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THERMO-PHYSIOLOGICAL RESPONSES AND OXIDATIVE STATUS OF WEST AFRICAN DWARF RAMS FED DIETS CONTAINING SUPPLEMENTAL TETRAPLEURA TETRAPTERA FRUIT MEAL

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Abstract

Plant secondary metabolites in *Tetrapleuratetraptera* fruit meal (TTFM) could be exploited as natural safe feed additives alternative to non- nutritive chemical and antibiotics to enhance rumen fermentation and feed utilization efficiency with negative oxidative stress. The study investigated the responses of West African Dwarf (WAD) rams to the diets containing varying levels of supplemental *Tetrapleura tetraptera* fruit meal on the oxidative status and thermo-physiological parameters. Thirty five (35) WAD rams with an average live weight of 13.20±0.2 kg were used in a completely randomized design for 140 days. Five concentrate diets containing varying levels (0, 0.5, 1.0, 1.5 and 2.0 %) of TTFM were formulated while *Panicum maximum* was fed as a basal diet. The rectal temperature, pulse rate and respiratory rate were measured at two week intervals while blood was collected through jugular veins at the onset and at the end of feeding trial to determine oxidative status parameters in terms of superoxide dismutase (SOD), glutathione peroxidase, thiobarbituric acid reactive substance (TBARS).Data collected were subjected to one way Analysis of Variance (ANOVA). No significant difference observed (p>0.05) in the rectal temperature while the pulse rate and breathing rate increased significantly (p<0.05) till 12th week of the experiment. Increased glutathione peroxidase, superoxide dismutase and lowered thiobarbituric acid reactive substance were recorded on the rams at the end of the feeding trial. It was therefore concluded that inclusion of *Tetrapleura tetraptera* up to 2 % level reduced the oxidative stress in the experimental animals coupled with better thermo-physiological responses.

Keywords: rectal temperature, stress, breathing rate, pulse rate, oxidative, superoxide dismutase.

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1. Introduction

Domestic animals do not have constant normal temperatures and considerable variations will be found in the temperature of normal animals under different conditions. In general, animal temperatures will vary, depending on physical activity, stage of pregnancy, the time of day, and enviro Nmental surroundings [1]. Oxidative stress results when pro-oxidants (free radicals) exceed the capacity of antioxidants. A free radical is defined as any species capable of independent existence that contains one or more unpaired electrons [2]. Reactive oxygen metabolites (ROMs) are capable of attacking all of the major classes of bio-molecules, although lipids are particularly susceptible [3]. Oxidative stress is a phenomenon associated with pathogen ethic mechanisms of several diseases including atherosclerosis, neurodegenerative diseases such as Alzheimer's and Parkinson's diseases, cancer, diabetes mellitus, inflammatory diseases, as well as psychological diseases or aging processing [4]. Oxidative stress can be particularly dangerous because no clinical symptoms are shown and the condition is diagnosed by means of dedicated analytical methods. Therefore, this experiment was designed to determine thermo-physiological responses and oxidative status of West African Dwarf rams fed supplemental *Tetrapleura tetraptera* fruit meal.

2. Materials and methods

The study was conducted at the small ruminant unit of the Federal College of Animal Health and Production Technology, Moor Plantation, Ibadan. The unit is located in the south western part of Nigeria. The area lies within the rain forest ecological zone and fall within longitude and latitude 7°–27°Nand 3°–25°E respectively and altitude of 220−300 m above sea level◦ with the average rainfall of about 1250 mm. The temperature and relative humidity ranges from 30–35 °C and 76–84 % respectively. Thirty five (35) West African dwarf rams rando mly allotted to five dietary treatments in a completely randomized design with 5 replicates chosen from each treatment between 6 and 8 months of age and weighing between 12.80 and 13.00kg were used for the experiment. The fresh *Tetrapleuratetraptera* fruits were purchased from a repuTable market in Ibadan, Oyo State Nigeria. This was identified and authenticated at the Herbarium unit of the Forest Research Institute of Nigeria (FRIN) Ibadan, Oyo state, Nigeria. The authenticated fruits were rinsed in sterile water and air-dried for two (2) consecutive weeks at room temperature and later milled into powdery form before compounding with other feedstuffs as fruit meal at 0 %, 0.5 %, 1.0 %, 1.5 % and 2.0 % inclusion levels for treatments 1, 2, 3, 4 and 5 respectively as shown in **Table 1**. Each animal was served with *Panicum maximum* grass *ad-libitum* and concentrate diets at 3 % body weight twice daily.

