Effect of oral administration of liquid moringa leaf meal on blood profile, serum lipid and liver function enzymes of growing yankasa rams

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Abstract

Moringa oleifera leaves have the potential to enhance nutritional status, growth performance and health of ruminant animals. This study investigated the effects of graded levels of supplementation of liquid moringa leaf meal (LMLM) on haematological indices, serum biochemistry, lipid profile and liver function enzymes of growing Yankasa rams. Sixteen growing Yankasa rams, aged eight to nine months old with average body weight of 16.59 ± 3.0 kg were allotted into four dietary treatments in a complete randomised design (CRD). The rams were fed a total mixed ration at 5% live body weight. Fresh moringa leaves were shade dried, milled into powder and reconstituted into solution by dissolving 250 g of the moringa leaf powder in 1 L of water for oral administration once daily. From this, equivalent doses of 0, 4, 8, and 12 g DM kg^{-1} feed intake of liquid moringa leaf meal was administered orally to the respective treatment groups at 7:30 am daily for a period of 85 days. The results showed that dietary supplementation of growing Yankasa rams with LMLM at 0, 4, 8 and 12 g DM kg^{-1} feed intake had no significant ($p>0.05$) effect on all the parameters investigated except urea, creatinine, albumin and lactate dehydrogenase. There was significant ($p<0.05$) increased in serum blood urea, albumin and lactate dehydrogenase levels with increasing supplementation level of LMLM but with no consistent trend in creatinine levels. The values obtained in this study are all within the acceptable physiological reference range for healthy animals, signifying no adverse effect on the rams. Hence, in this study it is concluded that dietary oral administration of LMLM up to 12 g DM kg^{-1} feed intake increased serum albumin and urea concentrations, with no adverse effect on the haematological indices, serum biochemical parameters, serum lipid profile and liver function enzymes of growing Yankasa rams. Further studies using higher supplementation levels of LMLM and other classes of livestock are suggested to elucidate its physiological effects.

Keywords: Moringa leaf, serum lipid, liver enzymes, Haematology, Yankasa rams

Effet de l'administration orale de farine liquide de feuilles de moringa sur le profil sanguin, les lipides sériques et les enzymes hépatiques chez des béliers Yankasa en croissance

Résumé

Les feuilles de Moringa oleifera ont le potentiel d'améliorer l'état nutritionnel, les performances de croissance et la santé des ruminants. Cette étude a examiné les effets de différents niveaux de supplémentation en farine de feuilles de moringa liquide (LMLM) sur les indices hématologiques, la biochimie sérique, le profil lipidique et les enzymes hépatiques chez des béliers Yankasa en croissance. Seize béliers Yankasa en croissance, âgés de huit à neuf mois et présentant un poids corporel moyen de 16,59 ± 3,0 kg, ont été répartis en quatre groupes alimentaires selon un plan d'expérimentation aléatoire complet (CRD). Les béliers ont reçu une ration totale mélangée représentant 5 % de leur poids vif. Des

feuilles fraîches de moringa ont été séchées à l'ombre, broyées en poudre, puis reconstituées en solution en dissolvant 250 g de cette poudre dans 1 L d'eau, pour une administration par voie orale une fois par jour. Sur cette base, des doses équivalentes de 0, 4, 8 et 12 g de matière sèche par kg de ration consommée de farine liquide de feuilles de moringa ont été administrées par voie orale aux groupes de traitement respectifs tous les jours à 7 h 30, pendant une période de 85 jours. Les résultats ont montré que la supplémentation alimentaire de béliers Yankasa en croissance avec du LMLM à des doses de 0, 4, 8 et 12 g de matière sèche par kg d'alimentation n'avait pas d'effet significatif (p > 0,05) sur l'ensemble des paramètres étudiés, à l'exception de l'urée, de la créatinine, de l'albumine et de la lactate déshydrogénase. On a observé une augmentation significative (p < 0,05) des taux sériques d'urée, d'albumine et de lactate déshydrogénase à mesure que la dose de LMLM augmentait, sans toutefois de tendance constante concernant les taux de créatinine. Les valeurs obtenues dans cette étude se situent toutes dans la fourchette de référence physiologique acceptable pour des animaux en bonne santé, ce qui indique l'absence d'effet indésirable sur les béliers. Par conséquent, cette étude conclut que l'administration orale de LMLM dans l'alimentation, à raison de 12 g de matière sèche par kg d'aliments consommés, a augmenté les concentrations sériques d'albumine et d'urée, sans effet indésirable sur les indices hématologiques, les paramètres biochimiques sériques, le profil lipidique sérique et les enzymes hépatiques des béliers Yankasa en croissance. Il est recommandé de mener d'autres études utilisant des doses de supplémentation plus élevées en LMLM et portant sur d'autres catégories d'animaux d'élevage afin d'élucider ses effets physiologiques.

