parity. Raw milk samples (approximately 50 ml) were collected from each udder quarter under aseptic conditions during the morning milking. After milking the raw water buffalo milk into plastic containers composed of 2-bromo-2-nitropropane-1.3-diol (Bronopol), milk samples of 50 mL were prepared by transferring the collected raw milk into clean, aseptic milk bottles. The milk samples were then stored cold inside the sterile bottles.

### Analysis of Milk Composition

The dry matter (%w/w), nonfat dry matter (%w/w), fat (%v/v), protein (%w/w), lactose (%w/w), and casein (%w/w) contents of water buffalo milk samples were determined by using a FOSS Milko Scan$^{TM}$ 120 milk analyzer.

### Statistical Analysis

In this study, lactation stage, parity, village condition and season were evaluated as fixed factors. To determine the environmental effects on milk production, the general linear model (GLM) procedure was used SPSS program (SPSS. IBM Corp Ver. 20.0). Data were analyzed by using a least square analysis of variance in order to identify significant fixed

effects. Duncan's multiple range test (1955) was applied to compare means between subgroups.

The utilized model was as follows:

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

Where:

$Y_{ijklmn}$: Observation value for milk components

$\mu$: Population mean

$a_i$: The effect of village conditions (j: 1,2,….12)

$b_j$: The effect of the parity (k: 1, 2, …….7)

$c_k$: The effect of calving age (I =3, 4,5, …9)

$d_l$: The effect of sampling time (m: 1,2,3)

$f_m$: The effect of the lactation stage (n = 1: early; 2: mid; 3: late)

$e_{ijklmn}$:The random residual effect

## RESULTS AND DISCUSSIONS

Chemical Composition of the Milk Samples

According to the study results, the mean dry matter, nonfat dry matter, fat, protein, lactose, and casein content of raw milk samples from the Anatolian water buffalo were 16.99±0.108%, 10.88±0.036%, 5.98±0.107%, 4.85±0.043%, 5.17±0,021%, and 3.61±0.036%, respectively. Similar results were obtained by Macedo et al. (2001) at São Paulo State (Brazil). A descriptive analysis of the variables evaluated within the content of the current study is provided in Table 1.

Table 1 Descriptive analysis of the variables studied

| Parameters | N | Mean | Se | Minimum | Maximum |
|---|---|---|---|---|---|
| Dry matter (%w/w) | 600 | 16.99 | 0.108 | 10.74 | 27.2 |
| Non fat dry matter (%w/w) | 600 | 10.88 | 0.036 | 8.868 | 19.446 |
| Fat (%v/v) | 600 | 5.98 | 0.107 | 1.01 | 16.829 |
| Protein (%w/w) | 600 | 4.85 | 0.043 | 2.146 | 15.643 |
| Lactose (%w/w) | 600 | 5.17 | 0.021 | 2.105 | 6.25 |
| Casein (%w/w) | 600 | 3.61 | 0.036 | 0.83 | 10.936 |

Se: standart error

The results obtained from the preliminary analysis of the mean dry matter, nonfat dry matter, protein, fat and lactose content values for fixed factors are shown in Figure 1, Figure 2, Figure 3, Figure 4, and Figure 5. Based on these analyses, it was determined that sampling time, parity, village conditions, lactation stage and calving age had a significant effect on the dry matter, nonfat dry matter, fat, protein, lactose, and casein content of raw milk from the Anatolian water buffalo ($p<0.05$). In the current study, the lactose content of the milk samples (5.17±0,021%) was found to be higher than some of the values reported in previous studies Lopes (2009), Lingathurai et al. (2009), Han et al. (2012), Gürler et al. (2013). There were also earlier studies that determined lactose content values similar to the ones in the current study Macedo et al. (2001), Mahmood and Sumaira (2010), Damé et al. (2010). On the other hand, fat content was identified as the characteristic that demonstrated the highest variability in our sample, with many different factors appearing to affect the fat content of Anatolian water buffalo milk.

