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BIOPOTENCY OF MACA (*Lepidium meyenii*) POWDER SUPPLEMENTATION ON PERFORMANCE AND HAEMATOLOGICAL PROFILE OF YANKASA RAMS DURING HOT SEASON

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ABSTRACT

Evaluation of hematological profile of Yankasa rams is a vital indicators of animal health, nutritional, welfare, physiological and pathological condition assessment therefore, this study was specifically designed to evaluate the effect maca (*Lepium meyenii*) powder supplementation on serum biochemistry of Yankasa rams raised during hot season. 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). At the end of experiment blood samples were collected and analyzed for hematological and red blood cell abnormality. Data obtained were analyzed using analysis of variance of statistical analysis system were treatment means were separated using Duncan Multiple Range Test (DMRT). The result showed that there were significant (P<0.05) differences in all growth performance with the exception of initial weight (P>0.05). Haematological profile of Yankasa rams supplemented maca have greatly showed significant (P<0.05) differences in red blood cell (RBCs), RBCs indices, white blood cell, neutrophils and eosinophils while packed cell volume, haemoglobin, monocytes and lymphocytes were not significantly (P>0.05) differences in this study. Among the red blood abnormalities T1 had moderate elliptocytes, rouleux, and acanthocytes with presences of anisocytosis, hypochromia, poikilocytes and microcytosis while other treatment groups contain either slight, presence or absent of red blood cells abnormality. It could therefore concluded that supplementation of maca powder at 10 and 15g/kg had an outstanding growth performance and haematological profile within the reference range.

Keywords: Growth, Haematology, Maca, 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).

Nutritional supplements plays a crucial role in enhancing livestock productivity by improving physiological and haematological profile of livestock. Maca (*lepidium meyenii*), a high-altitude Peruvian plant, that have been traditionally used as an adaptogen to improve fertility, energy metabolism, and overall health status of both humans and animals (Gonzales, 2012). Recent studies suggest that maca possesses numerous bioactive compound, such as macamides and glucosinolates, which may influence metabolic and haematological functions (Wang *et al.*, 2007; Gonzales-Arimborgo *et al.*, 2016). However, its effects on ruminant animals, particularly on the haematological profiles of Yankasa, remain highly insufficiently studied.

Haematological parameters, includes red blood cells count, hemoglobin concentration, white blood cell counts and hematocrits levels are essential indicators of an animal's health, oxygen transport efficiency, and immune responses. In ram, optimal blood parameters are crucial for maintaining reproductive performance, stress resistance, and general productivity (Al-Dawood, 2017). Stone et al., (2009) opined that given maca reported benefits in enhancing stamina and metabolic function. Therefore, dietary interventions that possibly enhances hematopoiesis could, likely improve the resilience and productivity of breeding rams during period of heat stress. Therefore, the key objective of this study is to evaluate the effect of maca root powder supplement on the growth performance and haematological responses by assessing key blood parameters of Yankasa rams raised during hot weather condition of Sudan Savanna Zone, Nigeria.

MATERIALS AND METHODS

Experimental site

This experiment was carried out at Small Ruminant unit of 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.

Experimental animals and design

the first experiment was consists 20 pubertal Yankasa rams which was divided into four treatment groups of 0, 5, 10, and 15g/ kg powdered maca with five (5) rams each per treatment in a completely randomized design (CRD).

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 will be sliced to 2-mm-thick pieces and dried at 42ºC in oven drying machine for

24 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, sieved through 1-mm wire-mesh, and stored at -20ºC before use.

Data collection

Performance

Data for initial live weight of the rams were taken by weighing the goat before introducing them to the experimental diets. Subsequently, weekly live weight and feed intake was recorded while average daily weight gain (ADG) and average daily feed intake (ADFI) was determined by dividing their totals against the number of days that the feeding trails. At the end of the experiment, the total feed intake (TFI) and the total weight gain was calculated and the feed conversion ratio (FCR) was determined by dividing the total feed intake by the weight gain.

$$FCR = \frac{Feed\ intake}{Body\ weight\ gain}$$

$$\text{Performance index (PI)} = \frac{Final\ live\ weight\ (kg)}{FCR}$$

$$\text{Production efficiency factor (PEF)} = \frac{Livability \times mass\ (kg) \times 100}{FCR \times Age\ of\ study\ (days)}$$

Livability = 100 – mortality rate (%)

Where,

Mass (kg) = Final live body weight

FCR = Feed conversion ratio

Mahdy *et al.,* 2024).

