



## **IMPROVEMENT OF THERMOREGULATORY INDICES OF LACTATING BUNAJI, WADARA AND FRIESIAN X BUNAJI COWS FED DIETARY ORGANIC ANTI-OXIDANT UNDER TROPICAL ENVIRONMENT**

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### **ABSTRACT**

The study was conducted at the dairy research and development centre of Abubakar Tafawa Balewa University, Bauchi to evaluate the effects of baobab fruit pulp meal supplementations as organic anti-oxidants on improvement of thermoregulatory indices of Bunaji, Wadara and Friesian x Bunaji cows fed dietary organic anti-oxidant under tropical environment. Twenty (24) lactating cows in their first and second parity were used. They were allotted to four dietary levels (0.00, 5.30, 10.60 and 15.90 kg/100 kg diet of BFPM) with six animals per treatment in a Completely Randomized Design (CRD). The data generated was subjected to analyses of variance of SPSS software and the means were separated using Tukey Pairwise Comparison method. Friesian x Bunaji cows had higher ( $P \leq 0.05$ ) respiratory rate, rectal temperature, pulse rate and skin temperature compared to Wadara and Bunaji breeds. Second parity had higher respiratory rate, pulse rate and skin temperature compared to first parity. Lactating cows fed diet supplemented with baobab fruit pulp meal at level 15.90 kg/100 kg had higher ( $P \leq 0.05$ ) thermoregulatory values while the cows fed control diet had lower values. In conclusion, the inclusion of baobab fruit pulp meal at 15.90 kg/100 kg had reduced heat stress (rectal temperature) by reducing thermoregulatory indices in dams. It is recommended that, under tropical conditions baobab fruit pulp meal as organic anti-oxidants and constituent of glutathione peroxidase could be added at 15.90 kg/100 kg in the diet of lactating cows for improved body physiological processes and reduction of negative **effects of thermoregulatory stress indices without any deleterious effect.**

**Keywords:** Thermoregulatory, Physiology, Lactating, Cows, Anti-oxidant, Improvement

### **INTRODUCTION**

Climate and weather are important environmental factors that could affect the feeding, production and management of livestock all over the world (Aggarwal and Singh, 2008). It has been shown that an effective physiological regulation under high climatic conditions seem to be expressed by animals through systematic reduction of heat load or increasing heat loss via rectal



temperature and respiratory rate (Velayudhan *et al.*, 2023). Measurement of respiratory rate, rectal temperature, pulse rate and skin temperature are critical biomarkers and indicators of animal physiological status. It is a reliable method for judging the degree of abnormal temperature (hyperthermia) and Subnormal temperature (hypothermia). However, this may or may not indicate disease. Nutritional supplementations have been used to maintain homeostasis and mitigate the effect of oxidative and heat stress in lactating cows. Lactating cows may experience oxidative stress when any combination of environmental factors such as temperature, humidity, solar radiation and air movement causes ambient temperature to exceed body temperature. Surai *et al.* (2019) reported that, the maximum response of heat stress on milk yield is observed within 24 to 48 hours after exposure due to changes in the metabolic state of the cows. Moreover, it altered the physiological responses which manifested when the temperature-humidity index (THI) and ambient temperature exceeded 68 % and 32.2 °C, respectively (Habeeb *et al.*, 2018). The baobab fruit pulp meal as an important source of organic anti-oxidant, is a nutritious feed with great potential for enhancing the antioxidant status and lowering of thermoregulatory indices of lactating cows under tropical environment but grossly under-utilized (Magdi, 2016). It increases feed intake, improve metabolism and was effective in alleviating thermal stress in lactating cows (Magdi, 2016). In recent times, there has been a shift of interest from the use of synthetic anti-oxidants against free radicals and reactive oxygen species produced in body fluids and tissues of animal to the use of organic anti-oxidants which are viable, affordable and physiologically safe to improve health and performance of lactating cattle under thermal stress environment (Okunlola *et al.*, 2015). The aim and objective of this study focused on the improvement of thermoregulatory indices of Bunaji, Wadara and Friesian x Bunaji cows fed dietary organic anti-oxidant under tropical environment. The study is very critical for sustainable climate resilient livestock production to improve food security.