The mean dry matter (16.99±0.108 %w/w), fat (5.98±0.107 %v/v), protein (4.85±0.043 %w/w), and lactose (5.17±0.021 %w/w) content of this milk samples were higher than the content values reported by Enb et al. (2009), and lower than the content values reported by Sekerden and Avsar (2008). Furthermore, the fat and dry matter content of this samples were lower than the content values reported by Han et al. (2007), while fat content this samples was lower than the values reported by Gürler et al. (2013). The mean dry matter content of this samples was lower than the results reported by certain authors Kök (1996), Macedo et al. (2001), Coelho et al. (2004), Mahmood and Sumaira (2010), yet higher than the results reported by Damé et al. (2010) and Gürler et al. (2013). Moreover, the protein content values of this samples were similar to the content values reported in previous studies on intensive water buffalo farming " Rosati and Van Vleck (2002), Zicarelli (2004), Cecchinato et al. (2012), and also similar to the statistics published by the National Water Buffalo Breeders Association ANASB (2010).

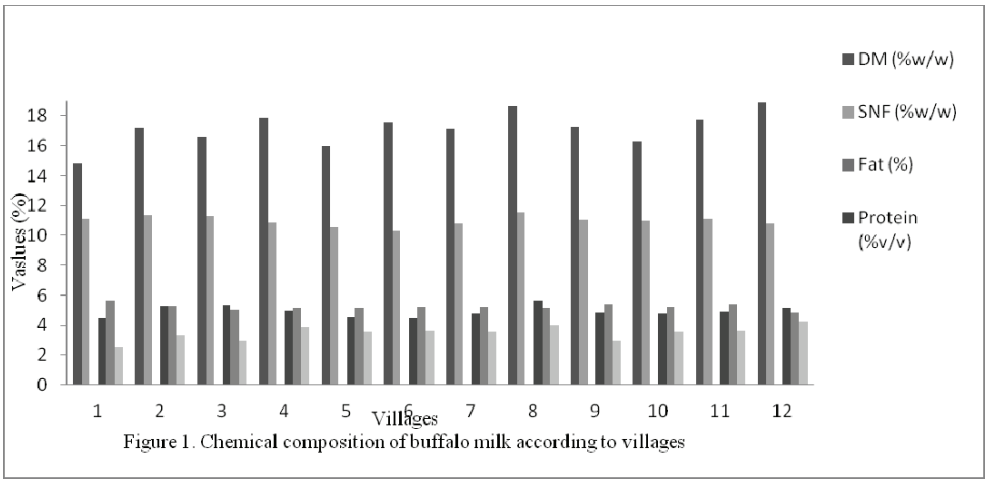

Figure 1. Chemical composition of buffalo milk according to villages

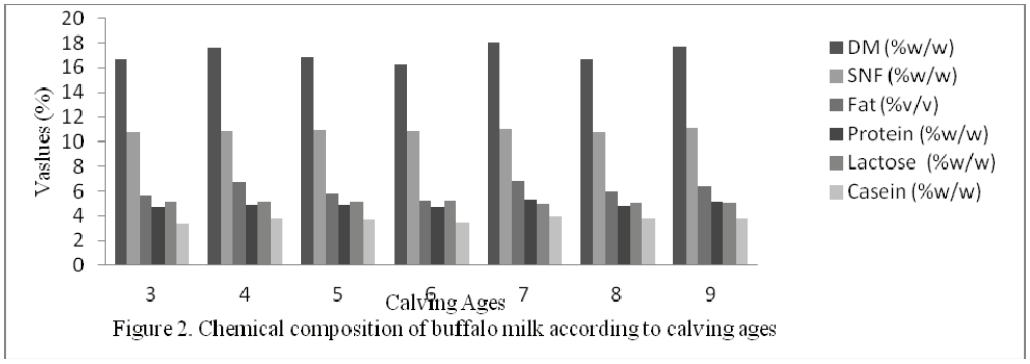

Figure 2. Chemical composition of buffalo milk according to calving ages

This research samples' protein content was also higher than the content values identified by certain researchers Lingathurai et al. (2009), Damé et al. (2010), Gürler et al. (2013). The fat content values identified in the milk samples from this study were lower than the values reported in previous studies Kök (1996), Macedo et al. (2001), Rosati and Van Vleck (2002), Zicarelli (2004), Coelho et al. (2004), Lingathurai et al. (2009), Lopes (2009), Mahmood & Sumaira (2010), Cecchinato et al. (2012). An exception to this was Tiezzi et al. (2009) study, which identified fat content values similar to our own in two herds in Northeastern Italy. Yet, the fat content value reported by Tiezzi et al. (2009) was higher than the value reported by Damé et al. (2010) for Murrah and Mediterranean water buffaloes. The casein content of this samples was very similar to the content values (3.86%w/w) reported by Ariota et al. (2007) and Cecchinato et al. (2012).