Metabolic weight was determined mathematically according to Willems et al (2013)

$$\text{Metabolic weight (MW)} = \frac{(\text{Initial body weight (kg)} + \text{final body weight (kg)})^{0.75}}{2}$$

Haematological parameters determination

Blood was collected at the end of experiment I (12 weeks post trail) by using sterile syringe and needle using jugular venepuncture of four bucks per treatment and was put into well labelled blood collection bottles, which contained ethylene diamine tetraacetic acid (EDTA). The blood samples were put in an ice pack and transported to the haematology unit of Medical Laboratory of Federal Medical Centre, Katsina State for determination of haematological parameters. Which includes: the haemoglobin content, white blood cells, red blood cells, neutrophils, lymphocytes, eosinophil, monocytes, basophils and packed cell volume were determined by the procedure outlined by Decie and Lewis (2001). The haemoglobin was determined using the cyan-methaemoglobin method (Pratt, 1985 as reported by Nafisat *et al.,* 2021). Twenty-four empty test tubes were assembled in a rack including an extra tube for blank. Five millitres of cyanide was poured into each test tube followed by 0.02ml of individual blood samples except the blank. The tubes were thoroughly mixed and allowed to stand for not less than 3 minutes after which haemoglobin concentration was read using the electronic colorimeter. The colorimeter was first zeroed using the blank and both the fine and coarse adjusters. Subsequently the absorbances of the samples were recorded. The final results were obtained using the Hb reference table (John *et al.,* 2013). Red cell distribution (RCD) was determined using the sysmex haematology analyser coefficient of variation (CV) of RDW was used to calculate for RDW as standard deviation of RBC size x 100 / mean corpuscular volume. Packed cell volume (PCV) was determined using capillary tubes method. After centrifugation of the prepared capillary tubes at 10,000 to 15,000 gravity for 5 minutes, the PCV values was read using a reader (Pratt, 1985) while the mean corpuscular Haemoglobin Concentration (MCHC), mean corpuscular Haemoglobin (MCH) and mean corpuscular Volume (MCV) were computed using appropriate formulae (Olaniyi *et al.,* 2012).

MCV, MCH and MCHC will be calculated as follows:

$$\text{Mean corpuscular Volume (MCV)} = \frac{\text{PVC X 10}}{\text{RBC count (in 106/ MM3)}}$$

$$\text{Mean corpuscular haemoglobin (MCH)} = \frac{\text{Hb} \times 10}{RBC\ (in\ 10^6/MM^3)}$$

$$\text{Mean corpuscular haemoglobin concentration} = \frac{\text{Hb (g/dl)} \times 100}{\text{PCV\%}}$$

Red Blood Cell Abnormality Determination

Immediately after blood collection from the jugular vein the blood was put into lavender-top tube and transported to laboratory. Smear was prepared by placing a small drop of blood near the end of a glass slide, a spreader was used at a slide of 30-45° angle to pull the blood into a thin film. After which the slide were air-dry quickly to prevent artefact formation. After 1 min the smear was fixed in methanol and the Wright-Giemsa stain was applied for period of 3-5 min and rinsed gently with buffer at pH of 6.8 to remove excess stain. The slide was air-dry and examine under microscope x40 objective magnification for RBC morphological count and classification. Oil immersion were applied for the detailed determination of RBC size (anisocytosis) and shape (Poikilocytosis) at x100 magnification (Rodak and Carr, 2020).

RESULTS AND DISCUSSION

Effect of Maca supplementation on growth performance of Yankasa rams

The result on the effect of maca (*Lepidium meyenii*) on growth performance of Yankasa rams were presented in the table 1 below.

The result indicated no significant (P>0.05) differences in the initial weight of rams in this study. This clearly illustrated that animals were properly weight balance prior to the commencement of this experiment which is in accordance with the guidelines for the proper randomization and un bias assembly of experimental animals in completely randomized design (CRD), since it was required that experimental animals need to be homogenous in terms of sex, breed, age and weight to suite for CRD design. The result showed that there were significant (P<0.05) differences in the final body weight of Yankasa rams supplemented diet with levels of maca. Interestingly, the result showed linear increases in final weight with increasing supplementation levels of maca in this study, were T4 had significantly higher final weight (25.42kg), followed by 24.85kg, 23.65kg and 22.96kg for T3, T2, and T1 respectively. This increases in final body weight concurred with the findings of Garba and Adeola (2022) on the significant increases in final weight of Yankasa rams fed maca diet. This clearly indicated that maca can enhance growth by muscular development, feed conversion efficiency, weight gain and overall health as reported by Gonzales *et al.* (2003). The result further revealed significant (P<0.05) increases in weight gain with the increases supplementation levels of maca were T4 had the highest weight gain value (5.04kg) followed by T3 (4.46kg), T2 (3.31kg) while T1 had the lowest value (2.66kg). the most provable possible scientific and physiological explanation of this increase in growth performance of Yankasa rams fed maca-diet could be either one or combination of the following mechanisms: i) hormonal regulation: because maca has been shown to influence testosterone and estrogen levels, which play a vital role in muscle development ii) enhanced nutrient absorption:

