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Epigenetic effects of climate on dairy parameters of Prim'Holstein breed in west coast Algeria

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Abstract

This research aimed to evaluate the effect of the epigenetic climatic factor of heat stress expressed by the THI on some parameters of milk production of Prim'Holsteins cows kept in the climate of the Algerian West coast. The THI was used as an indicator of the heat stress threshold. A sample of 75 lactating cows was divided into three groups according to THI level. The cows of group 1, with severe stress (THI>78), those of group 2, with light stress (THI 72-78), and those of group 3 in thermal comfort (THI<72). The daily milk production (DMY), the Physico-chemical quality (TB, TP, and EST), and the hygienic quality (total flora FMAT) of raw milk showed a decrease with the increase of the THI threshold. A significant effect ($p<0.05$) of heat stress is recorded on the Physico-chemical and microbiological parameters of milk. The FMAT count values of raw milk samples were highest for groups 1 and 2, while a low bacterial load was recorded for group 3 (THI<72). Heat stress had a negative impact on the performance of Prim'Holsteins cows. These preliminary results show the severity of the negative impact of heat stress in the littoral region on the production and the physicochemical and hygienic quality of milk and will serve as a useful guide for farmers to adopt actions to mitigate the impact within the barns for the sustainability of livestock.

Keywords: epigenetic, milk, composition, coastal, Algeria.

الملخص:

الخلاصة: يهدف هذا البحث إلى تقييم تأثير العامل المناخي اللاجيني للإجهاد الحراري المعبر عنه بواسطة THI على بعض معايير إنتاج لبن أبقار Prim'Holsteins في مناخ الساحل الغربي الجزائري. تم استخدام THI كمؤشر لعتبة الإجهاد الحراري. تم تقسيم عينة مكونة من 75 بقرة إلى ثلاث مجموعات حسب مستوى THI. أبقار المجموعة 1 تحت ضغط شديد (THI> 78) ، وأبقار المجموعة 2 ذات الإجهاد الخفيف (THI 72-78) وأبقار المجموعة 3 في حالة الراحة الحرارية (THI <72). أظهر إنتاج الحليب اليومي (DMY) والجودة الفيزيائية والكيميائية (TB و TP و EST) والجودة الصحية (مجموع فلورا FMAT) للحليب الخام انخفاضًا مع زيادة عتبة THI. تم تسجيل تأثير معنوي (P <0.05) للإجهاد الحراري على المعايير الفيزيائية والكيميائية والميكروبيولوجية للحليب. كانت أعلى قيم تعداد FMAT لعينات الحليب الخام للمجموعتين 1 و 2 ، بينما تم تسجيل مستوى بكتيري منخفض للمجموعة 3 (THI <72). كان للإجهاد الحراري تأثير سلبي على أداء أبقار Prim'Holsteins. تظهر هذه النتائج الأولية شدة التأثير السلبي للإجهاد الحراري في المنطقة الساحلية على الإنتاج والجودة الفيزيائية والكيميائية والصحية للحليب وستكون بمثابة دليل مفيد للمزارعين لاعتماد إجراءات لتخفيف التأثير داخل الحظائر ، من أجل استدامة الثروة الحيوانية.

الكلمات المفتاحية: الوراثة اللاجينية ، الحليب ، التركيب ، الساحل ، الجزائر.

Introduction

Genetics can only explain part of the phenotypic variability of traits of interest to the breeder; epigenetic modifications also contribute to this variability (Beaujean and al., 2020). Epigenetic marks are involved in the expression of genetic potential (phenotype). It is heritable, modifiable according to the environment, and reversible with consequences. Hence they are of primary