## **MATERIALS AND METHODS**

### **Experimental Site**

The research work was conducted at Dairy Research and Development Centre (DRDC), Abubakar Tafawa Balewa University, Bauchi, Nigeria. Bauchi is in the North-East geo-political zone and lies within Northern Guinea Savannah, located between latitudes 9° 30' and 12° 30' North of the equator and between the longitudes 8° 50' and 11° 0' East of the Greenwich meridian. The rainfall ranges between 700 to 1,300 millimetres (28 to 51 inches) per annum. Consequently, rains start in April/May and ends in October. It is usually hot and humid during the day in wet season. The range average daily temperature is 17 to 40 °C depending on the season. The average relative humidity also ranges from 16.5 to 75 % respectively (Reference).

### **Experimental Animal, Management and Design**

A total of twenty-four (24) lactating Bunaji, Wadara and Friesian x Bunaji cows at early, mid and late lactation were used for the study. The cows weighed between 200 and 400 kg, and between 3-7 years old. The experimental animals were maintained under similar condition of feeding, housing and management. They comprised four treatment groups, with six animals per treatment group in a factorial arrangement under a Completely Randomized Design (CRD).

### **Experimental Diets and Duration**

The experiment had four treatment diets comprising of T1= 0% inclusion of BFPM, T2= 5.30% inclusion of BFPM, T3= 10.60% inclusion of BFPM and T4= 15.90% inclusion of BFPM



all in kg/100 kg diet. The diets were fed once daily in the morning before milking to each experimental cow for the period of three months (April to June). The quantity of supplemental diet offered were based on milk production yield ( $\frac{1}{2}$  kg of concentrate to 1 litre of milk produced per cow per day, respectively).

### **Data Collection**

#### **Determination of thermoregulatory indices**

The parameters were; respiratory rate (c.p.m), rectal temperature ( $^{\circ}\text{C}$ ), pulse rate (b.p.c.) and skin temperature ( $^{\circ}\text{C}$ ). The variables were determined on daily basis from 12.30 to 1.30 pm respectively in order to ascertain daily physiological and health status of the experimental cows.

#### **Respiratory rate**

The respiratory rate (RR) was determined when the animal was at rest by counting the number of inward and outward flank movement (breath) per minute using a stop watch (count per minute) (Velayudhan *et al.*, 2023).

#### **Rectal temperature**

The rectal temperature (RT) was measured when the sensory tip of digital thermometer was inserted into the rectum (3-5 cm deep) via the anus for 1-3 minutes and removed after a beep sound of the instrument was overheard (Kumar *et al.*, 2018). The displayed body temperature is then recorded.

#### **Pulse rate**

This was determined by counting the number of the heart beat in one minute using a stethoscope (BK3002, Wenzhou Bokang Instruments Co. Ltd, China) (Kumar *et al.* 2018).

#### **Skin temperature**

This was recorded with the help of infra-red digital thermometer (Fisher Scientific TM Traceable TM Non-contact Infrared Thermometer, Catalog No. 06-664-38) placed at 5.1 to 7.7 cm away from the desired surface of the animal site (Yadav *et al.*, 2017).

#### **Statistical Analysis**

The data generated were subjected to analysis of variance (ANOVA) using the General Linear Model procedure of Statistical Package for Social Sciences (SPSS, 2007) version 16.0. Where significant difference was observed, means were separated using Tukey Pairwise Comparison method (Tukey, 1991).

## **RESULTS**

### **Effect of Breed and Parity on Thermoregulatory Indices of Lactating Cows Fed Diet Supplemented with Varied Levels of Baobab Fruit Pulp Meal (BFPM)**

The result of the thermoregulatory indices of lactating cows is presented in Table 1. Respiratory rate (RR), rectal temperature (RT), pulse rate (PR) and skin temperature (ST) were higher ( $P < 0.05$ ) in FR x BJ breeds. WD breeds had higher ( $P < 0.05$ ) RT. The values for RR, PR and ST were higher ( $P < 0.05$ ) in SP for all breeds, except RT ( $P > 0.05$ ). RR, RT, PR and ST were higher ( $P < 0.05$ ) in lactating cows fed control diet. RR, RT and ST were lower ( $P < 0.05$ ) in lactating cows fed 15.90 kg/100 kg BFPM diets.

