Genetic Evaluation of Heat Stress Effects on Milk Yield and Milk Composition Traits of Holstein-Friesian Cows in Kano State, Nigeria

Garba, M.S.*, Adedibu, I.I., Kabir, M. and Agboola, L.O.

Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria
*Corresponding author**

Abstract: **This study was conducted to evaluate the effect of temperature-humidity index on milk traits of pure Holstein-Friesian cows in Kano State. Twenty mid-lactating Holstein-Friesian cows (three years of age with a mean weight of 600kg) were used for this experiment. The cows were raised intensively in a covered free stall barn (3m^2 per cow) with straw bedding. Metrological data, both inside and outside, of the barn including temperature (maximum and minimum) from both digital and analogue (dry and wet bulb) thermometers and relative humidity were collected. Three composite samples of milk from the cows were taken per month (on the 15th day of each month) and were analysed for protein, fat and somatic cells. Meteorological data were analysed to identify the most appropriate temperature-humidity index (THI) to measure heat stress in this study. Data were analysed using Analysis of Variance (ANOVA) and correlation procedures in the Statistical package SAS (2013). Comparison of the Means was done using Duncan Multiple range tests of the same statistical package. The minimum temperature for the period of the experiment had the lowest value (23.08±0.62^{0}C) in the month of December in Early dry season while the highest value (33.64±0.83^{0}C) was recorded in the April of the Late dry season. The differences in the THI for the two periods resulted in significant different ($P < 0.05$) in milk yield and milk composition traits. It was concluded that, heat stress affect milk production, milk composition of Holstein-Friesians cows reared in Kano State environment.**

Keywords: **Heat stress, Milk yield, Milk composition traits, Holstein-Friesian, and Kano State**

I.INTRODUCTION

Nigeria population is increasing rapidly (Ibeawuchi *et al*., 2000) and domestic output of 407,000 metric tonnes of milk (Olaloku, 1999) obtaining from 14 million cattle in the country (RIM, 1992) can barely satisfy the milk demands of the growing population. For this reason, milk production in the country is being supplemented by milk from imported breed of dairy cows. Holstein Friesian is one of the commonly exotic breeds of cows being used for milk production in Nigeria. This breed however tends to perform below their potential when compared with their level of production abroad.

Thermal environment is a major factor that can negatively influence milk production of dairy cattle especially those of high genetic merit (Kadzere *et al*. 2002). Yano *et al.* (2014) indicated that individual cow genetic composition and some environmental conditions such as temperature are contributing factors that affect milk yield in dairy cow. The temperature-humidity index (THI) could be used to determine the influence of heat stress on productivity of dairy cows (Ghavi *et al*., 2013; Adedibu *et al*., 2015). Extensive efforts have been made to quantify the effect of heat on milk production, investigating such factors as humidity, wind speed, daylight length, and temperature and humidity indices (THIs) (Bouraoui *et al*., 2002; Ghavi *et al*., 2013; Yano *et al*., 2014) for different breeds of cattle in different environments in the world. Results from such works would provide useful information on heat tolerant traits and could be used as a guide in making selection decision from existing breeds and also a guide in management of dairy breeds. This kind of information however is limited for Holstein breed of cattle in Nigeria. The objective of this research is to evaluate the effect of temperature-humidity index on daily milk production of Holstein cows under climate conditions in Kano State.

II. MATERIALS AND METHODS

Study Area

The study was conducted at Sa'ada Farm Dawakin Kudu Local Government Area of Kano State, Nigeria. The State covers an area extending between Latitudes 10º 3'N and 12º 4'N of Equator and Longitude 7º 4'E and 9º 3'E of the Prime meridian. The State experiences two seasons, the rainy season, which starts in April and ends in late October, and the dry season, which starts in November and ends in April (Asimalowo, 2011). This can be subdivided into early dry (November, December and January), late dry (February, March and April), early rain (May, June and July) and late rain (August, September and October) (Josiah *et al*., 2015).

Experimental Animals and their Management

Twenty mid-lactating Holstein Friesian cows (three years of age with a mean weight of 600kg) were used for this experiment, the cows were raised intensively in a covered free stall barn (3m^2 per cow) with straw bedding. They were fed according to the production level. The metal roofs used in covering the stall barn is covered with straws.

Data Collection

Daily Milk Yield and Milk Composition

The cows were milked two times daily (6:00 - 7:00, and 17:00 – 18:00 h) with Asin® electric milking machine manufactured by Popsort® of China. Three composite samples were taken per month (on the 15th day of each month) and were analyzed for protein, fat and somatic cells. Milk samples were prepared following the method proposed by Bobe *et al*. (1998) and were preserved using Bronopol, 2-Bromo-2-Nitropropane-1,3-diol that was added immediately to raw milk samples at 0.6:100 to prevent microbial growth. The samples were later stored at 4^0C (Nagy *et al.*, 2013) before it they were transported for laboratory analysis.

The milk samples were taken to the Biochemistry laboratory, Department of Biochemistry, Bayero University, Kano to analyse for, milk fat (%) and milk protein (%). Fat yield and protein yield were deduced from milk fat (%) and milk protein (%) respectively, following the methods of Bouraoui *et al.* (2002). The fat yield was estimated as milk fat (%) times milk yield (kg.d^{-1}) and protein yield was estimated as milk protein (%) times milk yield (kg.d^{-1}).