Mots-clés : feuilles de moringa, lipides sériques, enzymes hépatiques, hématologie, béliers Yankasa

Introduction

The use of natural feed additives in animal nutrition has gained significant interest due to their potential benefits in enhancing animal health and productivity. One such additive, *Moringa oleifera* (MO), commonly known as the 'drumstick tree', has been extensively studied for its rich nutritional profile and medicinal properties. The MO leaves are particularly valued for their high protein content, vitamins, minerals, and bioactive compounds, making them a promising supplement in animal feeding system (Gopalakrishnan *et al*., 2017). Research on the dietary inclusion of Moringa leaf meal in animal feed has shown promising results in improving growth performance, nutrient digestibility, and health parameters across various livestock species (Su and Chen, 2020; Amad and Zentek, 2023).

The use of synthetic additives and supplements has raised concerns regarding environmental and health risk, hence necessitating the need for exploration natural and sustainable alternatives. Previous studies have suggested that Moringa can enhance growth performance and improve health parameters in various livestock species (Anjorin *et al.,* 2010; Ibrahim *et al*., 2025). Kholif *et al*. (2019) reported that dietary *Moringa oleifera* (MO) leaf extract up to 20 mL dose in basal diet improved milk yield and fatty acid profile of a dairy cows. Ben Salema and Makkarb (2009), reported that supplementation of MO defatted seed meal at 2, 4, and 6 g DM per lamb/day had no adverse effect on lamb performance, while in another study, supplementation of male Barki sheep with MO seeds at 4 g DM per lamb/day increased body weight (Amad and Zentek, 2023). Biochemical and haematological parameters are critical indicators of an animal's health and nutritional status. Biochemical parameters reflect the metabolic processes occurring within the body, while haematological parameters provide insights into the animal's immune status, oxygen-carrying capacity, and overall health (Odedire and Oloidi, 2014). Changes in these parameters due to dietary interventions can provide valuable

information on the physiological responses of livestock.

Also, liver function enzymes are critical indicators of metabolic and hepatic health status in animals, while lipid profiles are essential for understanding the nutritional and health impacts of dietary interventions (Yakubu *et al.*, 2015). Liver function enzymes, such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP), are critical indicators of liver health and metabolic status in animals. Any alteration in the levels of these enzymes can signify metabolic disturbances or liver damage, making them valuable biomarkers for assessing the impact of dietary interventions (Gowda *et al.*, 2009). According to Kaur *et al*. (2014), lipid profiles are essential parameters for evaluating the nutritional and health impacts of dietary supplements. Lipids play a crucial role in energy storage, cell membrane structure, and signaling pathways. The inclusion of dietary supplements can influence lipid metabolism, potentially improving the lipid profile and overall health status of the animals (Kaur *et al*., 2014). However, most earlier studies on dietary intervention of *Moringa oleifera* supplementation focused on non-ruminant species or general livestock health, with limited available information on its effects on Yankasa rams. Therefore, this study was designed to bridge this knowledge gap by evaluating the effects of liquid moringa leaf meal on the haematological indices, serum biochemical parameters, lipid profile and liver function enzymes of Yankasa rams.