Table 1

Gross compositions of concentrate diets containing varying levels of *Tetrapleuratetraptera* fruit meal for WAD rams

	Inclusion levels of TTFM (%)				
Ingredients	**0**	**0.5**	**1.0**	**1.5**	**2.0**
Corn bran	30.00	30.00	30.00	30.00	30.00
Palm kernel cake	25.00	25.00	25.00	25.00	25.00
Rice bran	20.00	20.00	20.00	20.00	20.00
Wheat offal	15.00	15.00	15.00	15.00	15.00
Groundnut cake	5.00	5.00	5.00	5.00	5.00
TTFM	–	+	++	+++	++++
Dicalcium phosphate	3.00	3.00	3.00	3.00	3.00
ǂPremix	1.00	1.00	1.00	1.00	1.00
Salt	1.00	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00	100.00

Note: TTFM – Tetrapleuratetraptera fruit meal; + – 0.5 kg TTF; ++ – 1.00 kg TTFM; +++ – 1.50 kg TTFM; ++++ – 2.00 kg; ǂ – contains: Vitamin A (I.U.) 10,000.000; Vitamin D_2 (I.U.) 2,000,000; Vitamin E (I.U) 20,000; Vitamin K (mg) 2,250; Riboflavin (mg) 5000; Pyridoxine (mg) 275; Biotin (mg) 50; Pantothenic acid (mg) 7500; Vitamin B_1 (mg) 175; Vitamin B_{12} (mg) 15.0; Niacin (mg) 27,500; Folic acid (mg) 7500. Choline Chloride (mg) 400; Antioxidant (mg) 125; Fe (g) 20.0; Zn (g) 50.0; Mn (g) 80.0; Cu (g) 5.0g; I (g) 12.0; Co (mg) 200; Se (mg) 200.

The chemical compositions of the experimental diets containing varying levels of *Tetrapleuratetraptera* fruit meal was presented in **Table 2**. The dry matter content ranged from 80.90 to 81.55 %, the crude protein (15.20–15.43 %). The neutral detergent fibre (NDF) ranged from 48.64 to 60.38 %. The highest value of minerals in terms of calcium, phosphorus, magnesium, phosphorus and sodium values recorded were 2.31, 2.22, 4.01, 0.98 and 0.34/kg respectively.

Table 2

Chemical compositions of experimental diet containing varying levels of *Tetrapleuratetraptera* fruit meal

