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Physiological and Antioxidative Responses of Feedlot Bulls Fattened during the Hot Period of Dry Season in Mubi, Adamawa State, Nigeria

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Abstract
Feedlot bull fattening is one of the most profitable livestock business particularly in Mubi because of the presence of the International cattle market (‘Tike’). They are fattened around the river banks in the dry season of Mubi when there is rise in temperature and other environmental factors that can affect the performance and carcass quality of such bulls. This experiment therefore was carried out to evaluate the effect of locations on physiological and antioxidative responses of feedlot bulls fattened in Mubi. A total of sixty (60) clinically healthy bulls comprising of twenty (20) heads each at Buladega, Tike cattle market and Njairi feedlot sites were used for this experiment. Data obtained was subjected to statistical analyses using SAS software package and means that were significantly different were separated using Least Square Difference. Parameters measured include physiological traits, anti-oxidative traits and heat stress indicator (Heat Tolerance Coefficient). Location of fattening significantly ($p<0.05$) affected physiological traits except for Rectal Temperature ($p>0.05$). Tike cattle market recorded the highest of all the significantly affected heat indices except for pulse rate where Buladega shared superiority with Tike cattle market (35.67 and 35.75 beat/minute), respectively. Location of fattening has affected ($p<0.05$) all the antioxidative traits. Higher values of Gluthione Transferase (GTT), and Superoxide dismutase (SOD) were recorded in bulls fattened at Tike cattle market while Gamma Glutamyl Tranferase (GGT) was higher in bulls reared at Njairi. Bulls reared at Njairi and Buladega shared superiority in Glutamine Perioxide (GP). It was therefore concluded that heat stress has resulted in an increase in physiological and oxidative stress in cattle fattened at Tike cattle making them more prone to heat load and oxidative stress caused by heat stress.

Keywords: physiology, antioxidants, bulls, fattening, heat-stress, hot period

Introduction
Agriculture has remained a key sector in Nigeria despite the contribution of crude oil to present economy (Sertoglu *et al*., 2017; Rekwot *et al*., 2019). Cattle production across the world is characterized by diverse management systems, geographical locations, feed, marketing systems and breed (Islam *et al*., 2021). The cattle value chain is estimated to contribute up to half of the total value of agricultural gross output and up to a third in developed and underdeveloped countries (Hamidu, 2014). Cattle fattening serves as an additional source of income and feedlot beef cattle subsector is becoming more popular in many countries (Syrucek *et al*., 2017; Gabdo *et al*., 2020; Dadi, 2023). Besides, feedlot system serves as a major source of employment, protein supply, revenue generation as well as increased foreign exchange through export (Gabdo *et al*., 2020; Ja’afar-Furo *et al*., 2021) particularly in Mubi where they are fattened and transported to the south eastern and south western part of Nigeria where demand is very high and thus attract high price (Jibrin *et al*., 2023). Despite the recognition feedlot is gaining and the importance of livestock sub-sector coupled with the fact that outdoor feedlot is advantageous, the industries receive less attention and are still operating at traditional level due to several reasons such as inappropriate scale of production and management problems (Wagner, 2016; Salendu *et al*.., 2019; Elly *et al*., 2019; Gona

et al., 2017; Gabdo *et al*., 2020; Ja'afar-Furo *et al*., 2021).

One of the major concerns of feedlot fattening is how those cattle are exposed to prolonged, direct sunlight and other harsh environmental conditions at various locations of fattening, making them susceptible both to heat and oxidative stress which is described as a biological response to thermal stimuli in a given environment (Constable *et al*., 2017; Saleh *et al*., 2022). Heat stress is an important factor that affects cattle performance and productivity traits negatively, especially in hot climate or summer in all parts of the world (Rolf, 2015). Heat stress in feedlot cattle causes decrease in feed intake, growth and in extreme cases death (Brown-Brandl *et al*., 2005).