importance in breeding. In the current context of global warming, one of the main issues for the livestock industry is the adaptation of animals to heat waves, and cattle are particularly sensitive to heat stress, which negatively affects their well-being and performance. In Algeria, the milk production and reproductive performance of imported breeds (Holstein Pie-Noire and Pie-Rouge) remain lower than their production potential in their countries of origin (Kaouche-Adjlane et al., 2015; Yerou et al., 2019; Zoghlami et al., 2022). The consumption of milk occupies an important place in Algerians' daily diet. That is partly because of its low price, which is supported by the state, and it is consumed to fill the lack of protein that originates from animals (Makhlouf et al., 2015; Yerou et al., 2019). The production of raw cow's milk in Algeria remains insufficient compared to its demand, which is estimated at almost 6 billion liters for a population of about 40 million inhabitants (ONIL, 2019; Abdelli et al., 2021). Consequently, more than 40% of the country's needs come from abroad in the form of milk powder; nearly 1.06 billion $ (MADR 2020). Algeria is exposed to climate change, which has a significant impact on forage production and the technical and economic performance of dairy farms (Yerou et al., 2021; Zoghlami et al., 2022). The increase in temperature during the 20th century has been between 1.5 and 2°C in Algeria, which is more than the global average temperature increase, which is about 0.74°C. There is also a decrease in precipitation in the order of 10 to 20% (Meddi et al., 2009; IPCC 2014; Yerou et al., 2021). The western Algerian coastline is particularly exposed to climate change, which has affected the northwestern part of Algeria (Yerou et al., 2021; Zoghlami et al., 2022). This situation will lead to an increase in thermal stress in dairy cows and could influence all biological and physiological processes, with a negative impact on the quantitative and qualitative performances of milk and reproduction. The inter-annual fluctuation of climatic conditions in these regions is pronounced with climate change resulting in decreased precipitation, increased temperatures, and more common droughts. Like other regions of western Algeria, the coastline represents a dairy basin that supplies urban areas with raw milk. The present study aims to investigate the impact of heat stress expressed by the temperature-humidity index (THI) on the quantitative and qualitative indicators of raw milk from cows conducted in a climate on the Algerian coast.

Materials and Methods

Presentation of the study region

The region is located in the Algerian North West, between the geographical coordinates 0°8' West 36°29' North and 0°46' East 35°37' North. It covers an area of 2269 Km², with a sea front of about 120 km. The climate is typically Mediterranean with two alternating seasons, one wet and cools in winter and a dry and hot in summer (Figure 1). According to meteorological station of region, the average annual temperature is 18.2°C, the average diurnal amplitude of 7.0°C, the average minimum of January 9.0°C, the average maximum of August 28.4°C. Annual precipitation is 377 mm, of which 14 mm is summer precipitation (June-August) and 135 mm is winter precipitation (December and February).

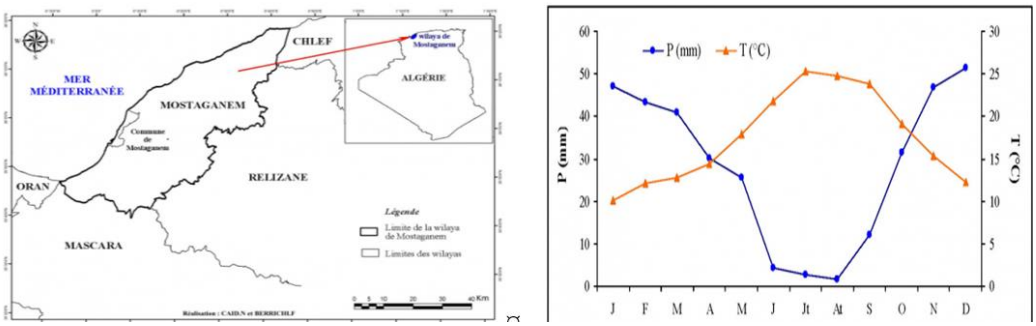

Figure 1: Geographical and climatic parameters of coast in West Algeria.

This region is one of the largest dairy basins in the country; it is ranked tenth nationally with a production of raw milk of 77.6 million liters with a herd of 21.000 heads of dairy cows (DSA 2021). The milk sector has 20.000 professionals working in the fields of breeding, production, collection, processing, and distribution of milk. Dairy farming is well developed in the Algerian coastal region. The feeding practice in western Algeria is based on 65% coarse feeds with strong use of commercial concentrates as supplementation ration (Yerou and al., 2019).

Protocol of the experiment

The research was conducted on 75 dairy cows of the prim'Holstein breed in lactation, conducted in an off-farm system on the Algerian western coast. The evolution of climatic parameters (temperature Tmoy, Tmax, Tmin, and relative humidity RH) is represented in Figure 2.