Materials and Methods

Study Site and Preparation of Moringa Leaf Meal

The research was conducted at the Small Ruminant Unit of the Department of Animal Science Teaching and Research Farm, Ahmadu Bello University, Zaria. Fresh and clean moringa leaves were shade dried for five days, milled using 1 mm sieve and stored in an air tight polythene bag for later use. The moringa leaf meal was reconstituted in clean water by dissolving 250 g of dried moringa powder in 1 L of water to produce the liquid moringa leaf meal (LMLM). The equivalent doses of 0, 4, 8 and 12 g DM kg^{-1} feed intake of LMLM were administered orally to the rams as treatment levels.

Experimental Animals and Design

Sixteen growing Yankasa rams, 8 to 9 months old with average body weight of 16.59 ± 3.0 kg were randomly allotted into four groups with four animals per treatment. They were individually housed and adapted to the pens for two weeks; a control diet and clean drinking water were given to the rams during the adjustment period. At the beginning of the trial, the rams were weighed and randomized into four treatments to balance for body weight distribution across treatment groups. The rams were fed a total mixed ration as presented in Table 1. Each animal was fed twice daily a total of 5% live body weight with a fortnightly adjustment according to the new body weight taken. A daily oral administration of 0, 4, 8 and 12 g DM kg^{-1} feed intake of LMLM was done at 7:30 am every day before feeding, for a duration of 85 days.

Chemical Analysis of Moringa and Experimental Diet

The milled moringa sample and the experimental diet were analysed according to the method of AOAC (2005) for dry mater, crude protein, crude fibre, ash, ether extract and nitrogen free extract. The acid detergent fibre (ADF), neutral detergent fibre (NDF) and lignin were analysed according to Van Soest (1991). In addition, oxalate, phytate and tannin contents were also analysed using the calorimetric methods as described by AOAC, (2005).

Blood Sample Collection and Analysis

Blood samples for heamatological and serological analyses were collected in sample bottles from the jugular vein of each ram using

needles and syringes. Three millilitres **(**3 mL) of blood samples were put into sample bottles containing ethylene diamine tetra acetic acid (EDTA) as anticoagulant to determine haematological indices including, haemoglobin (Hb), red blood cells (RBCs), packed cell volume (PCV), white blood cells (WBC), Neutrophils and Lymphocytes counts according to the methods described by Coles (1986). The Serum enzymes including aspartate aminotransferase (AST), alanine aminotransferase **(**ALT), alkaline phosphatase (ALP), lactate dehydrogenase (LDH), and Gamma-glutamyl transferase (GGT) were determined using standard procedure as described by Lamb, (1981). An additional 3 mL of blood serum samples were collected in plain bottles and analysed for biochemical analyses including, total protein, blood urea nitrogen, albumin, globulin, creatinine, triglycerides, high-density lipoprotein, and low-density lipoprotein analyses.

Data Analysis

The data collected were subjected to statistical analysis using a General Linear Model (GLM) procedure of SAS (2002). Significant differences among treatment means were separated using the Duncan Multiple Range Test (Duncan, 1955) as outlined in the SAS package.

Results and Discussion

Ingredients and Chemical Composition of Dietary Treatment alongside with Chemical Composition, Mineral profile and Phytochemicals of Moringa oleifera Leaf

Table 1 presents the ingredients and chemical composition of dietary treatment alongside with chemical composition, mineral profile and phytochemicals of *Moringa oleifera* (MO) leaf used in this study. The basal diet fed to all the growing Yankasa rams consisted of 11.56% crude protein, 31.43% crude fibre, and 50.70% soluble carbohydrate. The MO leaf contained 28.41% crude protein, 21.14% crude fibre, and 45.16% soluble carbohydrate.

