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RESPONSE OF MACA (*Lepidium meyenii*) POWDER SUPPLEMENTATION ON PHYSIOLOGICAL AND SERUM ELCTROLYTE RESPONSES OF YANKASA RAMS DURINGHOT SEASON

*Gaddafi, S., Garba, M.G., and Yahaya, M.A
Department of Animal Science, Federal University Dutsin-Ma, Katsina State, Nigeria
*corresponding author: sanigaddafi4@gmail.com: GSM: +234(0)7067212353

ABSTRACT

This study assessed the effect of maca (*Lepium meyenii*) powder supplementation on physiological and serum electrolyte responses of Yankasa rams raised during dry hot season of Sudan savannah zone of Nigeria. A total of 20 pubertal Yankasa rams were divided into four treatment groups of 0, 5, 10, 15g/ Kg powdered maca per kg diet with five (5) rams each per treatment in a Completely Randomized Design (CRD). Data were analysed using Statistical Analysis System (SAS) where treatment means were separated using Duncan multiple range test (DMRT). The result revealed that maca supplementation significantly ($P<0.05$) lower thermoregulatory responses of Yankasa rams in this study. No significant ($P>0.05$) differences of meteorological data of study area across the experimental period. With the exception of potassium all other plasma electrolytes were not significantly ($P>0.05$) differences. No adverse and detrimental changes were observed in plasma electrolytes of Yankasa rams supplemented maca powder in this study. It could be concluded that supplementation of maca power from 5 to 15g/kg diet have beneficial adaptogenic effect of modulating rectal temperature thereby reducing respiratory rate and pulse rate. This study provides insights into maca powder potentials as a natural intervention for improving thermal tolerance and hydration status of Yankasa rams during dry hot season. It is therefore recommended that farmer should supplement maca at 15g/kg during hot dry season to mitigate negative physiological responses and electrolyte balance.

Key Words: Maca, Physiological, Electrolyte, and Yankasa Rams

INTRODUCTION

Climate change refers to a change in climate which is attributed directly or indirectly to human activities and natural variability that alters the composition of the global atmosphere over a long period of time (IPCC, 2007). The variations in climate parameters affect different sectors of the economy, such as agriculture, livestock production, heath, water, energy, e.t.c. According to Intergovernmental Panel on Climate Change, Africa is one of the most vulnerable continents to climate change and climate variability (IPCC, 2007). In mammals, global warming causes significant increases in body temperature above the physiological homoeothermic point (hyperthermia) with consequent organic suffering (heat stress) that leads to impaired physiological and reproductive activities (Raffaela, 2019). Heat stress has become one of the most important factors affecting the reproductive performance of mammals. Thermoregulation and electrolyte balance are critical physiological processes that maintain homeostasis in the body. Disruptions in these systems can lead to heat-related illnesses, dehydration, and impaired physical performance (Kenefick and Sawka, 2007).

Natural supplements, such as *lepidium meyenii* (maca), have gain attention for their potential adaptogenic properties, including effects on energy metabolism, thermoregulation and electrolyte balance (Gonzales, 2012). Maca as a traditional Peruvian herb, known as "*Gadali* or *Albasar tamoji*" in hausa language (Gaddafi *et al.,* 2023) is rich in bioactive compounds such as glucosinolates, pholyphenol and minerals (e.g. calcium, potassium, and magnesium), which may influence thermoregulatory mechanisms and serum electrolyte levels (Wang *et al.,* 2007). Some studies suggest that maca enhance physical endurance and may mitigate heat stress by modulating metabolic pathways (Stone *et al.,* 2009). Additionally, its mineral content could help maintain electrolyte equilibrium, particularly during strenuous animal activities, exercise or heat exposure (Gonzales *et al.,* 2014). However, the exact mechanisms by which maca affect thermoregulation and serum electrolytes remain unclear. While some evidence points to its adaptogenic and ergogenic effects (Hermann and Petraglia, 2019). This study aims to evaluate the impact of maca supplementation on thermoregulatory responses and serum electrolyte balance of Yankasa rams raised during dry hot season.