the presence of bioactive compounds may improve gut health, leading to better digestion and efficient nutrient uptake and utilization and iii) antioxidant properties of maca: maca contains polyphenols that may help reduce oxidative stress, promoting cellular growth and repair.

Table 1: Effect of Maca supplementation on growth performance of Yankasa rams

Parameters	T1	T2	T3	T4	SEM	LOS
Initial weight (kg)	20.30[a]	20.33[a]	20.36[a]	20.38[a]	0.036	NS
Final weight (kg)	22.96[b]	23.65[b]	24.85[a]	25.42[a]	0.45	*
Weight gain (kg)	2.66[b]	3.31[b]	4.46[a]	5.04[a]	0.43	*
ADWG (g)	31.71[b]	39.44[b]	53.05[a]	60.00[a]	5.11	*
Feed intake (kg)	29.72[b]	29.82[b]	30.59[a]	30.99[a]	0.33	*
ADFI (g)	353.8[b]	355s.00[b]	363.80[b]	368.9[a]	3.76	*
FE	0.09[c]	0.11[bc]	0.13[a]	0.16[a]	0.02	*
FCR	11.24[a]	9.38[a]	6.90[b]	6.17[b]	1.07	*
Performance index	2.061[b]	2.646[b]	3.628[a]	4.138[a]	0.413	*
PEF	8.22[c]	10.08[bc]	13.00[ab]	14.43[a]	1.267	*
MW	15.39[b]	15.53[b]	15.75[a]	15.85[a]	0.088	*

ADWG = Average daily weight gain, ADFI = Average daily feed intake, FE = Feed efficiency
FCR = Feed Conversion ratio, PEF = Production efficiency factor, MW = Metabolic weight

Effect of Maca supplementation on haematological profile of Yankasa rams

Blood is constituted by cells and the plasma, which is the fluid portion. It functions to transport nutrients, regulates bio-functions, protect the entire animal body as well as exercise homeostatic control (Nasyrova, *et al.,* 2006). The usefulness of blood in assessing the quality of foods and feed additives has been underscored by various researchers. Blood is therefore, a fastest and readily available means of assessing chemical and nutritional health status of animals in feeding trails (Maxwell, *et al.,* 1990). Presence of metabolites and other constitutes of stress could be investigated through blood examination thus helping to detect condition of stress as could be occasioned by nutrition, environment or disease agent (Aderemi, 2004). Therefore, the result on the effect of maca on haematological profile of Yankasa rams were presented in table 2 below.

The packed cell volume (PCV) values of Yankasa rams fed maca diet did not showed significant (P>0.05) differences, although the PCV values demonstrated a linear trend of increasing with increasing level of maca. However, the PCV values are within the normal ranges of apparently healthy Yankasa rams. Significantly (P<0.05) higher red blood cells (RBCs) were recorded in T4 ($9.19 x10^6$µ/L) followed by T3 (7.83 $x10^6$µ/L), T2 (7.70 $x10^6$µ/L) while lower RBC count were obtained in T1 (6.59 $x10^6$µ/L). This signifies that maca has a vital role in the improvement of RBCs formation and this may likely be attributed to the iron content of maca. Because the iron and amino acids in maca support erythropoiesis (red blood cell production), which improve oxygen transport and energy metabolism. This can be supported by scientific research in sheep and cattle which was indicated that maca supplementation increases RBC count and Hb levels, potentially due to its high iron content and ability to stimulate erythropoiesis. Higher iron content is essential for haemoglobin synthesis (Balick and Lee, 2002).

Supplementation of maca did not statistically (P>0.05) influence haemoglobin (Hb) values of Yankasa rams in this study. However, T4 had the highest (10.30g/dl) Hb values while T1 has the lowest (8.67g/dl) Hb. Generally, increases in the Hb concentration despite non-significant (P>0.05) differences is associated with greater ability to resist infection and low level is an indication of poor nutrition and high susceptibility to infection (Tambuwal *et al.,* 2002). Hb has the physiological function of transporting oxygen to tissue of the animal for oxidation of ingested food so as to release energy for the other body functions as well as transport carbon dioxide out of the body of animals (Soetan *et al.,* 2013). This implies that increased Hb level with increased maca supplements in this study would enhance perfusion rate in the animal tissue and adequate removal of carbon dioxide with improve animal health and production.