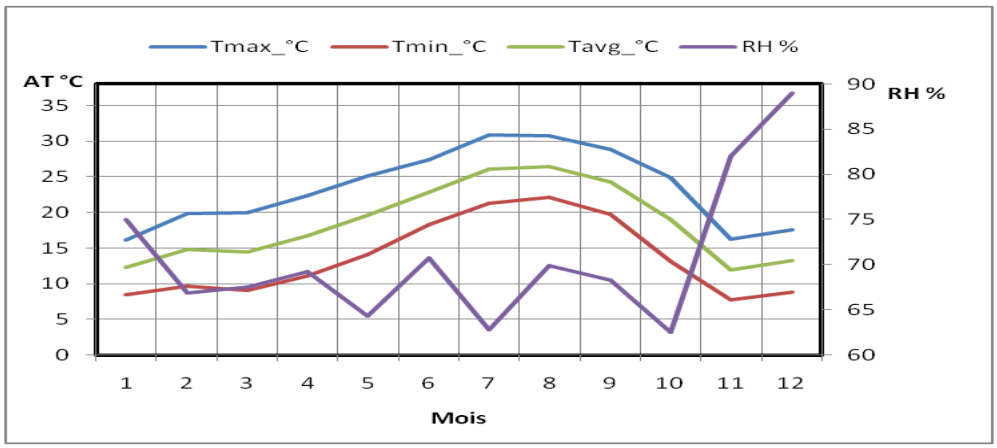

Figure 2: Evolution of climatic parameters in the Algerian coastal region

The research was conducted during the year 2021 by choosing the classification of thermal stress adopted by Kadzere et al (2002). The temperature and humidity index (THI) was calculated using the formula proposed by Vitali et al (2009): THI = (1.8×T+32) - (0.55-0.0055×RH) × (1.8×T-26), with RH: relative humidity in % and T: temperature in degree Celsius °C. Three groups of 25 lactating cows per barn were determined according to the heat stress threshold; (THI): group 1 exposed to severe stress (THI>78), group 2 with mild stress (THI 72-78), and group 3 in thermal comfort (THI<72). Cows had free access to water and received a ration composed of roughage and commercial concentrate according to the recommendations for dairy cows. The three groups were balanced for parity (4.3±0.4 years) and days in milk (56±3 days). Mechanical milking of the monitored cows was performed twice a day at 6:00 am and at 6:00 pm.

The parameters monitored were the daily milk production (DMP), the physicochemical composition of the raw milk expressed in (g/kg) (butyrate TB and protein TP content), and total aerobic mesophilic flora expressed in Log FMAT. The physicochemical parameters were measured automatically with a Lactoscan SP (milk analyzer). The FMAT, which represents a good indicator of contamination, was counted on PCA agar incubated for 24h at 30°C and the result was expressed in CFU (colony forming unit).

Statistical analysis

The data were subjected to statistical analyses using SPSS software, with a complete randomized design model: Yij= μ + Si+ Eij, where Yij represents the observation of the dependent variable, μ the

population means for the variable, Si the effect of heat stress and Eij the random effect associated with the observation.

Results and discussion

Characterization of microclimatic conditions

The monthly average values of the microclimatic characteristics of the stables (maximum ambient temperature °C, minimum relative humidity in %, and the THI index) in the Algerian North West littoral are presented in figure 3.

The highest values of maximum ambient temperature (31.6±3.32°C) were recorded in July and August and gradually decreased to a minimum of 16.7±2.14°C in March. The lowest value of minimum relative humidity was recorded in July (62.8%) and reached a maximum of 89% in December. On the other hand, the average value above thermal comfort (THI<72) according to the classification of Kadzere and al., (2002), was recorded for five consecutive months from May to October (Figure 3).