Environmental effects

The ratio of milk components (fat, protein, lactose, and total solids) can vary according to nutrition, the season of the year, and other factors such as the age, breed, and lactation stage of the animal Amaral et al. (2005), Damé et al. (2010). In this study, the effect of lactation stage on water buffalo milk fat content was identified as significant ($p>0.05$). Sekerden and Avsar (2008) had similarly reported that lactation stage significantly affected the fat content of water buffalo milk ($p<0.05$), while the effect of the village conditions on the protein content was not significant ($p>0.05$). Patel et al. (1991) and Sethi et al. (1994) had similarly determined that the mean fat content of water buffalo milk was significantly affected by the lactation stage.

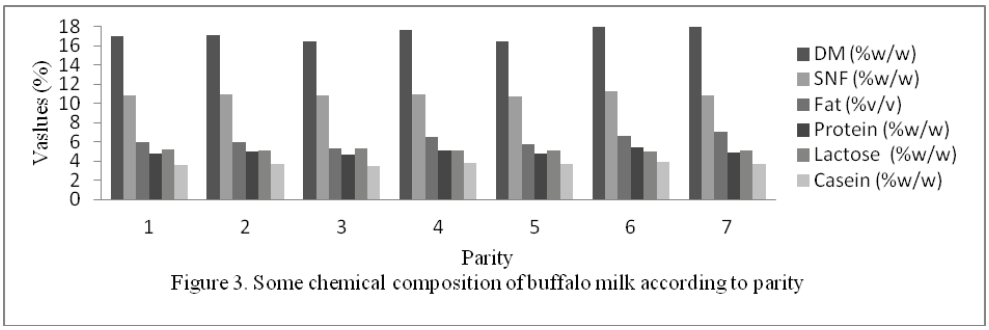

Figure 3. Some chemical composition of buffalo milk according to parity

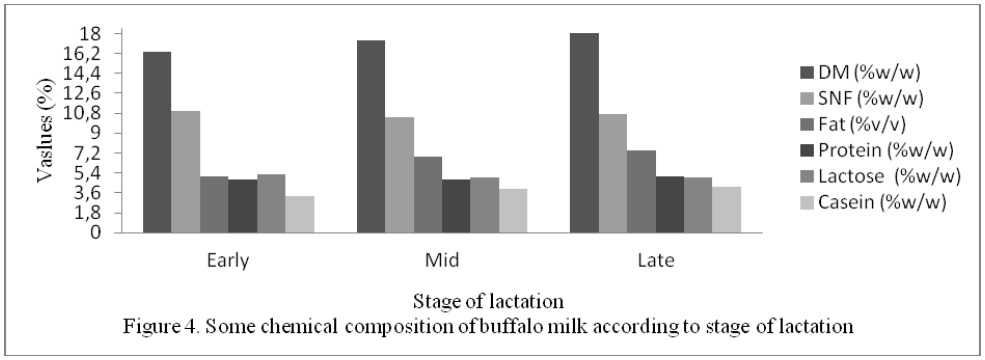

Figure 4. Some chemical composition of buffalo milk according to stage of lactation