The red blood distribution were not significant (P>0.05) differences in this current study. The result revealed that there were significant (P<0.05) differences in mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC) and mean corpuscular haemoglobin (MCH). MCV measures the average of single red blood cell (Hoffbrand and Moss, 2016), it categorized the RBCs based on their size which is very essential in classifying anaemia. The normal MCV values ranges from 80 – 100 femtoliters (fl) (kumar *et al.,* 2020). The MCV values obtained in this study fall within the normal ranges.

The result revealed that there were significant (P<0.05) differences in MCHC, were T2 had the higher value of MCHC (38.38g/dl) this is a condition called ''hyperchromia'' which indicates that haemoglobin concentration is higher-than-normal (Turgeon, 2016). This condition is common when RBCs are spherical in shape under haemolytic anaemia also called spherocytosis. The normal MCHC ranges 28 – 36 g/dl (Kumar *et al.,* 2020). Therefore, T4 had the normal MCHC values in this study. Low MCHC values were recorded in T1 (21.20g/dl) which clearly indicate condition called hypochromia which suggest that rams in T1 had RBCs with lower-than-normal haemoglobin concentration. This condition is very common in iron deficiency anaemia or thalassemia (Turgeon, 2016). There were significant (P<0.05) differences in MCH were T2 had the higher values (11.03pg). MCH measures the average amount of Hb per red blood cells. It helps in assessing whether RBCs contain normal, increased, or decreased amount of haemoglobin. Higher MCH values indicates macrocytic anaemia (e.g vitamin B_{12} or folate deficiency) while low MCH values suggest microcytic anaemia (e.g iron deficiency, anaemia and thalassemia) (Kumar et al., 2020). Therefore, the MCH values obtained in this study collaborate with the MCH values of Yankasa rams reported by Garba *et al.* (2022) and Salisu *et al.* (2023).

The major function of white blood cells (WBCs) and other differential counts is to defend the body by phagocytosis against invasion by foreign organisms and to produce, transport and distribute antibodies in immune response (Etim *et al.,* 2014). Animals with high WBC and leucocytes counts are capable of generating high volume of antibodies during phagocytosis and have high degree of resistance to disease (Soeten *et al.,* 2013) and enhance adaptability to local environment (Kabir *et al.,* 2011; Isaac *et al.,* 2013). This study showed that WBCs were significantly (P<0.05) differences. Higher WBCs values were recorded in T1 (21.95) while T4 had the lowest (8.76) WBC values in this study. This study contradicts the findings in sheep and goats that maca supplementation has been linked to increased total WBC count and enhanced neutrophil activity, suggesting improved innate immunity. The WBC values obtained in this study were fall within the WBC values of healthy Yankasa rams reported by Nafisat *et al.* (2021); Garba and Adeola, (2022).

The differential count has a specific role in the immune response to different pathological conditions. It helps to evaluate body`s immune response to infections, inflammations, allergies, bone marrow disorders and monitoring treatment response (AACC, 2023). This study showed that there were no significant (P>0.05) differences in lymphocytes, monocytes and basophils. However, the result indicates significant (P<0.05) differences in neutrophil and eosinophil in this study. the significantly (P<0.05) higher neutrophils of 62.14% observed in T1 may likely signifies condition called neutrophilia (high neutrophils) which were likely caused by bacterial infections, inflammation, tissue injury or stress condition probably from the environment (Kumar *et al.,* 2020)

Table 2: Effect of Maca supplementation on haematological profile of Yankasa rams

Parameters	T1	T2	T3	T4	SEM	LOS
PCV (%)	34.15	35.80	36.03	38.66	3.20	NS
RBC (x10^{6}µl)	6.59^b	7.70^{ab}	7.84^{ab}	9.19^a	0.66	*
Hb (g/dl)	8.67	8.91	8.89	10.30	0.96	NS
MCV (fl)	20.07^b	23.79^a	27.43^a	27.30^a	1.58	*
MCHC (g/dl)	21.20^c	30.38^a	23.55^{bc}	29.23^{ab}	2.66	*
MCH (pg)	7.90^b	11.03^a	9.70^{ab}	9.81^{ab}	0.96	*
RCD	14.32^a	14.25^a	15.04^a	14.93^a	0.71	NS
WBC (x10^9/l)	21.95^a	10.37^b	9.11^b	8.76^b	1.55	*
Lymphocyte (%)	32.97^a	33.50^a	36.35^a	36.11^a	2.72	NS
Neutrophils (%)	62.14^a	39.03^b	32.93^b	30.99^b	3.73	*
Eosinophils (%)	1.71^b	2.800^a	2.33^{ab}	2.73^a	0.40	*
Monocytes (%)	3.30^a	4.43^a	4.37^a	3.89^a	0.68	NS
Basophils (%)	1.33^a	0.67^a	0.67^a	0.33^a	0.62	NS