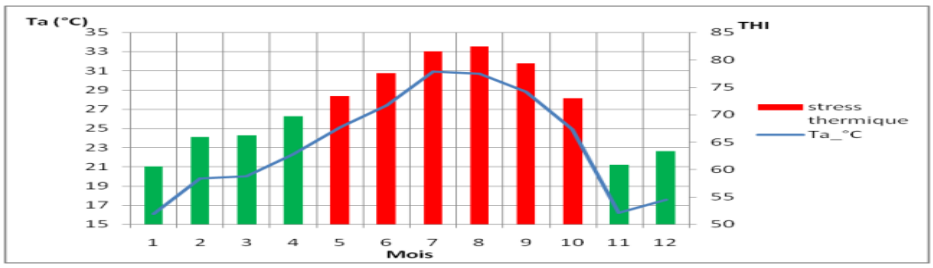

Figure 3. Variation of heat stress index in the littoral region

This variation in ambient conditions indicates that the Prim'Holstein cows are subjected to heat stress, with ambient temperatures above the critical threshold of 25-26 °C which is considered a threshold beyond which production performance is affected (Kadzere and al., 2002; Talbi and El Madidi., 2015; Yerou and al., 2021). In Mediterranean climatic conditions, environmental conditions were high and sufficient to stimulate heat stress between June and September (Bellagi and al., 2017; Yerou and al., 2021; Zoghlami and al., 2022). Under the climatic conditions of Tunisia, Bouraoui and al., (2002) reported a reduction in milk yield when THI was above 68 in lactating Holstein cows. The analysis of climatic data indicates that Prim'Holsteins cows raised in western Algerian coastal conditions are exposed to heat stress during a period ranging from five to six months of the year, characterized by THI values exceeding the critical threshold of 72.

Effect of heat stress on dairy parameters

The results of the quantitative and qualitative parameters of raw milk of the Prim'Holsteins cows kept in the coastal climate of western Algeria are shown in Table 1.

Table 1. Impact of thermal stress on the physico-chemical parameters of raw milk

Parameters	**Group 1**	**Group 2**	**Group 3**
DMY (Kg)	15,8±1,32 ^{a}	17,6±1,61^{b}	19,4±1,74^{c}
TB (g/Kg)	30,3±1,98 ^{a}	32,1±1,86^{b}	36,7±2,64^{c}
TP (g/ Kg)	27,3±1,89 ^{a}	28,2±1,76^{b}	29,3±1,68^{c}
EST (g/ Kg)	113,4 ±8.61 ^{a}	114,3 ±9,01^{b}	116,4 ±8,42^{c}
Ratio TB/TP	1,1^{a}	1,13 ^{a}	1,25 ^{b}
FMAT Log (ucf/ml)	8,68 ±0,34 ^{a}	6,45 ±0,32^{b}	5,96 ±0,28^{c}

Daily milk yields ranged from 15.8 to 19.4 Kg/d, depending on the heat stress threshold. As expected, milk yield was negatively affected ($p<0.05$) by THI. Several authors confirm the drop in daily production with increasing THI (Hammami and al 2013; Bernabucci and al 2014; Tao and al 2017; Yerou and al 2021; Zoghlami and al 2022). Similarly, the butyrate, protein content, and total dry matter decreased significantly with increasing THI in favor of group 3. Similar results were reported by (Bernabucci and al 2014; Lambertz and al 2014; Cowley and al 2015; Ouarfli and Chehma 2018; Zoglmami and al 2022). The results obtained for the TB/TP indicator were significantly lower for groups 1 and 2 compared to the group without heat stress. This indicator gives a prediction of energy deficit that is more expressed in heat stress situations that leads to the decrease of ruminal efficiency. In fact, according to some authors, the ratio TB/TP is a more reliable parameter for predicting energy deficit than TP or TB alone. The maximum TB/TP ratio is set at 1.4; a threshold that can be used for the first 63 days of lactation. Some authors propose a threshold of 1.5 Buttchereit and al., (2010), Toni and al., (2011). In breeding, this ratio is used to judge the balance of the ration, it should be between 1 and 1.5. If it is lower than 1, there is a risk of acidosis and higher than 1.5 there is a risk of ketosis Agridea (2007). This ratio (TB/TP) is used as an indicator of metabolic diseases, with ratios above 1.5 being indicative of a subketotic state, while ratios below 1 are suggestive of subacidosis (Ennuyer 2008). The physico-chemical parameters studied under heat stress by Hammami and al., (2013), Lambertz and al (2014), Bertocchi and al (2014), Zeinhoum and al (2016), Zoghlami and al (2022) indicate a change in the butyric, protein and total dry matter content of raw milk during the heat period, could be attributed to the reduction of dry matter intake, and consequently energy intake, which in turn may be responsible for the reduction of milk synthesis. On the other hand, Cowley and al (2015) indicate that the drop in protein level could also be attributed to the direct effects of heat stress on mammary gland synthesis. Indeed, Colin and al (1992) indicated that in the cheese industry, this ratio should not exceed 1.2, or else it will slow down the draining process and lead to maturation defects. A ratio of 1.15 is considered optimum for manufacturing.