Materials and methods

Experimental site

This experiment was carried out at in Small Ruminant unit of Prof. Lawal Abdu Saulawa, Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State. The site lies between latitude 12º27`18`N and 7º29`29`E and 605 meters above sea level with an annual average rainfall of 700mm within Sudan Savannah.

Experimental animals and design

A total of twenty (20) pubertal Yankasa rams which was divided into four treatment groups of 0, 5, 10, 15g/Kg powdered maca with five (5) rams each per treatment in a completely randomized design (CRD).

Experimental Feed Preparation

All the feed materials that were used in the experimental diets' preparation was purchased from selling and processing centres in Dutsin-Ma. Maize and cotton seed cake was ground and packed in sacks for experimental diets compounding. Whereas groundnut hay was chopped before mixing, other feed ingredients such as wheat offal, maize bran, bone meal, and table salt were purchased from the different centres in Dutsin-Ma town.

Diet was formulated to meet the dietary requirement for breeder rams according to dietary recommendation of NRC (2016) for tropical rams.

Preparation of Maca Powder

Fresh maca was procured from herbal vendor in Dutsin-Ma Market, the maca was washed by tap water, and the fibrous roots was separated from the top. the roots was sliced to 2-cm-thick pieces and sun dried for 72 hours at Animal Science Laboratory, Department of Animal Science, Federal University Dutsin-Ma to the moisture content of 6-9%. The maca slices was ground into powders, using laboratory mortar and pastel later the ground maca were sieved through 1-mm wire-mesh, and stored at -20ºC before use.

Data collection

Thermoregulatory indices determination

The thermoregulatory parameters determined were respiratory rate, rectal temperature, and pulse rate:

Rectal temperature: the sensory tip of a digital thermometer was inserted 1cm depth into the rectum of animals at the display of LºC by a thermometer is indicated that the thermometer is set for temperature reading). Each rams was restrained gently and calmly and the reading lasted until the thermometer beeped.

Pulse rate: this was measured using a stethoscope and stop watch. The stethoscope was placed on the left region of the thoracic vertebrae of the rams while the stop watch was used to count the number of heart contractions (rhythms) in one minute.

Respiratory rate: the respiratory rate was determined while the rams is resting by visually counting the flank movements for one minute using a stop watch.

Meteorological Observation

The ambient temperature and relative humidity of the internal and external environment of the experimental site was recorded in the morning and evening daily and was measured with the aid of digital thermometer and hygrometer throughout the experimental period.

Serum biochemical determination

Blood and serum samples were collected at the end of the experiment (12 weeks post trail) using sterile syringe and needle through jugular venipuncture from three (3) overnight four fasted rams from each treatment. About 5 ml of blood were collected into labelled sterile lithium heparin sample bottles and were used for the serum biochemical analysis. The sample was centrifuged at 3000 rpm for 15 minutes. Separated serums was stored frozen at -20ºC in sample bottles without anticoagulant until the time of analysis. The serum electrolyte indices determined were serum calcium, potassium, phosphorus, creatinine, sodium, chloride, and blood urea nitrogen.

Data analysis

All data obtained in this study were subjected to statistical analysis using Statistical Analysis System (SAS) and treatment means were separated using Duncan multiple range test (DMRT).

Result and discussion

Meteorological Data of Experimental Site

The records on the meteorological information of experimental site during the study period were presented in table 1 below. Information on meteorology of the study area is very essential in assessing direct and indirect effects of climatic condition on animal physiology, behaviour, feed availability and diseases prevalence. Bohmanova *et al.* (2007) states that heat stress reduce feed intake, growth rates, milk production and reproductive efficiency in dairy cattle. Records showed that there were no significant (P>0.05) differences in ambient temperature however, there were considerable numerical differences between months in which the month of June (39.62°C) had the highest ambient temperature followed by July (38.55°C) while low temperature were recorded in the month of May (38.17°C). No significant (P>0.05) differences of relative humidity were recorded in this study. Research findings showed that high humidity reduces evaporative cooling (sweeting and panting), making the animals more vulnerable to heat stress (Gaughan *et al.,* 2019).