Nigeria and other West African countries are likely to have agricultural losses of up to 4% of gross domestic product (GDP) due to climate change (Mendelsohn *et al*., 2006). A reduced milk yield was recorded in Nigerian indigenous breeds of cattle during the hot season of 2022 in Nigeria (Abbaya, 2023). Inter-governmental Panel on Climate Change (IPCC, 2021) predicted that losses due to heat stress will continue to increase. In the global perspective, they have predicted that the increase in worldwide average surface temperature by the end of 21st century may be between 2.6°C and 4.8°C and that cattle are most vulnerable (Islam *et al*., 2021).

Oxidative stress has been defined as disturbance in the state of concentrations of pero-oxidants and antioxidants, leading to overproduction of free radicals and reactive oxygen species and decrease in antioxidant defense (Ganaie *et al*., 2013; Belhadj Slimen *et al*., 2016).

Antioxidants are vital sources of defense substances against free radicals induced by heat stress and other factors (Abbaya *et al*., 2023). Oxidative stress causes an imbalance in the activities of antioxidants and peroxides molecules and this is said to be increased when cattle are exposed to thermal stress (Sordillo and Aitken, 2009; Li *et al*., 2021).

Animals respond to heat stress differently, depending on meteorological conditions over space and time (location and time of season) (National Weather Science, 2005). Therefore, the improvement of animals' ability to cope with adverse environmental conditions is one of the great challenges of animal scientists for the future (Bernabucci *et al*., 2014; Nayak *et al*., 2018). Among the traits that contribute to defining animal adaptability to environmental variation, tolerance to heat stress plays a major role (Bernabucci *et al*., 2014; Macciotta *et al*., 2016).

Some physiological and oxidative characteristics have reportedly been linked to an animal's capacity to deal with heat stress (Garner *et al*., 2016; Li *et al*., 2021). Previously, studies have been carried out on the physiological responses of cows in Mubi (Abbaya *et al*., 2022; 2023; Abbaya, 2023). But there is dearth of information on the thermo-tolerant ability of the feedlot bulls reared in Mubi and its environs. Therefore, there is the need to study the response of these bulls in relation to the effect of the prevailing environmental factors they are subjected to so as to advice the farmers and other stakeholders on the effects of heat stress and the possible mitigation measures. This experiment was therefore carried out to evaluate the effect of locations of fattening on the heat stress indices of feedlot bulls fattened in Mubi. The information obtained will serve as a base line data for improving the condition of feedlot bulls fattened in Mubi and its environs particularly during the hot season.

Materials and Methods

Study location

The study was conducted on three purposively sampled feedlot herds in Mubi (Buladega, Tike cattle market and Njairi feedlot fattening Areas). Mubi is located at an altitude of 200 to 300 meters above sea level, between latitudes 9°20' and 9°33'N and longitudes 12^0 30' and 12°50' E (Ovimaps, 2018). It shares an eastern border with the Cameroun Republic and borders Borno, Gombe and Taraba. Its daily minimum and maximum temperatures are at about 23.2 °C and 35.2°C, respectively. The average relative humidity is 44.2% and the average yearly rainfall is 718.1 millimeters. The area covers about 39,742.12 square kilometers (Adebayo *et al*., 2020).

Bull Sampling

Five (5) herds from each location were randomly selected and four (4) bulls were sampled from each herd making a total of twenty (20) bulls per location. The experiment spanned four months (March-June, 2024) which is the hot period of the year.

Physiological traits determined

1. **Rectal temperature (RT):** This was taken using a digital thermometer. The sensory tip was disinfected and inserted into the rectum at the display of L^{0}C by a thermometer (which is an indication that the thermometer is set for temperature reading) and was removed by the sound of alarm signal. It was recorded in ^{0}C
2. **Respiration rate (RR):** This was determined by counting the number of flank movements per minute using …. It was recorded in breaths per minute.
3. **Pulse rate:** It was measured by placing the stethoscope on the femoral arteries of the hind leg for 60 seconds. It was recorded in beats/minute
4. **Heat tolerance coefficient (HTC**): HTC was calculated based on heat tolerance index developed by Benezra (1954). The formula was based on both respiration rate and rectal temperature.

$$HTC = \frac{RR}{23} + \frac{RT}{38.33} \qquad (1)$$

All the aforementioned thermoregulatory indices were recorded weekly within the experimental period on the sixty (60) bulls (20from each location) in the morning at 08:00am and in the afternoon at 16:00 pm for the study periods.