Research has shown that *M. oleifera* leaves have high crude protein contents, making them suitable for improving the protein level in livestock diets (Makkar *et al*., 2022). The mineral profile of *M. oleifera* leaf in this study revealed its richness in essential minerals like calcium (6917 mg kg^{-1}), phosphorus (5365.58 mg kg^{-1}), and sulfur (5583.63 mg kg^{-1}), alongside a relatively high phytate content (10.43 mg/100 g) compared with other phytochemicals analysed. These minerals like calcium, phosphorus and sulfur in *M. oleifera* leaf are crucial for bone development, energy metabolism, and protein synthesis, respectively (Fahey, 2005; Tolba *et al.,* 2018). Potassium levels (3500 mg kg^{-1}) are beneficial for maintaining electrolyte balance, while the significant iron content (5087.75 mg kg^{-1}) could enhance blood health in animals, reducing anemia risk. The presence of trace elements like manganese, copper, and zinc further enhances its role in boosting overall animal health and immunity (Tolba *et al*., 2018). The phytochemicals presence in *M. oleifera* such as tannin and saponin offer potential health benefits; however, their level has to be managed properly to avoid their anti-nutritional effects when supplemented in livestock diets (Anwar *et al.,* 2007).

Table 1. Ingredients and Chemical Composition of Dietary Treatment alongside with Chemical Composition, Mineral profile and Phytochemicals of *Moringa oleifera* Leaf

Dietary ingredients	**% composition**	**Chemical composition of Moringa Leaf (%)**	
Soyabean shell	30.00	Dry matter	93.69
Rice offal	26.00	Crude protein	28.41
Maize offal	20.00	Crude fiber	21.14
Groundnut cake	20.00	Crude ash	3.40
Bone meal	2.50	Ether extract	1.18
Limestone	1.00	Nitrogen free extract	45.16
Common salt	0.50	Acid detergent fibre	24.95
Total	100.00	Neutral detergent fibre	38.46
Chemical composition		Lignin	3.68
Dry matter	92.38	**Mineral profile**	**mg kg^{-1}**
Crude protein	11.56	Calcium	6917.00
Crude fibre	31.43	Magnesium	761.00
Crude ash	5.19	Potassium	3500.00
Ether extract	1.12	Phosphorus	5365.58
Nitrogen free extract	50.70	Sulfur	5583.63
Acid detergent fibre	38.45	Iron	5087.75
Neutral detergent fibre	60.15	Manganese	91.75
Lignin	8.17	Copper	48.75
		Zinc	18.00
		Phytochemicals	**mg/100 g**
		Alkaloid	4.25
		Oxalate	3.28
		Phytate	10.43
		Saponin	3.75
		Tannin	3.29

Effect of different supplementation levels of liquid moringa leaf meal on the haematological indices of growing Yankasa ram

Table 3 presents the effects of different supplementation levels of liquid moringa leaf meal on the haematological parameters of growing Yankasa rams. The results showed there was no significant effect ($P > 0.05$) on all haematological indices investigated in the experimental growing Yankasa rams. The values for haematological indices recorded in this study falls within the reference value documented by (Jackson *et al*., 2002), indicating that the oral administration of LMLM did not have adverse effect on the physiological state of the animals. Also, these findings corroborated with the earlier report by Ewuola *et al.* (2012) who found no significant difference in hematological parameters across the treatments for growing rabbits fed diet containing graded levels of *Moringa oleifera* leaf meal.

Table 2. Effect of different supplementation levels of liquid moringa leaf meal on the haematological indices of growing Yankasa ram

	Liquid moringa leaf meal (g DM kg^{-1} feed intake)					
Parameters	**0**	**4**	**8**	**12**	**SEM**	**P value**
Pack cell volume (%)	28.00	33.50	28.50	34.50	2.18	0.07
Haemoglobin (g/dL)	9.38	11.15	9.45	11.48	0.73	0.07
Red blood cell ($x10^{12}$/L)	3.30	3.80	3.05	3.90	0.33	0.17
White blood cell ($x10^{9}$/L)	8.35	7.55	10.25	11.15	1.41	0.19
Neutrophil (%)	38.25	30.00	27.75	34.50	2.99	0.06
Lymphocyte (%)	61.00	65.50	71.25	63.75	3.68	0.19

[abc]Means with different superscripts across the rows differ significantly at $p<0.05$. SEM: Standard error of means

Effect of different supplementation levels of liquid moringa leaf meal on the serum biochemistry of growing Yankasa rams