**Table 1:** Effect of breed, parity and diet on thermo regulatory indices of lactating cows fed diet supplemented with varied levels of baobab fruit pulp meal

Parameters	RR (breath/min)	RT (°C)	PR (beat/min)	ST (°C)
<b>Breed</b>				
BJ	30.78 <sup>c</sup>	38.23 <sup>b</sup>	48.15 <sup>c</sup>	21.34 <sup>c</sup>
WD	36.77 <sup>b</sup>	38.26 <sup>a</sup>	53.41 <sup>b</sup>	23.30 <sup>b</sup>
FR x BJ	43.29 <sup>a</sup>	38.30 <sup>a</sup>	62.08 <sup>a</sup>	26.58 <sup>a</sup>
SEM	0.09	0.02	0.11	0.06
P. value	0.001	0.05	0.001	0.001
<b>Parity</b>				
FP	36.23 <sup>b</sup>	38.28	53.87 <sup>b</sup>	23.22 <sup>b</sup>
SP	37.67 <sup>a</sup>	38.25	55.22 <sup>a</sup>	24.26 <sup>a</sup>
SEM	0.08	0.02	0.09	0.05
P. value	0.001	0.21	0.001	0.001
<b>Diet (kg/100 kg)</b>				
0.00	38.32 <sup>a</sup>	38.53 <sup>a</sup>	55.80 <sup>a</sup>	23.98 <sup>a</sup>
5.30	37.48 <sup>b</sup>	38.19 <sup>b</sup>	54.48 <sup>b</sup>	23.83 <sup>b</sup>
10.60	36.10 <sup>c</sup>	38.19 <sup>b</sup>	53.56 <sup>c</sup>	23.82 <sup>b</sup>
15.90	34.99 <sup>d</sup>	38.15 <sup>c</sup>	54.35 <sup>b</sup>	23.32 <sup>c</sup>
SEM	0.11	0.01	0.13	0.06
P. value	0.001	0.001	0.001	0.001
Reference values	26-70	37.5-39.5	40-70	18.6-38.6

**SEM**- standard error of mean, <sup>abcd</sup>; means within the same column followed by different superscripts are significantly different at  $P\text{-value} \leq 0.05$ , **BFPM**- baobab fruit pulp meal, **RR**-respiratory rate, **RT**-rectal temperature, **PR**-pulse rate, **ST**- skin temperature, °C- degree celsius, **BJ**- Bunaji, **WD**- Wadara, **FR x BJ**- Friesian x Bunaji, **FP**- first parity, **SP**- second parity

**Source:** Kumar *et al.* (2018); Velayudhan *et al.* (2023)

Table 2, shows an interaction between breed and BFPM diets. Respiratory rate was higher ( $P < 0.05$ ) in Bunaji breeds fed control, 5.30 kg/100 kg BFPM diets. Respiratory rate was higher ( $P < 0.05$ ) in Wadara and Friesian x Bunaji breeds fed control diets. Pulse rate was higher ( $P < 0.05$ ) in Wadara and Bunaji breeds fed control diets. Pulse rate was higher ( $P < 0.05$ ) in Friesian x Bunaji breeds fed control, 5.30 kg/100 kg BFPM diets. Skin temperature was higher ( $P < 0.05$ ) in Bunaji breeds fed control, 5.30 kg/100 kg BFPM diets. Skin temperature was higher ( $P < 0.05$ ) in Wadara and Friesian x Bunaji breeds fed control, 5.30, 10.60 and 15.90 kg/100 kg BFPM diets.



**Table 2:** Interaction between breed and diet on thermoregulatory indices of lactating cows fed diets supplemented with varied levels of baobab fruit pulp meal

Parameter	BJ				WD				FR x BJ				SEM	P. value
	0.00	5.30	10.60	15.90	0.00	5.30	10.60	15.90	0.00	5.30	10.60	15.90		
PR(b/m)	50.35 <sup>a</sup>	49.12 <sup>b</sup>	48.26 <sup>c</sup>	44.87 <sup>d</sup>	55.80 <sup>a</sup>	54.53 <sup>b</sup>	51.87 <sup>c</sup>	51.42 <sup>c</sup>	63.65 <sup>a</sup>	63.32 <sup>a</sup>	60.13 <sup>c</sup>	61.21 <sup>b</sup>	0.23	0.002
ST (°C)	21.68 <sup>a</sup>	21.52 <sup>a</sup>	20.90 <sup>b</sup>	19.88 <sup>c</sup>	23.83 <sup>a</sup>	23.77 <sup>a</sup>	23.37 <sup>b</sup>	23.65 <sup>a</sup>	26.76 <sup>a</sup>	26.73 <sup>a</sup>	26.33 <sup>b</sup>	26.42 <sup>b</sup>	0.11	0.001