Parameters	Inclusion levels of TTFM (٪)				
	0	**0.5**	**1.0**	**1.5**	**2.0**
Dry matter	81.50	81.40	81.10	80.90	81.55
Crude protein	15.20	15.28	15.34	15.38	15.43
Ether extract	8.40	8.70	8.95	8.96	9.02
Ash	110.90	10.95	10.75	11.02	10.93
Crude fibre	115.89	15.91	16.05	16.10	16.23
Nitrogen free extract	49.51	49.16	48.71	48.54	48.39
Neutral detergent fibre	48.64	52.62	54.69	58.19	60.38
Acid detergent fibre	34.64	36.84	38.93	43.64	47.19
Acid detergent lignin	9.87	11.64	14.62	16.32	17.11
Hemicelluloses	14.00	15.78	15.76	14.55	13.19
Cellulose	24.77	25.20	24.31	27.32	30.08
Tannin	0.32	0.38	0.45	0.56	0.74
Saponin	0.71	0.73	0.78	0.84	0.95
Flavonoid	2.32	2.44	2.67	2.82	3.54
Alkaloid	1.87	1.86	1.90	2.01	2.23
Hydrogen cyanide	0.12	0.15	0.22	0.25	0.26
Sterol	0.76	0.96	1.11	1.36	1.45
Macrominerals (g/kg)					
Calcium	0.84	0.92	1.24	1.68	2.31
Phosphorus	1.12	1.32	1.65	1.97	2.22
Magnesium	2.47	2.54	2.95	3.54	4.01
Potassium	0.74	0.56	0.98	0.79	0.98
Sodium	0.24	0.28	0.28	0.31	0.34
Microminerals (mg/kg)					
Manganese	234.12	242.23	251.23	264.33	267.67
Iron	184.60	177.80	173.30	195.45	205.54
Copper	11.34	8.79	10.33	11.65	10.98
Zinc	55.32	44.76	45.65	51.21	48.87

2. 1. Thermo-physiological and blood oxidative determination

Vital signs or responses of the animals such as heart beat rate, pulse rate and rectal temperature were taken fortnightly. The heart beat was taken with the use of effective stethoscope which was placed on the animal's thoracic region on the left hand side to observe the numbers of beats in a minute. Pulse rate was also taken by allowing the rams to calm down, then find the arteries at the hock joint of the hind leg, watching a stop clock and count the number of beats in a minute. The rectal temperature was taken with the use of reliable digital thermometer placed at the side of the rectum. Blood (2 ml) was also collected into lithium heparin tubes placed on ice for determination of the activities of thiobarbituric acid reactive substance (TBARS), gluthathione peroxidase, superoxide dismutase and protein thiol. This was determined using the methods of [5]. To determine superoxide dismutase, 0.05 ml of sample diluted in 4.5 ml of distilled (1:9) dilution factor. An aliquot of 0.2 ml of the diluted sample was added to 2.5 ml of the 0.05M carbonate buffer (pH 10.2) in a cuvette and left to equilibrate. The reaction was started by addition of 0.3 ml of freshly prepared 0.3 Nm epinephrine. The reference cuvette contained 2.5 ml of carbonate buffer, 0.3 ml of substrate (adrenaline) and 0.2 ml of distilled water. The increase in absorbance at 480 Nm

was monitored, while in Thiobarbituric acid reactive substance (TBARS) determination, 1.0 ml of TBARS reagent was added and incubated in boiling water bath for 15 minutes. The tube was immediately placed on ice or under running tap to cool. It was centrifuged at 1000 rpm for 10 minutes and then the absorbance of the clear supernatant was read against blank at 535 Nm. Estimation of protein thiol was done using the method of [6]. 0.5 ml of the blood sample and the absorbance is read within 5 minutes of addition of DTNB at 412 Nm against a blank containing 0.5 ml of water instead of sample

2. 2. Statistical analysis and experimental design

Data obtained were subjected to analysis of variance using [7] SAS (2013) in a Completely Randomized Design. One-way analysis of variance (ANOVA) was used to determine the means and standard error. Treatment means were compared using Duncan's new multiple range test in the package.

3. Result and discussion

Table 3 shows the rectal temperature, pulse rate and heart beat of West African Dwarf rams fed diets containing *Tetrapleura tetraptera* fruit meal respectively. The rectal temperature was not significantly affected (p>0.05) by dietary inclusion of TTFM. The rectal temperature ranged from 37.24–38.20 ^{o}C.Significant differences (p<0.05) were observed in the heart beat rate observed from the beginning of the experiment till week 12.