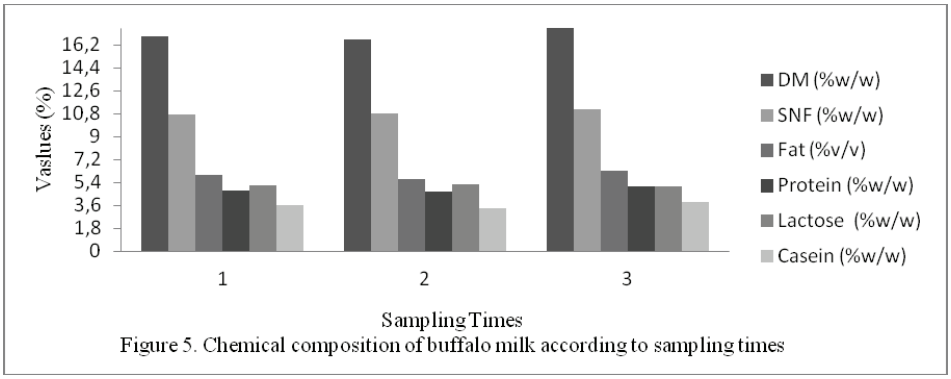

Figure 5. Chemical composition of buffalo milk according to sampling times

In this context, a considerable variation was observed in the fat, dry matter, and casein content of this milk samples depending on the lactation stage of the animal. This observation was in parallel with the findings from the studies of Patel et al. (1991), Darshan et al. (1991), and Sethi et al. (1994). Previous studies have also determined that nutrition Waldner et al. (2002) and lactation stage Sethi et al. (1994), Sekerden et al. (1999a) can considerably affect the fat, protein, and dry matter content of water buffalo milk.

The effect of sampling time on the fat content of this milk samples was identified as significant. On the other hand, another study conducted with Anatolian water buffaloes demonstrated that the effect of sampling time on fat content was not significant ($p>0.05$) Sekerden and Avsar (2008). The effect of sampling time of the protein content of this milk samples was identified as significant. In a similar study conducted in Turkey, Sekerden

and Avsar (2008) also reported that the effect of sampling time on the protein content of water buffalo milk was significant ($p<0.05$). In the current study, we observed that the lactation stage had a significant effect on both the dry matter and nonfat dry matter of the milk samples ($p>0.05$). This observation was in parallel with the results of previous studies Sekerden et al. 1999, Sekerden and Avsar (2008). Furthermore, Sethi et al. (1994) also described that the mean dry matter and nonfat dry matter content of water buffalo milk were both significantly affected by the stage of lactation. The protein and fat content of these samples were significantly affected by the lactation stage. Sekerden and Avsar (2008) have also determined that the lactation stage had a significant effect on the protein and fat content ($p<0.05$). Lactation stage had a significant effect on the casein content of this samples ($p<0.05$). Similar results pertaining to the lactation stage were obtained in the study of Sekerden et al. (1999), which also determined that the lactation stage had a significant effect on the dry matter and fat content. This observation was consistent with the result of this study, and also the results of the study of Sethi et al. (1994). Darshan et al. (1991) have reported that the effect of lactation stage on the dry matter content was insignificant ($p>0.05$). According to previous studies, the fat content of water buffalo milk was affected by both the number of lactation Patel et al. (1991), Sethi et al. (1994), Sekerden et al. (1999), and the lactation stage Sekerden et al. (1999).

## CONCLUSIONS

The chemical composition of water buffalo milk is rich in nutrients; it thus offers considerable opportunities for the expansion of local dairy production, and also for meeting the increasing demand for milk. The composition that was indentified within the context of this study for raw milk from the Anatolian water buffalo was in agreement with the results of previous studies. The chemical composition of these milk samples also met the requirements of the Turkish Food Codex. In the current study, it was also determined that the dry matter, nonfat dry matter, fat, protein, lactose, and casein content of raw milk from the Anatolian water buffalo were affected by environmental factors.

The quality and composition of milk are of great importance for the dairy industry, since the composition of milk is also directly associated with the milk yield. The most significant finding of this study was the observation that different village conditions resulted in different dry matter, nonfat dry matter, fat, protein, lactose, and casein content values. Additional studies need to be conducted in Turkey to further elucidate the effects of environmental factors on the composition water buffalo raw milk.

## ACKNOWLEDGEMENTS

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## REFERENCES

Ahmad S., Gaucher I., Rousseau F., Beaucher B., Piot M., Grongnet J.F., Gaucheron F., 2008. Effects of acidification on physico-chemical characteristics of water buffalo milk: A comparison with cow's milk. Food Chem. 106: 11-17.

Amaral F.R., Carvalho L.B., Silva N., Brito J.R.F., 2005 Qualidade do leite de búfalas: composição. Rev. Bras. Reprod. Anim. 29, 2: 106-110.

