Effect of environmental temperature and humidity on milk production and milk composition of Guanzhong dairy goats

Xiaoyan Zhu\textsuperscript{a}, Jing Wen\textsuperscript{a}, Jianguo Wang\textsuperscript{a,}\textsuperscript{*}

\textsuperscript{a} College of Veterinary Medicine, Northwest A & F University, Yangling, Shaanxi 712100, PR China
\textsuperscript{b} College of Animal Science and Technology, Northwest A & F University, Yangling, Shaanxi 712100, PR China

ARTICLE INFO

Keywords:
Temperature
Humidity
Milk yield
Milk composition
Guanzhong dairy goats

ABSTRACT

The present study was undertaken with the aim to examine the relationship between temperature and humidity and milk production traits in Guanzhong dairy goats reared in China, and to assess the possibility of future genetic selection in dairy goats for increased tolerance to adverse environmental conditions, thereby improving goat farm management in China. Production data included 149 Guanzhong dairy goats with the first-lactation collected throughout 2019. The traits investigated were milk yield, and indicators of milk composition of Guanzhong dairy goats. For high temperature, significant and marked daily milk yield drops, up to 16% (about 0.23 kg/d per head) were observed in July and August when compared with the other months. The fat content, protein content, and dry matter were significantly lower in July and August. Importantly, milk production traits present significant correlations with high temperature, while high humidity had little effect on milk composition of Guanzhong dairy goats. Therefore, the adverse environmental conditions on farm profit is not negligible, and the strategies could be improving the goat farm management as well as obtaining thermotolerant animals through genetic selection.
Previous study reported that, in dairy cows, high temperatures caused changes in milk composition (Peana et al., 2007). Since milk quality and production is a real challenge for the goat farmer as it is for the cow farmer, a successful strategy for improving goat farm management in Shaanxi Province will have to take into account environmental conditions such as high temperature and high humidity. Therefore, the aim of the present study is to evaluate the effect of environmental temperature and humidity on milk production and milk composition of Guanzhong dairy goats in a commercial dairy farm in Shaanxi Province, China.

A total of the 149 first-lactation Guanzhong dairy goats housed in a...
commercial dairy farm in Shaanxi Province, China were used for data collection between January and December 2019. Daily records of milk, fat, protein yields and other indicators of milk composition of the Guanzhong dairy goats were provided. The experimental procedures of this study were in accordance with the Chinese law on animal protection and were conducted with the approval of the Institutional Animal Care and Use Committee of Northwest A&F University, Yangling, Shaanxi, People's Republic of China. Goats were fed TMR (total mixed ration) three times daily at 7:30 am, 2:30 pm, and 9:30 pm. The TMR primarily contained corn silage, soybean meal, wheat bran and alfalfa hay balanced to meet or exceed nutrient requirements for lactating dairy goats, based on the NRC (National Research Council) standards (NRC, 2001) and previous study (Zhao et al., 2015). Milk samples were analyzed for fat, protein, dry matter, and non-fat milk solid by an automatic milk composition analyzer (DELTA LactoScope FTIR, Holland).

The daily milk yield presented certain regularity during the year of 2019. The highest mean temperature of August was 27.4°C and chosen as control. The daily milk yield rose rapidly from the month of January to May, and decreased from the month of June. The lowest daily milk yield was observed in July and August, and kept steady at the lowest value. From September, the daily milk yield began to increase gradually until to the month of December, and the levels reached to the same like the month of January. Moreover, significant and marked daily milk yield drops, up to 16% (about 0.23 kg/d per head), were observed in July (26.6°C) and August (27.4°C) when compared with the other months (Fig. 1A). For milk composition, we found that except July, the fat content, protein content and dry matter were significantly higher in the other months when compared to that of August (Fig. 1B-D). In addition, except the month of January, July, September and October, the non-fat milk solid was significantly higher in the other months when compared to the August (Fig. 1E). These results pointed to the existence of high temperature influencing daily milk yield and milk composition of Guanzhong dairy goats.

In fact, the analysis of correlation demonstrated that temperature and humidity, and daily milk yield were highly and inversely associated (Fig. 2A, F). Highly significant negative correlations were also observed between temperature and the related indicators of milk composition (Fig. 2B-E). When the temperature increases to almost 30.0°C, the daily milk felt to the lowest yield about 1.2 kg (Fig. 2A), and the fat content, protein content, dry matter and non-fat milk solid were also decreased to the lowest levels, approximately 3.0, 3.2, 11.2, and 8.2 (Fig. 2B-E), respectively. Thus, the high temperature is an important factor on the milk composition of Guanzhong dairy goats. However, no significant correlations were observed between humidity and related indicators of milk composition (Fig. 3G-J), pointing that humidity had little effects on milk composition of Guanzhong dairy goats.

It is accepted that reduction in milk production and milk composition is thought to be the most and well-known negative responses to extreme temperature (Armstrong, 1994; Herbut et al., 2018; Ravagnolo & Misztal, 2000; Silanikove et al., 2009). In the present study, environmental conditions, particularly the changes of temperature caused a decrease in milk production, fat content, protein content, dry matter and non-fat solid in milk. Under extreme temperature, the decreased feed intake and the disorder of the endocrine functions of animals could indirectly affect the lactation performance, further leading to a decline in milk production (Sanchez et al., 1994). Importantly, these changes were observed in the month of July and August in 2019. Our study was consistent with a previous report that found a sharp decline in milk production from June to August (Bohmaova et al., 2007). This could explain the decrease and changes of milk production and milk composition in Guanzhong dairy goats. Adverse environmental conditions may induce the different levels to the body sensation of milk goats, leading to the influence on the metabolism of the goats, which is further reflected in the decline of milk yield and the changes of milk composition. Therefore, the effort to reduce the influence of adverse environmental conditions on dairy goats is urgently needed.