Antioxidative traits

Antioxidants parameters determined were glutamine peroxide, superoxide dismutase, catalase and glutathione transferase determined using a modified form of Liebermanns-Burchard's method as described by Kingsley and Schaffert, (1949).

Serum antioxidant enzymes

Concentrations of serum antioxidant enzymes including total antioxidant capacity (TAC) were determined through spectrophotometer using the Nanjing Built-in kit according to manufacturer's instructions.

Results and Discussion

Table 1: Effect of location on heat on Physiological and stress indices of feedlot bulls fattened in the hot period of Mubi

Parameters	Buladega	Njari	Tike cattle market	SEM
Rectal Temperature (˚C)	38.65	38.50	38.75	0.37
Pulse Rate (beats/minutes)	35.67^a	30.40^b	35.90^a	0.84
Respiration Rate (Breaths/minutes)	31.78^b	33.90^b	34.40^a	1.45
Heat Tolerance Coefficient	2.39^b	2.48^{ab}	2.51^a	0.06

^{ab} Means with different superscripts within the same row differed significantly at 5%

The effect on location on physiological and heat stress index of feedlot bulls fattened in Mubi are shown in Table 1. Location of fattening significantly ($p<0.05$) affected physiological and heat stress indices except for rectal temperature (RT) which was non-significant ($p>0.05$). Tike cattle market recorded the highest of all the significantly affected the traits evaluated except for pulse rate where Buladega shared superiority with Tike cattle market (35.67 and 35.75 beats/minute), respectively. The least recorded values of most of the heat stress indices were in Njairi fattening site.

Animal response to heat stress becomes evident with altered physiological responses [increased RT, respiratory rate (RR) and panting] and behavior (Islam *et al.*, 2021). Respiration rate had been known to be one of the important biomarkers of heat stress in farm animals. Rashamol *et al.* (2018) also opined that RR may act as an early signal of heat stress condition in livestock. The higher values of RR and PR in the cattle fattened at Tike cattle market is an indication that the cattle are under heat stress. In a similar study on sheep, RT and RR increased due to heat stress which stimulated the hypothalamus' respiratory and heat centers (Habeeb *et al*., 2018; Saleh *et al*., 2022). Physiological adaptations leading to altered behavioral organizations are one of the ways animal's responses to heat stress (Becker *et al*., 2020; Islam *et al*., 2021). The increased values of RR, pulse rate (PR) and heat tolerance coefficient (HTC) is an indication that feedlot cattle fattened at Buladega and Tike Tike cattle market are more susceptible to heat stress. Respiration rate in cattle is the most appropriate indicator of thermal stress. The significant variations in RR obtained for location concur with the report of Brown-Brandl *et al*. (2005) who reported variation in RR when feedlot cattle were subjected to different environmental conditions with and without access to shade. They further reported that shade appears to reduce RR during portions of the day in all-weather categories. In the previous finding, it was reported that a simple provision of shade has reduced the animal's radiant heat load by 30% or more (Bond *et al*., 1967; Brown-Brandl *et al*., 2017). The animal's ability to cope with thermal stress is dependent on factors such as skin color, relative fatness, sex, prior exposure to heat and health status (Gaughan *et al*., 1999; Brown-Brandl *et al*., 2005; Brown-Brandl *et al*., 2017). Other areas that heat stress affect include males' reproduction functions such as sperm motility, spermatozoa mortality and abnormalities (Belhadj Slimen *et al*., 2016). Animals' susceptibility to stress depends on their individual intrinsic factors such as genotype, coat type, coat color, sex, total mass, body condition, health physiological and metabolic heat production and extrinsic factors such as temperature, relative humidity, wind, solar radiation, cloud cover and the general management (Gaughan *et al*., 2002; Islam *et al*., 2021). Other factors that affect the physiological responses in cattle include cow's parity, age, the production type, housing system, the frequency of milking and milking system the producers use (Smith and Risco, 2005; Isaksson, 2017).