ANASB (National Breeders Association of Water buffalo Species). 2010. National production statistics. Accessed May 15, 2011. http://www. anasb.it/home.htm.

Ariota B., Campanile G., Potena A., Napolano R., Gasparrini B., Neglia G.L., Di Palo R., 2007. Ca and P in water buffalo milk: Curd yield and milk clotting parameters. Italian J. Anim. Sci. 6 (Suppl. 1), 497-499.

Atasever S., Erdem H., 2008. Water buffalo breeding and the future of Turkey.Ondokuz Mayıs Uni. J. Agri. Sci. 23:1, 59-64.

Borghese A., 2005. Water buffalo production and research. REU technical series 67, FAO regional office for Europe Inter-Regional Cooperative

Research Network On Water buffalo (Escorena), Rome.
Coelho K.O., Machado P.F., Coldebella A., Cassoli L.D., Corassin C.H., 2004. Determinação do perfil físico-químico de amostras de leite de búfalas, por meio de analisadores automáticos. Ciênc. Anim. Bras. 5, 3: 167-170.
Cecchinato A., Penasa M., Cipolat Gotet C., De Marchi M., Bittante G., 2012. Factors affecting coagulation properties of Mediterranean water buffalo milk. J. Dairy Sci. 95, 1709-1713.
Damé M.C.F., Lima C.T.S., Marcondes C.R., Ribeiro M.E.R., Garnero A.D.V., 2010. Preliminary study on water buffalo (*Bubalus bubalis*) milk production in Southern Brazil, Milk Production, (Buenos Aires, Abril 2010) Proceedings 9 th World Water buffalo Congress, 582-584.
Darshan Lal K.M., Narayanan Lal D., 1991. Effect of lactation number of the animal on milk total solids. Indian J. Anim. Sci. 61: 3, 311-315.
Enb A., Abou Donia M.A., Abd-Rabou N.S., Abou-Arab A.A.K., El-Senaity M.H., 2009. Chemical Composition of Raw Milk and Heavy Metals Behavior During Processing of Milk Products. Global Veterinaria, 3, 3, 268-275.
Foltys V., Pazmova J., Chobotova E., Zatopkova V., 1995. Influence of season on composition of bulk milk in relation to its technological processing. EAAP 46th Meeting European Association for Animal Production, Prague. p. 210.
Gürler Z., Kuyucuoğlu Y., Pamuk Ş., 2013. Chemical and microbiological quality of Anatolian Buffalo milk, African Journal of Microbiology Research, 7( 16), 1512-1517.
Han B.Z., Yun M., Li M., Yang Y.X., Ren F.Z., Zeng Q.K., Nout M.J.R., 2007 A survey on the microbiological and chemical composition of water buffalo milk in China. Food Control, 18: 742-746.
Han X., Lee L.F., Zhang L., Guo M.R., 2012. Chemical composition of water buffalo milk and its low-fat symbiotic yogurt development, Functional Foods in Health and Disease, 2, 4:86-106.
Kök S., 1996. Research on some morphological and genetical characteristics of water water buffalo population in various region of maramara and Karadeniz. Msc Thesis, Tekirdağ University, Department of Animal Sciences.
Lingathurai S., Vellathurai P., Vendan S.E., Anand A.A.P., 2009. A comparative study on the microbiological and chemical composition of cow milk from different locations in Madurai, Tamil Nadu, Indian J Sci. Tech. 2, 2: 51-54.
Lopes F.A., 2009. Caracterização da produtividade e da qualidade do leite de búfalas na Zona da Mata Sul de Pernambuco. Tesis Doctoral (MSci), Universidade Federal Rural de Pernambuco, Pernambuco, Brasil, 4p.8.
Macedo M.P., Wechsler F.S., Ramos A.A., Amaral J.B., Souza J.C., Resende F.D., Oliveira J.V., 2001. Composição físico-química e produção de leite de búfalas da raça Mediterrâneo no Oeste do estado de São Paulo. Revista. Brasileira de Zootecnia, 30, 3: 1084 1088.