PCV = packed cell volume RBC= red blood cell Hb = haemoglobin MCV= mean cell volume MCHC = mean corpuscular haemoglobin concentration

Effect of Maca on RBC Morphological Abnormality of Yankasa Rams

The result on the effect of maca supplementation on red blood cell morphological abnormalities were presented in table 3 below. The result revealed that there was slight presence of ovalocytes/elliptocytes in all treatment with the exception of T2. Elliptocytes is the slightly oval shape of red cells and it is common red blood cell morphological abnormalities in a severe iron deficiency, megaloblastic anaemia and dyserythropoiesis. It also occurs in animal with hereditary elliptocytosis or thalassemia (Bannerma and Renwick, 1962). Rouleux were moderately (++) present in T1 and slightly occur in T2 (+) while absent in both T3 and T4. Rouleux are red cell aggregates resembling a stack of coins. They are caused by an increase of asymmetric macromolecules, such as globulin and fibrinogen. Associated clinical conditions include multiple myeloma, acute infection or inflammation and macroglobulinemia (Constantino, 1994). Slight roulex formation is of normal occurrence especially in patients with low red cell counts because of the relative fibrinogenemia (Constantino, 2014).

Schistocytes are absent in T1, T2 and T4 while presence in T3Schistocytes is the fragments or small pieces of red cells with irregular outline characterized by triangular, crescentic, and half-moon-shaped cells. They are seen especially in syndromes of microangiopathic hemolytic anaemia such as thrombotic thrombocytopenic purpura and hemolytic uremic syndrome (Constantino, 2013). It also occurs in hereditary pyropoikilocytosis, severe burns, chronic renal failure, unstable haemoglobin, iron and enzyme deficiency and chemotherapy. The schistocytes slightly occur in T3. This may likely occur due to individual ram with unstable haemoglobin concentration as it was seen in haematological table above or may be attributed likely due iron or enzymes deficiencies. The result showed that there were presence of anisocytosis in the blood of rams in T1 and T2 while absent in T3 and T4. No incidence of hyperchromia was found in this study. This could further validate the above findings of MCHC concentration that hyperchromia is occur when the MCHC values is greater than 38.38g/dl as reported by Turgeon, (2016).

Acanthocytes were slightly present in all treatment in this study. This showed that rams in this study are free from asplenia, starvation, or hypothyroidism. Acanthocytes are spheroidal dense cells with multiple unevenly distributed spikes of varying length. Few acanthocytes is very significant to indicate asplenia (Constantino, 2014). Acanthocytes, it occurs in severe burns, newborn/old age, enzymes deficiencies, anorexia nervosa, starvation, vitamin e deficiency and hypothyroidism (Constantino, 2015). Poikilocytes and microcytes are presence in all the treatment group while spherocytes and macrocytosis are absent.

Table 3: Effect of Maca on RBC Morphological Abnormality of Yankasa Rams

Parameters	T1	T2	T3	T4
Elliptocytes	++	-	+	+
Anisocytosis	*	*	-	-
Rouleux	++	+	-	-
Hyperchromia	-	-	-	-
Hypochromia	*	-	*	-
Poikilocytes	*	*	*	*
Schistocytes	-	-	+	-
Spherocytes	-	-	-	-
Acanthocytes	+	+	+	+
Micorcytosis	*	*	*	*
Macrocytosis	-	-	-	-

+ = (6-10%) slight, ++ = (10-25%) moderate, +++ = (25-50%) marked, - = absent, * = presence

CONCLUSION

It could therefore concluded that supplementation of maca powder at 10 and 15g/kg had an outstanding growth performance. Supplementation of maca tend to modulate the haematological profile of Yankasa rams within the reference ranges without any adverse effect. Supplementation of maca powder from 5 -15g/kg play a vital role in reducing red blood cell morphological abnormalities. It is therefore recommended that farmers should use maca at 15g/kg diet for maximum growth performance and stabilizing haematological parameters especially during hot season of the year. Further studies are therefore encourage especially in different animal models.

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