**SEM**- standard error of mean, **bh/m**- breath/minute, **b/m**- beat/minute, <sup>abcd</sup>; means within the same row followed by different superscripts are significantly different at P-value ≤ 0.05, **BFPM**- baobab fruit pulp meal, **BJ**- Bunaji, **WD**- Wadara, **FR x BJ**- Friesian x Bunaji, **RR**- respiratory rate, **PR**- pulse rate, **ST**- skin temperature, °C- degree celsius



The interaction between parity and diet is presented in Table 3. Respiratory rate was higher ( $P < 0.05$ ) in both parity fed control diets. Pulse rate was higher ( $P < 0.05$ ) in first parity cows fed control, 5.30 kg/100 kg BFPM diets. Pulse rate was higher ( $P < 0.05$ ) in second parity cows fed control diets. Skin temperature was high ( $P < 0.05$ ) in first parity cows fed control, 5.30 and 10.60 kg/100 kg BFPM diets. Skin temperature was also high ( $P < 0.05$ ) in second parity cows fed control, 5.30 and 15.90 kg/100 kg BFPM diets.



**Table 3:** Interaction between parity and diet on thermoregulatory indices of lactating cows fed diets supplemented with varied levels of baobab fruit pulp meal

Parameter	FP				SP				SEM	P. value
	0.00	5.30	10.60	15.90	0.00	5.30	10.60	15.90		
RR (breath/min)	37.54 <sup>a</sup>	36.99 <sup>b</sup>	36.14 <sup>c</sup>	34.25 <sup>d</sup>	39.65 <sup>a</sup>	37.85 <sup>b</sup>	37.42 <sup>b</sup>	35.73 <sup>c</sup>	0.15	0.001
PR (beat/min)	54.64 <sup>a</sup>	54.47 <sup>a</sup>	53.83 <sup>b</sup>	52.54 <sup>c</sup>	56.59 <sup>a</sup>	55.13 <sup>b</sup>	54.58 <sup>c</sup>	54.23 <sup>c</sup>	0.18	0.001
ST (°C)	23.54 <sup>a</sup>	23.49 <sup>a</sup>	23.14 <sup>a</sup>	22.69 <sup>b</sup>	24.51 <sup>a</sup>	24.36 <sup>a</sup>	23.96 <sup>b</sup>	24.16 <sup>a</sup>	0.09	0.004

**SEM**- standard error of mean, <sup>abcd</sup>, means within the same row followed by different superscripts are significantly different at P-value  $\leq 0.05$ , **BFPM**- baobab fruit pulp meal, **FP**- first parity, **SP**- second parity, **RR**- respiratory rate, **PR**- pulse rate, **ST**- skin temperature, °C- degree celsius





## DISCUSSION

In the current study, respiration rate (RR), rectal temperature (RT), pulse rate (PR) and skin temperature (ST) were high ( $P < 0.05$ ) in breed and parity. However, RT was similar ( $P > 0.05$ ) in parity. According to Kumar *et al.* (2018) the thermoregulatory indices are cardinal physiological variables, helps to maintain heat balance, health status, well-being and homeostasis for the vast category of animals and were established to be ideal indicators for quantifying heat stress in lactating cattle. The present study was in agreement with Abbaya *et al.* (2020) who reported significant ( $P < 0.05$ ) breed effect on thermoregulatory indices measured on indigenous breeds (Gudali, Rahaji, Bokoloji and Bunaji). According to Velayudhan *et al.* (2023), any breed that recorded higher thermoregulatory values (37.5-39.5 °C), had poor heat dissipation and thermo-adaptability mechanisms, therefore, was in thermal discomfort zone.