Mahmood A., Sumaira U., 2010. A Comparative Study on the Physicochemical Parameters of Milk Samples Collected from Water buffalo, Cow, Goat and Sheep of Gujrat, Pakistan, Pakistan J. Nutr. 9, 12: 1192-1197.
MARA., 2011. The Master Plan of Tokat Province, Tokat. MARA (2011). Statistical Data of Tokat Province, Tokat.
Patel K.S., Majmudar S.V., Patel H.B., Saıyed L.H., 1991. Lactation curve for milk fat content in Surti buffaloes. Gujarat Agricultural Univ. Research J. 16(2), 82-83.
Rosati A., Van Vleck L.D., 2002. Estimation of genetic parameters for milk, fat, protein and Mozzarella cheese production for the Italian river water buffalo Bubalus bubalis population. Livest. Prod. Sci. 74: 185-190.
Sahin A., Ulutaş Z., Yıldırım A., 2011. Water Water buffalo Husbandry in Turkey and the World, VII. National Animal Science Congress, 14-16 September, Çukurova University Adana, Turkey.
Sethi R.K., Khatkar M.S., Kala S.N., Tripathi V.N., 1994. Effect of pregnancy on milk constituentsd uring later stages of lactations in Murrah Water buffaloes. Proceedings 4th World World Water buffalo Congress. San Paolo, Brazil 2: 27-30.
Sharif A., Muhammad G.. 2009. Mastitis control in dairy animals. Pakistan Vet. J. 29, 3: 145-148.
Soysal İ., Özkan E., Kök S., Tuna Y.T., Gürcan E.K., 2005. Genetic characterization of indigenous anatolian water water buffalo breed using microsatellite DNA markers. Journal of Tekirdağ Agriculture Faculty 2, 3: 240-244.
Sekerden Ö., Erdem H., Kankurdan B., Özlü B., 1999. Factors Affecting Milk Composition and Changes in Milk Composition with Lactation Stage in Anatolian Water buffaloes. Turk.J.Vet.Anim.Sci., 23, 505-509.
Sekerden Ö., Küçükkebapçı M., 1999. Afyon Kocatepe Tarımsal Araştırma Enstitüsü Anadolu Mandalarında Süt Verim Ve Bileşiminin Laktasyon Dönemlerine Göre Değişimi, Süt Ve Bazi Döl Verim Özellikleri. Atatürk Üniv. Zir. Fak. Derg. 30 (2), 151-159.
Sekerden Ö., Tapkı İ., Kaya Ş., 1999b. Anadolu mandalarında Hatay ili köy şartlarında verim mevsimive laktasyon dönemi ile süt verimi ve kompozisyonundaki değişiklikler. Atatürk Universitesi Ziraat Fakültesi Dergisi 30:161-168 (in Turkish).
Sekerden Ö., 2001. Büyükbaş Hayvan Yetiştirme (Manda Yetiştiriciliği). Temizyürek Ofset Matbaacılık 296 s 1-12. Hatay (in Turkish).
SPSS. IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.
Tiezzi F., Cecchinato A., De Marchi M., Gallo L., Bittante G., 2009. Characterization of water buffalo production of northeast of Italy. Italian J. Anim. Sci. 8 (Suppl. 3): 160-162.
TUIK. 2014. Livestock Statistics Statistical Institute Turkstat Turkey. Available from: http//www. Tuik.gov.tr preHaberBultenleri. Doid=1979

Preistatistik.Tablo.doistab_id=1 40, 141 and 487 Accessed (12.09.2014).

Yılmaz A., Ekiz B., Soysal M.İ., Yılmaz İ., Yalçıntaş H., 2011. Certain carcass and meat quality characteristics of Anatolian water waterbuffalos. 8th Global Conference on the Conservation of Animal Genetic Resources, Tekirdağ. Department of Animal Science, Faculty of Agriculture Namık Kemal University.

Waldner D.N., Stokes S.R., Jordan E.R., Looper M.L., 2002.Managing milk composition: Normal sources of variation. http://www.osuextra.okstate.edu/pdfs/F4016web.pdf. Accessed (05.06.2012).

Zicarelli L., 2004. Water buffalo milk: Its properties, dairy yield and Mozzarella production. Veterinary research communications. 28: 127-135.