Hygienic aspect of raw milk

The aerobic mesophilic flora is a good indicator of general hygiene, allowing assessment of the microbial contamination and the general quality of raw milk. This indicator plays a key role in the payment of milk quality and reveals the production conditions, specifically the hygienic practices during milking (Yabir and al 2013). The FMAT values range from 5.96 (912×103 CFU/ml) to 8.68 (47.8×105 CFU/ml). This result is higher than the standard set in the Algerian official journal Jora (2018), which recommends an FMAT value lower than <105 CFU/ml. Similarly, this FMAT load is higher than that found in western Algeria with 5.91 (83×104 CFU/ml) according to Aggad and al, (2009) and comparable to that found in the Tissemsilt region with values between 5.04 (1.1×105) and 6.74 (5.6×106 CFU/ml) by Tir and al (2015). The increase in FMAT flora for groups 1 and 2, mid-heat stress is likely due to the multiplication of microorganisms with the increase in ambient temperature exceeding 31.6 °C on the near shore. This is in agreement with the results obtained by Ghazi and al (2010), Jora (2018), and Zoghlami and al. (2022), who agree that a load higher than 105cfu/ml signifies contamination. According to Kaouche (2018) Zoghlami and al (2022), high FMAT values can be an indication of poor hygiene practice during milking. Moreover, milk with such a load is less demanded in the food industry due to the risks of spoilage or manufacturing accidents. Aggad and al (2009) reported an average contamination level of 83x104 CFU/ml for raw milk samples from reception tanks in Western Algeria. This is consistent with the values found by Srairi and al. (2005); Mennane and al (2007), Affif and al. (2008); Labioui and al. (2009); Bousbia and al. (2013);

Zoghlami and al (2022). Indeed, the total microbial load was significant and exceeded the standards set by the Algerian national law (Jora 2018), which are 105cfu/ml. According to Mhone and al (2011), the presence of FAMT flora in raw milk tells us about the overall hygienic quality of the farms. The FAMT includes microorganisms of alteration or contamination, acidifying lactic flora, and sometimes pathogenic bacteria. The enumeration of this flora is the most commonly used method to evaluate the bacterial quality of milk, and therefore it is an important indicator of hygiene conditions during milking. The findings on germs in raw milk from the Prim'Holsteins cows reflect, on one hand, the lack of respect for hygiene practices in barns and contamination of soil and water by cow's droppings, and on the other hand, the conditions of heat stress that accelerate intense bacterial multiplication, favored by the lack of control of hygiene conditions during milking and milk storage. These observations suggest that heat stress can amplify the susceptibility of the cow to infection, either by decreasing the host's resistance or by increasing the host's exposure to pathogens, created by conditions that favor their growth and spread in the dairy barn.

Conclusion

In the light of the results obtained on the Algerian western coast, a negative impact of the threshold of thermal stress on the quantitative and qualitative parameters of raw milk of the Prim'Holsteins cows. All the parameters decreased significantly with the increase of the THI values above the comfort state of the cows. The Physico-chemical and hygienic characteristics of the milk observed under the conditions of thermal stress on the Algerian coast reveal a considerable loss on the economic level of the breeders and a loss of earnings for the dairy industry following the disruption of the collection and the industrial transformation of milk. The results of this study could help breeders and the processing sector to adopt actions to mitigate the heat stress of exotic breeds introduced far from the country of origin.

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