Table 1: Meteorological Data of Experimental Site

Parameters	May	June	July	SEM	LOS
Ambient temperature (ºC)	38.17	39.62	38.55	0.944	NS
Relative humidity (%)	51.34	47.19	52.34	2.92	NS

SEM= Standard error mean, LOS= Level of significance

Effect of Maca supplementation on thermoregulatory responses of Yankasa rams

The result on the effect of maca supplement on thermoregulatory responses of Yankasa rams during hot season were presented in table 2 below. The result revealed no significant (P>0.05) changes in rectal temperature. However, there were considerable numerical variations where T2 had the highest (39.30°C) followed by T1 (38.83°C), T3 (38.77°C) while lowest rectal temperature was recorded in T4 (38.70°C). These findings authenticate the literatures stating maca has vital role on body temperature and thermoregulation in which maca has been traditionally used by Andean population to enhance thermogenesis and endurance to climate changes of either cold or heat stress (Gonzales *et al.,* 2003). Research further indicates that maca may influence thermoregulation through hormonal and metabolic pathways because maca contain vitamin C and E which play important role in ameliorating thermoregulatory parameters by directly alters the thermal set point thereby decreasing prostaglandin output which has a direct effect on hypothalamic-thermoregulatory zone (Ganong, 2001). The result revealed significant (P<0.05) differences in respiratory rate of Yankasa rams fed diet containing maca. T1 had the highest respiratory rate (RR) (29.67brpm) followed by T2 (28.33brpm), T3 (26.67brpm) and T4 (26.00brpm). This descending order of RR with increased level of maca could be linked to the adaptogenic properties of maca for the maintenance and stabilizing respiratory rate and this assertion could further validate with the research carried out in cattle on high-altitude that maca supplementation may help maintain normal respiratory function by enhancing oxygen utilization. Similarly, research in poultry, (Tossen *et al.,* 2023) showed that maca-fed birds exhibited lower stress-induced respiratory fluctuations, suggesting a role in reducing physiological stress. The physiological mechanisms of maca on reducing respiratory rate could be due to metabolic regulations of bioactive compounds such as glucosinolates which may enhance metabolic rate and oxygen utilization, affecting heart rate, respiration stabilization and temperature control. Secondly, could be due to adaptogenic effects; maca as an adaptogen may help the body resist stress-induced fluctuation in vital parameters and promotes homeostasis (Gonzales, 2012). The result however, showed significantly (P<0.05) lower pulse rate with increase maca level in this study. T1 had the higher (88.33btpm) pulse rate while T4 had the lower (72.00btpm) pulse rate. This study further proved the maca effects on heart rate and cardiovascular function were some studies report that maca supplementation reduces resting heart rate, possibly due its adaptogenic effects on the autonomic nervous system (Lee and Chen, 2024). In another studies on cattle and sheep suggest that maca may help to maintain heart rate stability under stressful conditions, likely due to its adaptogenic properties (Gonzales et al., 2006). There are four likely mechanisms for maca role to influence thermoregulation: firstly, adaptogenic properties and stress response: maca is known for its adaptogenic properties, which help animals cope with environmental stressors, including temperature fluctuations. Maca`s potential to modulate stress responses might indirectly support thermoregulation by stabilizing physiological processes (Gonzales, 2012), secondly, antioxidant effect: maca contains bioactive compounds such as glucosinolates and polyphenols which have antioxidant properties. Antioxidants can mitigate the thermal stress. By reducing oxidative damage, maca may help maintain normal thermoregulatory functions (Wang, *et al.,* 2007), iii) nutritional support: maca is rich in essential nutrients, including amino acids, vitamins and minerals, which are crucial for metabolic processes involved in thermoregulation. Improved nutrition can enhance the resilience of livestock to thermal stress (Balick and Lee, 2002) and lastly, hormonal modulation: maca has been shown to influence endocrine function, which play a role in thermoregulation for instance thyroid hormones are critical for metabolic heat production. By supporting hormonal balance, maca may help livestock maintain optimal body temperature under varying environmental conditions (Gonzales *et al.,* 2003).