Table 3 shows the serum biochemical parameters of growing Yankasa rams fed different supplementation levels of liquid moringa leaf meal. The supplementation of liquid moringa leaf meals significantly ($P < 0.05$) increased albumin concentration compared to the control group. Blood urea nitrogen which is an important indicator for determining protein metabolism and renal function, increased significantly ($p<0.05$) with increased level of liquid moringa leaf meal from 11.75 mg/dL in the control group to 19.00 mg/dL in the 12 g DM kg^{-1} feed intake for the growing Yankasa rams. This finding agrees with Zeng *et al*. (2018) and Miah *et al*. (2025) who reported elevated blood urea concentration in cows fed with higher level of Moringa compared with unsupplemented groups. The result also corroborates with the report of Akinlolu *et al.* (2014) who observed elevated serum urea concentration of Wistar rats administered *Moringa oleifera* extract. The elevated blood urea nitrogen concentration in this present study could be attributed to higher ruminal nitrogen production which enhanced ammonia absorption into the bloodstream due to the high protein content of moringa leaves and improved protein digestion (Ibrahim *et al*., 2026). Serum creatinine concentration showed an irregular pattern across treatments, indicating that increased supplementation of liquid moringa leaf meals did not caused muscle wasting or renal failure in the growing Yankasa rams used in this study. Likewise, there was no significant effect ($P > 0.05$) observed in serum globulin and total protein concentration by the dietary treatments of growing Yankasa rams supplemented with different levels of liquid moringa leaf meals. The values obtained for albumin in this study fell within the normal physiological range for healthy rams (Fielder, 2022). Urea is a key by-product of protein metabolism, and its concentration in the blood reflects the breakdown and utilization of dietary proteins. Higher levels of urea with increased LMLM intake suggest enhanced protein metabolism, consistent with the high crude protein content of moringa leaves (28.41%, as shown in Table 4). This is in line with Yusuf *et al*. (2018), who observed similar increases in urea in goats supplemented with moringa-based diets. Elevated urea levels, within physiological limits, are often indicative of good protein utilization, especially when dietary intake is rich in nitrogenous compounds. *Moringa oleifera* is known for its rich nutrient content, particularly proteins and essential amino acids, which could enhance albumin synthesis in the liver (Moyo *et al*., 2011). The increased albumin levels observed

in this study are consistent with the findings of Imoru (2019), who also reported higher albumin concentrations in broiler chicken fed moringa leaf meal in the diets. Creatinine, a metabolic waste of muscle activity, and its concentration in the blood is often used to assessing renal function and muscle metabolism. The slightly higher serum creatinine in the group of rams fed 4 and 12 g DM kg^{-1} feed intake suggest that the moringa supplementation enhanced muscle metabolism rather than having adverse effect on the renal function glomerular filtration, thus safe for renal functioning (Millam et al., 2022). The creatinine recorded in this study is within the normal reference range for normal wear and tear of the muscle in the system created during normal functioning of the muscle (Portea Medical, 2019). This aligns with Fathy *et al*. (2022), who reported increased creatinine levels in sheep fed moringa-supplemented diets, while Sanchez-Machado *et al*. (2010) observed that moringa inclusion does not have adverse effect on renal function in goats. The total protein, globulin and albumin obtained in this study were within normal physiological range for healthy sheep as reported by Fielder (2015). Increased levels of albumin indicate good liver function and overall nutritional status, suggesting that liquid moringa leaf meal could improve the health and productivity of Yankasa rams by providing essential nutrients that support albumin production. This stability in globulin levels suggests that immune function was not compromised, while total protein shows that protein was efficiently utilized in spite the difference in albumin concentration (Onu and Aniebo, 2011). These findings are consistent with previous reports on ruminants fed moringa-based diets (Babiker et al., 2017; Leitanthem et al., 2023). The values obtained for serum profiles in this study fell within normal physiological ranges except for blood urea, which is slightly higher than the standard reference values for healthy Yankasa rams (Adejumo *et al.,* 2016).