A great of evidence reported a relationship between temperature and humidity, and milk yield losses, widely studied in dairy cows (Hammami et al., 2013; Ravagnolo & Misztal, 2000), but little in dairy sheep (Finocchiaro et al., 2005; Peana et al., 2007). In the present study, we found positive correlations between humidity and daily milk yield, while no significant correlations between humidity and related indicators of milk composition. These results indicated that milk composition is more susceptible to temperature than humidity. Prolonged exposure to air temperatures over the critical physiological level could bring an increased threat of heat stress in livestock (Herbut et al., 2018). Furthermore, although temperature and humidity have been widely used as indicators of heat stress in livestock, it should be noted that the extent to which milk composition is affected also depends on strains.

Taken together, the present study aimed to address the effect of adverse environmental conditions on milk production and composition traits of dairy goats reared in the Shaanxi province of China. This region is characterized by the presence of high temperature in July and August. This study of relationships between milk production traits and temperature variables allowed us identify a comfort zone, in which animals could express their highest milk production and quality. Therefore, the effect of adverse climate conditions on farm profit is not negligible, and economically affordable goat management measures for reducing these losses should be considered.

Ethical statement
A total of the 149 first-lactation Guanzhong dairy goats housed in a commercial dairy farm in Shaanxi Province, China were used for data collection between January and December 2019. All the animals in this research had veterinary care by the National Health Veterinary Service in accordance with the Animal Welfare Act. The experimental procedures of this study were in accordance with the Chinese law on animal protection and were conducted with the approval of the Institutional Animal Care and Use Committee of Northwest A&F University, Yangling, Shaanxi, People’s Republic of China.

Declaration of Competing Interest
The authors declare no competing financial interest.

Acknowledgments
This work was financially supported by the China Postdoctoral Science Foundation funded project (No. 2019T120957 to X. Z.), the Key Research and Development Project of Shaan’xi Province (No. 2019NY-075 to J. W. and 2019ZDXM3-02 to X. Z.), and the National Key Research and Development Program of China (2018YFD0127000 to X. Z.).
References

Armstrong, D. V. (1994). Heat stress interaction with shade and cooling. *Journal of dairy science*, 77, 2044–2050.

Bohmanova, J., Misztal, I., & Cole, J. B. (2007). Temperature-humidity indices as indicators of milk production losses due to heat stress. *Journal of Dairy Science*, 90, 1947–1956.

Carabano, M. J., Ramon, M., Diaz, C., Molina, A., Perez-Guzman, M. D., & Serradilla, J. M. (2017). Breeding and genetics symposium: Breeding for resilience to heat stress effects in dairy ruminants. *A Comprehensive Review. Journal of Animal Science*, 95, 1813-1826.

Finocchiaro, R., van Kaam, J. B., Portolano, B., & Misztal, I. (2005). Effect of heat stress on production of Mediterranean dairy sheep. *Journal of Dairy Science*, 88, 1855–1864.

Hammami, H., Bornmann, J., MHamdi, N., Montaldo, H. H., & Greglier, N. (2013). Evaluation of heat stress effects on production traits and somatic cell score of Holsteins in a temperate environment. *Journal of Dairy Science*, 96, 1844-1855.

Herbut, P., Angrecka, S., & Walczak, J. (2018). Environmental parameters to assessing of heat stress in dairy cattle—a review. *International Journal of Biometeorology*, 62, 2089–2097.

National Research Council. (2001). *Nutrient requirements of dairy cattle* (7th rev ed). Washington, D.C.: National Academies Press.

Peana, G. Fois, & Cannas, A. (2007). Effects of heat stress and diet on milk production and feed and energy intake of Sarda ewes. *Italian Journal of Animal Science*, 6(sup1), 577–579.

Ramon, M., Diaz, C., Perez-Guzman, M. D., & Carabano, M. J. (2016). Effect of exposure to adverse climatic conditions on production in Manchega dairy sheep. *Journal of Dairy Science*, 99, 5764–5779.

Ravagnolo, O., & Misztal, I. (2000). Genetic component of heat stress in dairy cattle, parameter estimation. *Journal of Dairy Science*. 83, 2126–2130.

Romo-Barron, C. B., Diaz, D., Portillo-Lorez, J. J., Romo-Rubio, J. A., Jimenez-Trejo, F., & Montero-Pardo, A. (2019). Impact of heat stress on the reproductive performance and physiology of ewes: a systematic review and meta-analyses. *International Journal of Biometeorology*, 63, 949–962.

Sanchez, W. X., McGuire, M. A., & Beede, D. K. (1994). Macromineral nutrition by heat stress interactions in dairy cattle: review and original research. *Journal of Dairy Science*, 77, 2051–2079.

Silanikove, N., Shapiro, F., & Shinder, D. (2009). Acute heat stress brings down milk secretion in dairy cows by up-regulating the activity of the milk-borne negative feedback regulatory system. *BMC Physiology*, 9, 13.

Zhao, X. J., Li, Z. P., Wang, J. H., Xing, X. M., Wang, Z. Y., Wang, L., & Wang, Z. H. (2015). Effects of chelated Zn/Co/Mn on redox status, immune responses and hoof health in lactating Holstein cows. *Journal of Veterinary Science*, 16, 439–446.