Table 2: Effect of Maca supplementation on thermoregulatory responses of Yankasa rams

Parameters	T1	T2	T3	T4	SEM	LOS
Rectal temperature (°C)	38.83	39.30	38.77	38.70	0.44	NS
Respiratory rate (brpm)	29.67^{a}	28.33^{ab}	26.67^{bc}	26.00^{c}	0.82	*
Pulse rate (btpm)	88.33^{a}	84.00^{b}	80.33^{b}	72.00^{c}	1.67	*

brpm = breath per minute, btpm = beat per minute

Effect of Maca supplements on Kidney function test Yankasa rams

The result on the effect of maca on kidney function test (electrolytes) were presented in table 3 below. The kidney function test is very essential to get insight on how the animal kidney regulate fluid balance, electrolyte, and waste excretion.

The result showed that blood urine nitrogen (BUN) and creatinine were not significant (P>0.05) differences. The values obtained for BUN and creatinine were fall within the values reported by Garba and Adeola (2022) for Yankasa rams. This indicates normal kidney functions since elevated levels of BUN and creatinine indicates impaired kidney function (Radostits *et al.*, 2007). Bilirubin is a lipid soluble substance usually carried in plasma as a plasma protein bound substance. It is removed from the plasma protein at the sinusoidal membrane of the liver cell, and it is thus excreted into bile. It is a pigment derived from the decomposition of haemoglobin within the red blood cell. Fasting causes an increase in the bilirubin level of the plasma, hence deep yellow colouration of plasma is seen in a fasting animal (Aka, 2004).

With the exception of potassium (K^+) (P<0.05) the plasma electrolytes were not significantly (P<0.05) differences in this study. T3 had significantly higher (3.58nmol/l) potassium followed by T4 (3.28nmol), T2 (3.21nmol/l) while lower potassium value in T1 (2.73nmol/l) therefore, maca supplementation tend to increase k^+ levels which may likely attributed to mineral element composition of maca. Very low K^+ or high imbalances can signal renal or metabolic disorders (Radostits *et al.,* 2007). K^+ is the major intracellular cation in the body, with a concentration 20 times greater inside the cell than outside. The K^+ concentration has a major effect on the contraction of skeletal and cardiac muscles. A lower K^+ causes cell excitability, leading to muscle weakness. Severe hyperkalemia can ultimately cause a lack of muscle excitability which may lead to paralysis or a fetal cardiac arrhythmia (Rose, 2001).

Sodium (Na^+) is the most abundant cation in the extracellular fluid, representing 90% of all extracellular cation, and largely determines the osmolality of the plasma.

Table 3: Effect of Maca supplements on Kidney function test Yankasa rams

Parameters	T1	T2	T3	T4	SEM	LOS
BUN (nmol/L)	11.32	11.91	11.87	12.09	0.77	NS
Creatinine (µmol/L)	113.0	118.2	110.5	113.7	5.32	NS
Na (nmol/L)	126.5	130.7	126.4	134.4	3.75	NS
K^+ (nmol/L)	2.73^b	3.21^{ab}	3.58^a	3.28^{ab}	0.28	*
Chloride (nmol/L)	1.72	1.80	2.19	2.15	0.29	NS
P (nmol/L)	1.25	1.53	1.32	1.36	0.40	NS

BUN = Blood urea nitrogen, Na = Sodium, K^+ = Potassium, P = Phosphorous, SEM = Standard error mean, LOS = Level of significance

CONCLUSION AND RECOMMENDATION

It could be concluded that supplementation of maca powder 15g/kg diet have beneficial adaptogenic effect of modulating rectal temperature thereby reducing respiratory rate and pulse rate. No adverse and detrimental changes were observed in plasma electrolytes of Yankasa rams supplemented maca powder in this study. It is therefore recommended that farmer should supplement maca at 15g/kg during hot dry season to mitigate negative physiological responses and electrolyte balance.

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