Table 3

Rectal temperature parameters of West African dwarf rams fed diets containing varying levels of *Tetrapleura tetraptera* fruit meal

Parameters, °C	Inclusion levels of TTFM						
	Weeks	0	0.5	1.0	1.5	2.0	SEM
Rectal temperature (°C)	0	37.96	37.70	38.14	38.12	38.28	0.12
	2	37.30	37.58	37.24	37.36	37.86	0.10
	4	37.34	37.30	37.30	37.56	37.64	0.11
	6	37.18	37.32	37.78	37.90	37.70	0.12
	8	38.20	37.80	38.00	37.90	38.00	0.14
	10	37.46	37.79	37.86	37.72	37.46	0.10
	12	37.70	37.68	37.76	37.80	37.86	0.09
	14	37.78	37.84	37.68	37.78	37.72	0.10
	16	37.32	37.56	37.70	37.34	37.36	0.10
	18	37.26	37.28	37.62	37.38	37.28	0.09
	20	37.62	37.26	37.00	37.42	37.16	0.09

Note: TTFM – Tetrapleura tetraptera fruit meal; SEM – Standard Error of Means.

Presented in **Table 4** was the pulse rate of West African dwarf rams fed diets containing *Tetrapleura tetraptera* fruit meal. The pulse rates were significantly influenced (p<0.05) from the onset of the experiment at week 0 till week 10. The lowest pulse rate 50.80 min/ was recorded at 0 % TTFM while the highest pulse rate (92.80/min) was obtained with animals offered with 1.0 % TTFM. Significant differences were not observed (p>0.05) from week 12 of the experiment till the end. Though the range of pulse rate recorded from week 12 (52.86–93.80/min) was numerically higher but no significant difference observed (p>0.05).

Table 5 shows the heart beat of West African dwarf rams fed diets containing varying levels of *Tetrapleura tetraptera* fruit meal. The range of heart beat ranged from 25.60–45.60 beat/min. Initial higher heart beat was observed at the beginning of the experiment till week 8 when the values continue to reduce until no significant difference (p>0.05) from week 14. The highest heart beat rate at week 20 was observed in the treatment 0 % TTFM with the value (38.20 beat/min) while the least value 28.40beat/min was observed at 1.0 % TTFM

Table 4

The Pulse rate of West African dwarf rams fed diets containing *Tetrapleura tetraptera* fruit meal

Parameters	Inclusion levels of TTFM						
	Weeks	0	0.5	1.0	1.5	2.0	SEM
Pulse rate (beat/min)	0	69.80^{b}	69.20^{b}	77.40^{ab}	77.40^{ab}	89.60^{a}	2.30
Pulse rate (beat/min)	2	71.60^{b}	80.40^{ab}	78.40^{ab}	71.40^{b}	88.80^{a}	2.29
Pulse rate (beat/min)	4	67.60^{c}	85.00^{ab}	78.40^{abc}	70.40^{bc}	87.20^{a}	2.53
Pulse rate (beat/min)	6	50.80^{c}	67.80^{b}	58.20^{bc}	83.80^{a}	57.20^{bc}	2.91
Pulse rate (beat/min)	8	68.20^{c}	88.60^{ab}	73.00^{bc}	83.80^{ab}	82.00^{abc}	2.49
Pulse rate (beat/min)	10	82.60^{ab}	86.20^{ab}	92.80^{a}	78.80^{b}	84.20^{ab}	1.91
Pulse rate (beat/min)	12	86.80	84.00	82.80	85.00	84.00	2.22
Pulse rate (beat/min)	14	85.00	75.80	92.00	75.00	69.60	3.93
Pulse rate (beat/min)	16	93.60	80.40	89.40	90.40	80.40	2.52
Pulse rate (beat/min)	18	80.20	85.60	84.60	93.80	85.80	1.76
Pulse rate (beat/min)	20	88.20	79.60	84.00	88.80	82.40	1.55

Note: TTFM – Tetrapleura tetraptera fruit meal; SEM – Standard Error of Means; ^{a,b,c} – means with different superscripts along the same row are significantly different($p>0.05$).