Heat tolerance coefficient measures the adaptability of an animal during heat stress. Hence lower HTC may indicate an improved thermo-tolerance which is useful in genetic improvement in cattle (Kumar *et al*., 2017). Feedlot cattle raised outdoors are more vulnerable to heat stress due harsh environmental conditions, high-grain diets and overall body condition (Brown-Brandl *et al*., 2013; 2017). Abbaya *et al*. (2020) also reported an increased RR, PR and HTC as a result of heat stress in Nigerian indigenous cows raised on the subsistence system. Therefore, the low value of HTC recorded at Buladega suggest that the bulls fattened at that location are more adaptable to the environment while bulls fattened at Tike cattle market are more susceptible to heat stress.

Table 2: Correlation between Heat stress indices in feedlot bull fattened in Mubi

	Rectal Temperature	Pulse Rate	Respiration Rate
Pulse Rate	0.09		
Respiration Rate	0.16	-0.05	
Heat Tolerant Coefficient	0.29*	-0.03	0.99***

*= significant at 5%; **= significant at 1%, *** = significant at 0.1%

Among the correlated physiological and heat stress index, only RT and RR were significantly ($p<0.05$ - 0.01; r= 0.29 and 0.99) correlated with HTC (Table 2). The positive correlation exhibited between HTC with RT and RR is an indication that the two traits are controlled by one gene, pleoitropy (Fayeye 2014; Abbaya *et al*., 2023). Rectal temperature and RR are two visible physiological biomarkers used for determining thermal regulatory responses in cattle (da Costa *et al*., 2015; Li *et al*., 2021). The positive correlation observed between RR and HTC concurred with previous findings (Singh *et al*., 2014; Li *et al*., 2021; Abbaya, 2023) who reported a significant positive correlation between RR and HTC. However, the significant positive relationship between RT and HTC in this study contradict the findings of Abbaya (2023) who reported a non-significant relationship between the two traits. In a study conducted by Li *et al*. (2021) on dairy cows in the sub-tropical, temperature–humidity index was reported to have a positive correlation with RT and RR.

Table 3: Effect of location on antioxidation properties of feedlot bulls fattened in Mubi

Parameters	Buladega	Njairi	Tike cattle maket	SEM
Glutathione Transferase (IU)	3.11^{b}	2.61^{c}	3.60^{a}	0.39
Glutamine Perioxide (mg/l)	5.22^{b}	5.48^{a}	4.99^{a}	0.19
Superoxide dismutase (IU)	130.82^{b}	132.10^{b}	143.45^{a}	191
Gamma Glutamyl Tranferase (U/L)	12.10^{b}	12.71^{a}	11.97^{b}	1.84

^{abc}Means with different superscripts within the same row differed significantly at 5%; SEM = Standard Error of Mean.

The effect of location on the antioxidation properties of feedlot bulls are shown in Table 3. Location of fattening has affected ($p<0.05$) all the antioxidation properties studied. Higher values of Glutathione Transferase (GTT), and Superoxide dismutase (SOD) were recorded in bulls fattened at Tike cattle market while Gamma Glutamyl Tranferase (GGT) was higher in bulls reared at Njairi. Bulls reared at Njairi and Buladega shared superiority in Glutamine Perioxide (GP).