Table 3. Effect of different inclusion levels of liquid moringa leaf meal on the serum biochemistry of growing Yankasa ram

	Liquid moringa leaf meal (g DM kg^{-1} feed intake)					
Parameters	**0**	**4**	**8**	**12**	**SEM**	**P value**
Urea (mg/dL)	11.75^{c}	12.75^{bc}	17.00^{ab}	19.00^{a}	1.33	0.002
Creatinine (mg/dL)	1.48^{bc}	2.53^{a}	1.18^{c}	2.00^{ab}	0.18	0.003
Albumin (g/dL)	2.05^{b}	2.75^{a}	2.90^{a}	2.58^{a}	0.13	0.001
Globulin (g/dL)	5.58	5.00	4.78	5.10	0.36	0.358
Total protein (g/dL)	7.63	7.75	7.68	7.68	0.29	0.990

^{abc}Means with different superscripts across the rows differ significantly at $p<0.05$. SEM: Standard error of means

Effect of liquid moringa leaf meal supplementation on the serum lipid profile and liver function enzymes of growing Yankasa rams

The serum lipid profile and liver function enzymes (Table 4) of growing Yankasa rams supplemented with liquid moringa leaf meals at 4, 8, and 12 g DM kg^{-1} feed intake showed no significant differences ($P>0.05$) in the parameters compared to the rams on the control group, except the lactate dehydrogenase (LDH) which increased significantly ($P<0.05$) in value up to 8 g DM kg^{-1} feed intake but decreased at 12 g DM kg^{-1} feed intake supplementation. The increase in LDH at 8 g DM kg^{-1} feed intake supplementation suggests an enhanced metabolic activity in the muscle or hepatic tissue suggesting an elevated energy turnover associated with dietary utilization of moringa bioactive compounds. This study revealed no significant differences

(P>0.05) in aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and gamma-glutamyl transferase (GGT) across the treatment groups, suggesting that liquid moringa leaf meal supplementation had no adverse effect on liver enzyme function, similar to the findings in other studies. These findings are in line with Hussein and Jassim (2019), who reported no significant variation in broiler chicken fed with 2 and 4 g kg^{-1} DM *M. oleifera* leaf meal, strengthening the report that moringa supplementation had no effects on aspartate aminotransferase and alanine aminotransferase activities, supporting the notion that moringa leaf does not impair liver function across species.

Table 4. Effect of different supplementation levels of liquid moringa leaf meal on serum lipid profile and liver function enzymes of growing Yankasa ram

	Liquid Moringa Leaf Meal (g DM kg^{-1} feed intake)					
Serum lipids (mg/dL)	**0**	**4**	**8**	**12**	**SEM**	**P value**
Triglycerides	88.20	69.80	74.40	56.40	18.08	0.11
High-Density lipoprotein	52.80	39.60	50.80	55.80	10.90	0.66
Low density lipoprotein	24.00	31.20	40.00	23.20	6.40	0.18
Liver function enzyme (U/I)						
Aspartate aminotransferase	69.25	80.75	73.00	73.50	7.20	0.63
Alanine aminotransferase	11.00	10.75	12.75	10.75	1.47	0.64
Alkaline phosphatase	22.75	17.75	21.75	18.75	3.89	0.69
Lactate dehydrogenase	61.50^{c}	71.75^{b}	82.75^{a}	66.00^{bc}	4.52	0.01
Gamma-glutamyl transferase	28.75	34.75	29.25	39.00	3.75	0.13

Conclusion

The supplementation of liquid moringa leaf meal (LMLM) up to 12 g DM kg^{-1} feed intake increased the serum albumin and urea concentrations in growing Yankasa rams. However, the dietary supplementation of LMLM on growing Yankasa rams up to 12 g DM kg^{-1} feed intake had no effect on heamatological indices, serum lipid profile and liver function enzymes. Therefore, it is concluded that oral administration of LMLM up to 12 g DM kg^{-1} feed intake does not have detrimental effects for use in growing Yankasa rams at the tested inclusion levels. Further studies evaluating higher inclusion levels of LMLM in Yankasa rams and other class of livestock species to establish its upper dietary threshold and wider physiological effects.

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