Table 5

The Heart beat of West African dwarf Ram fed diets containing varying levels of *Tetrapleura tetraptera* fruit meal

Parameters	Inclusion levels of TTFM						
	Weeks	0	0.5	1.0	1.5	2.0	SEM
Heart beat breaths/min	–	46.00^{a}	38.80^{ab}	41.40^{ab}	34.80^{b}	45.60^{a}	1.57
	2	44.40	39.60	45.60	37.00	44.00	2.02
	4	35.80	31.40	35.60	30.80	37.20	1.55
	6	32.00^{a}	42.40^{a}	43.60^{a}	32.60^{b}	37.20^{ab}	1.06
	8	39.20^{a}	32.60^{b}	30.00^{b}	31.40^{b}	29.60^{b}	1.53
	10	25.80^{c}	30.00^{bc}	40.40^{a}	37.60^{ab}	34.60^{ab}	1.54
	12	25.60^{c}	34.80^{ab}	41.00^{a}	30.80^{bc}	32.20^{abc}	1.68
	14	30.00	37.60	28.80	36.20	30.00	1.30
	16	30.80	35.40	30.40	34.40	34.80	1.48
	18	32.60	34.40	30.60	31.20	35.20	1.50
	20	33.60	38.00	28.40	31.40	31.20	0.12

Note: TTFM – Tetrapleura tetraptera fruit meal; SEM – Standard Error of Means; ^{a,b,c} – means with different superscripts along the same row are significantly different($p>0.05$).

Presented in **Table 6** is the effect of *Tetrapleura tetraptera* fruit meal on oxidative status of West African Dwarf (WAD) rams. There were significant differences ($p<0.05$) on Thiobabituric acid Reactive Substance (TBARS), Superoxide dismutase (SOD), Glutathione peroxidase (*GPx*) but there were no significant differences($p>0.05$) on the THIOL and Catalase. The initial and final Thiobabituric Acid Reactive Substance (TBARS) ranged from (1.53–2.41 mol/l) having a variation of –0.64 mol/l in rams fed with 2 % *Tetrapleura tetraptera fruit meal.* The initial and final Superoxide Dismutase (SOD) ranged from (28.67–33.99 mg/ ml) having a negative variation of –5.32 mg/ ml. The initial and final Glutathione Peroxidase (GP_x) ranged from (28.32–34.15 mg/ ml) having a variation of –5.83 in rams fed with 2 % *Tetrapleura tetraptera* fruit meal. Even though, there was no significant difference ($p>0.05$) in THIOL having the initial and final result ranged from 227.31 to 249.89 R-SH with a variation of –11.44 in ram fed with 2 % *Tetrapleura tetraptera* fruit meal and Catalase having the initial and final result ranged from (120.52–149.59 u/mol) with a variation of –3.45 u/mol in ram fed with 2 % *Tetrapleura tetraptera* fruit meal. However, Catalase has the lowest variation of –2.93 in rams fed with 2.0 % *Tetrapleura tetraptera* fruit meal.

Table 6

Oxidative status of West African Dwarf rams fed *Tetrapleura tetraptera* fruit meal