The higher RR, RT, PR and ST observed in Friesian x Bunaji lactating cows is in agreement with the report of Kumar *et al.*, (2018) who reported that, high milk producing animals have higher thermoregulatory indices due to higher metabolic activities in the body. Rejeb *et al.* (2016) also reported that Zebu cattle (*B. indicus*) had better thermoregulation than the Taurine cattle (*B. taurus*) in tropical climatic conditions in India. Bunaji breeds in this current study seems to be more thermally-stable (heat-tolerant) and well adapted to tropical conditions because of their lower thermoregulatory and HTC values compared to their counterparts (Friesian x Bunaji and Wadara breeds). Furthermore, higher thermoregulatory parameters observed in cows in second parity could be as a result of differences in genetic make-up, size of the animal and body colour (Paminto and Yulianti, 2021).

Paminto and Yulianti (2021) indicated that, animals with black hides are more thermally affected and significantly suffer heat stress than those with white hides (89 % and 55 %) respectively. Other factors could be age, stage of lactation, frequency of milking, housing system, physiological status of an animal, exercise, excitement, time of the day and ambient temperature of the surrounding environment (Paminto and Yulianti, 2021). Isaksson (2017) reported that different breeds and parities of cattle respond to environmental conditions differently, as sensitivity and adaptive mechanisms vary within and between breeds, parities and species. Rejeb *et al.* (2016) reported that body size, disease condition, exercise, metabolic heat, parity, environment, breed and humidity could lead to unusual increase in pulse and respiratory rate. Variation in thermoregulation indices between this study and other studies could be as a result of differences in experimental test materials, location and breeds used.

### **Effect of Varied Levels of Baobab Fruit Pulp Meal (BFPM) Diets on Thermoregulatory Indices of Lactating Cows**

Low performance of lactating cows during high ambient temperature is critical in tropical and subtropical regions as a result of heat stress (Soliman, 2013). Skin blood flow regulates transfer of heat from body core to the skin resulting in a shift in skin temperature in response to elevated thermal heat. In the present study, 15.90 kg/100kg BFPM diet was observed to be the best in terms of reducing the thermal stress values of the vital physiological indices in lactating cows under tropical climate. The thermoregulatory values in the current study were higher in cows fed control diet and linearly decreased as concentration of antioxidants increases. The level of BFPM diet fed to lactating cows with the lower thermoregulatory values were believed to be the best level in ameliorating heat stress. (Soliman, 2013). Similarly, Soliman (2013) reported that, steers fed control diet had higher ( $P < 0.10$ ) mean rectal temperature than the steers fed Zn





supplementation. The results obtained in Experiment I, demonstrate that BFPM contains high amount of vitamin C (organic antioxidants) which was able to counteract and decrease the effect of reactive oxygen species in the body tissues (Anoh, 2016). It regulates the functions of the immune system, redox mechanisms and other crucial cellular processes involved in innate and adaptive immune response (Anoh, 2016).

Adeosun (2012) reported BFPM lowered rectal temperature of broiler finishers. The vitamin C in BFPM, enhances antioxidant properties that scavenges free radicals. The inclusion of vitamin C in the diet of the lactating cows protects the cells from damage caused by reactive oxygen species and heat stress (Althwab *et al.*, 2019). According to Rashamol *et al.* (2018) RR, RT, PR and ST are the cardinal physiological variables and ideal biomarkers for quantifying heat stress and homeostasis in stressed animals. The current study was in agreement with Anoh (2016) who reported treatments with 4.50 % and 5.50 % inclusion levels of Vitamin C and BFPM had lower (RR, HR, RT and ET) compared to other dietary levels. Soliman (2013) reported RR, PR and RT values in cows (cross-breds) that disagrees with the current study, but higher ST value was observed. The interactions between breed, parity and diet in Experiment I was also observed however, demonstrating similar pattern with the main effects. Bello *et al.* (2016) reported that, increase in the environmental temperature induces elevation of rectal temperature and pulse rates and their measurements facilitate the determination of the degree of heat stress. Nervousness, lactation, fever, ambient temperature can result in a rapid rise in the rectal temperature, respiratory and pulse rates of animals (Rashamol *et al.*, 2018).

## CONCLUSION AND RECOMMENDATION

The supplementation of baobab fruit pulp meal (BFPM) at 15.90 kg/100 kg in the diets of lactating Bunaji, Wadara and Friesian x Bunaji cows under tropical environment had significantly reduced thermal indices (RT 38.15 °C) compared to control diets (RT 38.53 °C), respectively.

Hence, inclusion of baobab fruit pulp meal (BFPM) at 15.90 kg/100 kg in the diet of lactating cows would improve thermoregulatory indices of the cows under tropical environment.

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