In most of the evaluated antioxidants in this study, bulls fattened in Tike cattle market recorded the highest values. This implies that bulls fattened at Tike cattle market might be more susceptible to oxidative stress than their counterparts in other locations studied (Sikora *et al*., 2008; Abbaya *et al*., 2023). Chen *et al.* (2011) also opined that increase in antioxidants such as GP, Catalase (CAT), and SOD might be a compensatory regulatory response to increased oxidative stress. Superoxide dismutase (SOD) is an essential antioxidant that eliminate superoxide radicals in the body (Lei *et al*., 2015; Li *et al*., 2021). Also, Saleh *et al.* (2022) opined that when the body's ability to neutralize the increased prooxidant, oxidative stress develops. Heat stress was also reported to increases the production of reactive oxygen species (ROS) production, especially the superoxide anion (Mujahid *et al*., 2005; Belhadj Slimen *et al*., 2016). Contrary to this, the present study, Isanullah *et al.* (2017) opined that cow exposed to hot summers showed lower antioxidants status compared to those in the cold winter. Decreased levels of TAC and SOD was reported in lambs exposed to heat stress which is an indication of endogenous antioxidant mobilization to neutralize free radicals (Ellamie *et al*., 2020) and disruption in the redox equilibrium (Saleh *et al*., 2022). Heat stress was also reported to reduce feed intake, depress thyroid gland activity (Aleena *et al*., 2016). Again, previous studies also revealed that cows exposed to heat stress recorded reduced levels of SOD and TAC leading to oxidative stress (Safa *et al*., 2019; Li *et al*., 2021). Discrepancies between the present finding with other previous findings, could be due to different type of animals used and the fact there are many factors that can affect the antioxidative traits responses in cattle such as parity, age, the production type, housing system, (Smith and Risco, 2005; Isaksson, 2017). This is also a confirmation of the fact that thermal stress initiates alterations in biological functions such as rectal temperature, feed intake, respiration rate, oxidative stress and disturb the concentration of free radicals, resulting in cellular oxidative stress (da Costa *et al*., 2015; Belhadj Simen *et al*., 2015; Kurokawa *et al*., 2016; Li *et al*., 2021)

Gamma Glutamyl Transferase is a ubiquitous glycosylated protein found in the outer surface of a cell membranes, which catalyzes the transfer of glutamyl groups to provide antioxidant prooxidant balance (Lonardo and Ndrepepa, 2022). Even though, the recorded values of GGT in this study were within the normal range for cattle (6 -17u/l). The high level of GGT in cattle fattened at Njairi is an indication that the bulls are susceptible to liver diseases since high GGT in blood is an indication of liver disease or liver bile ducts damage (Brennan *et al.*, 2022)

Table 4: Correlation between antioxidation properties of feedlot bulls fattened in Mubi

Parameters	Glutathione Transferase	Glutamine Peroxide	Gamma Glutamyl Transferase
Glutamine Peroxide	0.15		
Superoxide dismutase	0.26*	-0.44*	
Gamma Glutamyl Transferase	-0.67**	0.04	-0.22

*= significant at 5%; **= significant at 1%

The correlated relationship between antioxidation properties are shown in Table 4. Significant ($p<0.05$; r = - 0.67 to 0.26) negative and positive relationship exist between the studied properties. Glutathione transferase and SOD correlated positively (0.26) while a negative correlation existed between GP and SD (-0.44) and between GT and GGT (- 0.67). The positive correlation exhibited between GT and SOD is an indication that the two traits are controlled by one gene, pleoitropy (Fayeye 2014; Abbaya *et al*., 2023). While the traits that correlated negatively with each other suggest an antagonistic relationship (Abbaya *et al*., 2023).

Conclusion

Heat stress has resulted in an increase in physiological and oxidative stress in cattle fattened at Tike cattle making them more prone to heat load and oxidative stress caused by heat stress.

Recommendation

We recommend that shades be provided for the feedlot cattle fattened at the studied location, particularly Tike cattle market. Also, further studies with more locations and cattle be conducted for holistic information on the effect of heat stress on the performance of feedlot cattle.

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Conflict of interest

Authors declare no conflict of interest regarding the manuscript

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