Parameters	Inclusion levels of TTFM (%)						
	0	0.5	1.0	1.5	2.0	SEM	P-value
Thiobarburitic Acid Reactive Substance (mol/l)	TBARS	TBARS	TBARS	TBARS	TBARS	TBARS	TBARS
Initial	2.14	1.53	1.65	1.12	1.08	0.21`	0.45
Final	2.41^{a}	2.17^{ab}	1.74^{ab}	1.33^{ab}	0.89^{b}	0.17	0.04
Variation	0.19^{ab}	0.64^{a}	0.09^{b}	0.21^{ab}	0.19^{ab}	0.08	0.03
Superoxide Dismutase (mg/ ml)	SOD	SOD	SOD	SOD	SOD	SOD	SOD
Initial	29.71^{b}	40.32^{a}	33.83^{b}	29.13^{b}	33.99^{b}	2.49	0.00
Final	30.26^{b}	28.67^{b}	28.64^{b}	31.39^{b}	38.37^{a}	2.72	0.03
Variation (mg/ ml)	0.55^{ab}	$–11.65^{b}$	$–5.19^{b}$	2.26^{ab}	4.38^{a}	0.73	0.02
Glutathione Perioxidase (mg/ ml)	GP_X	GP_X	GP_X	GP_X	GP_X	GP_X	GP_X
Initial	34.15	35.18	34.37	38.28	32.68	1.49	0.42
Final	28.32^{b}	31.22^{ab}	32.52^{ab}	34.17^{a}	35.19^{a}	1.63	0.04
Variation	$–5.83^{b}$	$–3.97^{ab}$	$–1.79^{ab}$	$–4.11^{ab}$	2.16^{a}	1.19	0.00
Thiol (R-SH)	R–SH	R–SH	R–SH	R–SH	R–SH	R–SH	R–SH
Initial	249.89	230.83	245.20	240.17	244.76	5.09	3.16
Final	244.68	227.31	240.80	234.12	233.32	5.22	3.24
Variation	–5.21	–3.52	–4.40	–6.05	–11.44	2.59	2.77
Catalase(U/ ml)	CAT	CAT	CAT	CAT	CAT	CAT	CAT
Initial	127.86^{b}	126.65^{b}	134.46^{ab}	138.57^{ab}	149.59^{a}	5.31	0.00
Final	122.73^{b}	120.52^{b}	129.94^{ab}	135.12^{ab}	146.66^{a}	5.45	0.01
Variation	–5.13	–6.12	–4.52	–3.45	–2.93	1.73	0.89

Note: TTFM – Tetrapleura tetraptera fruit meal; SEM – Standard Error of Means; GP_x – Glutathione peroxidase; SOD – Superoxide dismustase; CAT – Catalase; ^{a,b,c} – means with different superscripts along the same row are significantly different(p>0.05).

Oxidative stress is an active field of research in veterinary medicine and has been implicated in numerous disease and conditions including sepsis, mastitis, acidosis, respiratory and joint diseases. Compared to human medicine, only a limited number of conditions have been investigated with regards to the effect of oxidative stress in ruminant [8]. At the commencement of the study, Gluthathione peroxidase, thiol, catalase obtained for the oxidative biomarkers were not statistically affected by the inclusion of Tetrapleura tetraptera in the diet of the Sheep. However, thiobarburitic (TBARS) Superoxide dismutase (SOD) were significantly (P>0.05) affected by inclusion of Tetrepleura tetraptera fruit meal. The TBARS ranged between 0.89–2.41 mol/l and SOD ranged between 29.71–50.32 mol/l) were in agreement with recent finding by [9]. TBARS test offer at best a narrow and somewhat empirical on the complex process of lipid peroxidation, the value of TBARS (0.89–2.41 mol/l) was within the range [10] reported by [11] for clinically healthy male and female Iranian goats. Increased Thiol in all treatment suggested that the increase in protein supplementation acts in protecting both lipids and protein against oxidation by free radicals. Functional consequences of Thiol-SH group losses include protein unfolding catalytic inactivation and decreased anti oxidative capacity [12]. In [13] reported that when oxidative stress arises as a consequence of pathogenic event, a defense system promotes the regulation and expression of anti-oxidant enzymes but in protein, energy malnutrition, the defense is weak to promote the regulation of antioxidant enzymes. The negative variation Gluthathione, Thiol (*GPx*–1.79 to – 4.11), Thiol (–3.52 to 11.44) observed can be ascribed to the non – effective of anti-oxidant in treatment 2, 3, and 4 often resulted in poor growth and several diseases [14]. Lower TBARS variation can be responsible for higher mitochodrial SOD variance which has the ability to protect cell from damage due to the secondary generation of highly reactive hydroxyl group from superoxide ion to hydrogen peroxide H_2O_2 [15] The maintenance of body temperature within physiological limits is necessary for animals to remain healthy, survive and maintain its productivity [16]. It has been demonstrated that the ability of ruminants to regulate body temperature is species and breed dependent [17]. The rectal temperature obtained in this present study fell within the range 37.67–38.96 °C reported by [18] for