Somatic Cell Count

Part of the milk was also analysed for Somatic cell counts at the Clinical Microbiology Laboratory in the Department of Microbiology Bayero University, Kano. The electronic microscope was used to determine the somatic cell counts using the microscopic factor to determine the number of cells per ml of milk.

Meteorological data

Temperature and humidity both inside and outside of the barn were measured using two of Youkong® digital thermometer and hygrometer manufactured by HTC of China. Daily maximum and minimum temperatures were recorded at 7:00 hour, 13:00 hour and 17:00 hour using maximum-minimum thermometers.. This digital thermometer and hydrometer were mounted in the open, under the tree, and the other thermometer and hydrometer mounted in the shed

Data Analysis

Meteorological data was analyzed to identify the most appropriate temperature-humidity index (THI) to measure heat stress in this study. Temperature-Humidity index for the period of experiment was calculated using Angular (2008):

$THI = (1.8 \times T + 32) - (0.55 - 0.0055 \ x \ RH) \times (1.8 \ x \ Ta - 26);$ (Angular, 2008);

T = Temperature in degree Celsius (^{0}C); RH = Relative humidity in percentage (%)

Statistical analysis

To determine the effect of temperature humidity index on milk yield and milk compositions a fixed model where repeated measurements per cow was considered random. Data was analysed using Analysis of Variance (ANOVA) procedures in the Statistical package SAS (2013). Comparison of the Means was done using Duncan Multiple range tests of the same statistical package.

Statistical Models

$$Y_{ij} = \mu + P_i + \mathcal{E}_{ij}$$

Where: Y_{ij} = the i^{th} observations (milk yield, milk fat, milk protein) at the different i^{th} period;

μ = mean effect;

Pi = effect of i^{th} period (early dry and late dry);

$\mathcal{E}_{ijk}$ = residual effect.

III. RESULTS AND DISCUSSUION

The results of the average values of climatic factors for the period of experiment and the conventional comfort zone for Holstein-Friesian cows is presented in Table 1. There was variation in the average temperature (T), relative humidity (RH), the temperature-humidity index (THI) during the period of the experiment. T, RH and THI for the late dry season was higher than the early dry and also was higher than the values of the comfort zone for dairy cattle. This indicates that during these seasons Holstein cows reared in Kano state were subjected to heat stress. Gantner *et al*. (2011) gave the bovine thermal comfort zone to be between -13°C to +25°C, within this temperature range, the animal comfort is optimal, with a body temperature between 38.4°C and 39.1°C. However, in situation where temperature is above 25°C, and even as low as 20°C (Gantner *et al.*, 2011) the cow suffers from heat stress: its health status and production performance are affected. On the other hand, a mean daily THI in value of 72 is considered to be the critical point at which milk yield is reduced (Johnson, 1985; Gantner *et al*., 2011).

The results of the effect of heat stress on milk yield and milk composition is as shown in Table 2. Temperature humidity index (THI) values went from 69 in the early dry period to 74.38 in the late dry season period. The differences in the THI for the two periods resulted in significant different ($P<0.05$) in milk yield and milk composition traits. The milk production was higher in the Early dry season compared to the late dry season. Similar pattern was also observed for milk fat, milk protein, fat yield, protein yield and somatic cell counts. This results corroborate with the findings of Bouraoui *et al*. (2002) who indicated that a rise in THI from 68 in spring to 78 in the summer had effect on milk production in confined Holstein cows in the Mediterranean climate. This is because heat stress is known to result in reductions in voluntary feed intake and thus subsequent declines in milk production in lactating dairy cows (Johnson, 1985; Bouraoui *et al*., 2002). The resultant declination in milk yield lead to consequential reduction in the milk composition as researchers have found a high correlation between milk yield and other milk composition (Ghavi, *et al*., 2013). This explain the lower values recorded for milk composition traits in this study when the THI was above the comfort zone for Holstein-Friesian cows.

Table 1: Average value of climatic factors for the experimental period and the comfort zone for Holstein-Friesian cows

Factor	Early dry season	Late dry season	Comfort zone for Holstein cattle
Temperature (^{0}C)	25.88±0.36	31.22±0.31	-13 to +25 (Lefebvre and Plamondon, 2003)
RH (%)	13.10±0.31	13.19±0.49	0 to 45 (Gantner *et al*., 2011)
THI	68.99±0.44	74.38±0.47	Bellow 72 (Johnson, 1987)
THI- Temperature-Humidity index RH- Relative Humidity			

Table 2: Heat stress (THI) effect on milk yield and milk composition

Traits	Periods		
	Early dry season (THI = 69.00)	Late dry season (THI = 74.38)	P-value
Milk yield (kg·d^{-1})	20.12±1.04^a	12.99±1.04^b	0.0002
Milk fat (%)	3.56±0.16^a	2.84±0.16^b	0.0048
Milk protein (%)	3.26±0.12^a	2.48±0.12^b	0.0004
Fat yield (g·d^{-1})	0.72±0.039^a	0.36±0.039^b	0.0001
Protein yield (g·d^{-1})	0.66±0.04^a	0.33±0.04^b	0.0001
Somatic cell counts × 10^5	2.86±0.45^a	4.03±0.45^a	0.0482
THI- Temperature-Humidity index for the period ^{ab}means along the same row are significantly different			

IV. CONCLUSION AND RECOMMENDATION

Heat stress influence milk production traits, milk composition traits, body weight, body condition score and udder traits of Holstein-Friesians cows reared in Kano State environment. Breeder and dairy farmer should consider milk yield and milk composition traits in the selection and in the management of dairy cows.

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