Sulffolk sheep fed diets supplemented with yeast culture for 22 weeeks. This corroborated with the findings of [19] that feeding of yeast culture favourably affects the body thermo-regulation and the mineral content most especially selenium maintained body temperature. In [20] observed the same trend when working with Suffolk and Ossimi sheep by supplementing their diets with selenium, the rectal temperature tended to decrease gradually up to 16th week of gestation then increased till lambing. The range obtained in this study lower than the 38.71–41.02 °C reported by [21] who determined thermo-physiological responses of West African Dwarf bucks to diets containing *Pennisetum purpureum* and unripe plaintain peels. The difference might be attributed to different enviro Nmental conditions, production level and feeding status as higher producing animals are more susceptible to heat stress because they generate more metabolic heat [22]. For adult sheep fed above maintenance, the estimated lower critical temperature is 31 °C [23]. The increase of body core temperature and rectal temperature has been considered as good indicator to the level of heat stress upon animals [24]. The increase in rectal temperature was in agreement with [25] as a result of evolution of heat in the fermentation process, rumen temperature is effect of body temperature which can be used to predict diseases and heat stress.

The respiratory is an indicator of heat stress and to estimate the adverse effects of enviro Nmental temperature [24]. In [26] suggested that respiratory rate was a practical and reliable measure of heat load and stated that respiration above 80breath/min is an indicator of high heat stress. In sheep, panting is the major evaporatory heat loss mechanism and respiratory frequencies tend to follow closely the heat loss by evaporation [16]. The respiration rate obtained in this present study higher than the 26.22–28.41 breathe/min observed by [22] when supplementing diet of Suffolk sheep with selenium. It was also higher than the range16.95–19.67 breathe/min reported by [17]. The values obtained fell within the range 36.8–39.80 breathe/min reported by [18]. In [20] also suggested a range above 12–20 breathes/min as indicator of heat stress in sheep and goats. The pulse rate values observed in this current study was in agreement with the range 60–90 beats/min reported by Edward, 2015 for normal pulse rate in sheep and goats. It was also within the range of 65.62–90.01 beat/min reported by [22] for Ossimi sheep fed diets supplemented with selenium. The variation in the pulse rate has been reported by [26] to reflect the rate at which heart pumps blood through the body. The highest values of heat stress index obtained in animals fed diets containing 1.0 % TTFM until 10th week of the experiment was in consonance with high values exhibited in rectal temperature and pulse rate, which is an indication of heat stress. The rectal temperature and pulse rate are used to indicate the physiological status and adaptability of domestic animals to stressful condition [27]. The observed accelerated heart rate could be due to the reported redistribution of blood to peripheral tissues during heat exposure in sheep and goats [28]. The observed increase in serum total protein could be due to dehydration, which has been reported to occur as a result of increased breathing rate [5].

4. Conclusions

The pulse rate and breathing rate decreased as the days of experiment increased due to positive effect of African porridge in reducing stress. Higher levels of superoxide dismustase and glutathione peroxidase at 2 % inclusion indicated that the additive TTFM reduced oxidative stress in West African dwarf rams.

To reduce the levels of free radicals, TTFM could be added to the diets of WAD rams up to 2 % thereby reducing the oxidative stress in the animals.

Conflict of interest

The authors certify that they have no conflict of interest in relation to this research whether financial, personal, authorship or otherwise that could affect the research and its results presented in this paper.

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Data availability

This manuscript has no associated data.

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