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Performance of Yankasa Rams Fed Molasses-Treated Masakwa Stover Supplemented with Different Levels of Water Hyacinth

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Abstract— *The research was conducted to study the performance of Yankasa rams fed molasses-treated masakwa stover supplemented with different levels of water hyacinth. The experiments were conducted at the Federal College of Education, Yola Teaching and Research Farm. The objective of the study was to determine the nutrient digestibility of Yankasa rams fed molasses-treated masakwa stover supplemented with different levels of water hyacinth. The chemical composition of the masakwa plant was determined; dry matter (DM) ranged from 91.35% in week four (4) to 92.43% in week sixteen (16), crude protein (CP) from 8.75% in week four (4) to 10.60% in week sixteen (16), crude fiber (CF) from 9.35% to 20.36% from week four (4) to sixteen (16), ether extract (EE) from 0.94% to 2.29% from week four (4) to week sixteen (16), nitrogen-free extract (NFE) from 51.44% to 76.93% from week four (4) to sixteen (16), and ash from 4.03% to 15.31% from week four (4) to sixteen (16), respectively. The nutrient digestibility of Yankasa rams recorded dry matter digestibility (DMD) (51.46 to 60.72%), crude protein digestibility (CPD) (63.46 to 70.90%), crude fiber digestibility (CFD) (70.66 to 87.27%), ether extract digestibility (EED) (79.55 to 87.27%), nitrogen-free extract (66.79 to 71.01%), acid detergent fiber (ADF) (52.02 to 60.45%), and neutral detergent fiber (NDF) (70.12 to 79.12%). The highest values (79.55 to 87.27%) were recorded in crude fiber digestibility (CFD) and ether extract digestibility (EED). The study concluded that supplementing molasses-treated masakwa stover with water hyacinth significantly improved the digestibility of crude protein and energy in Yankasa rams. It is recommended that farmers in this region should consider incorporating water hyacinth into the diets of Yankasa rams to improve feed intake and utilization. Further research should be conducted to evaluate the long-term effects of water hyacinth supplementation on ram productivity and health.*

Keywords— Nutrient digestibility, Yankasa rams, Molasses, Treated masakwa stover, Water hyacinth, Feed utilization, Crop residues, Small ruminants, Nigeria, Ruminant nutrition.

I. INTRODUCTION

Livestock are fed with diverse feed resources all over the world (Abidi et al., 2009). In Nigeria, the major feed resources are crop residues and grass hay, which contain poorly digestible nutrients. To ensure better body condition of the animals, it is advisable that additional sources of carbohydrate and nitrogen be included in the diet of the animals, thereby improving the utilization of crop residues, which is mainly attained through the supply of energy and nitrogen to rumen microbes (Van Soest et al., 1991). Cereal stovers are relatively poor in nutritive value, which is concentrated in the harvested grain, but they are widely used for feeding ruminants, often when other feeds are inadequate or unavailable towards the end of the dry season. The total value of these crops therefore lies in their grain yield as well as the use of the stovers for livestock feed. Osafo et al. (1996) have demonstrated an important practical feeding strategy where chopped sorghum stover offered at a high rate of 800 g of raw forage per day for a ram of 35 kg with mineral lick is sufficient to maintain weight of rams aged 15 to 20 months.

Masakwa, which is one of the major staple foods in Adamawa State, is produced in large quantities, thereby generating large quantities of fodder that are sometimes not properly utilized in the feeding process of livestock. The stover sometimes is contaminated by animal feces during grazing, thereby rendering it unusable to the animal. It was concluded that chopped sorghum stover offered generously with minerals but no other supplement is a sustainable feeding strategy for maintaining weight in adult sheep (Ben and Smith, 2008).

Water hyacinth is found in most water bodies in the world (Khan et al., 2002) and is readily available in and around Adamawa State, particularly in the water bodies. Water hyacinth grows in the wild, hampers water transportation, and affects fishing gears and other water users. Moreover, it does not compete with other agriculturally useful vegetation for growing space (Brook and Iwanaga, 2016). Due to its high reproductive rate, this plant frequently causes blockage of navigable waters and irrigation ditches (Dugje et al., 2014). In this situation, the utilization of water hyacinth as feed for livestock may offset the cost of removal. The chemical composition of most aquatic plants suggests that they are acceptable animal feeds and that they have more minerals and protein content (Muhammed, 2008; Osarya, 2005). Therefore, this notorious plant can be utilized as an excellent source of animal feed.

II. MATERIALS AND METHODS

2.1 Study Area

The research work was conducted to study the nutrient digestibility of Yankasa rams fed molasses-treated masakwa stover supplemented with graded levels of water hyacinth. All the experiments were conducted at the Federal College of Education, Yola Teaching and Research Farm.

2.2 Digestibility Trials

At the end of the feeding trial, eight (8) grower rams (two per treatment) were randomly selected for the digestibility trial. The rams were separately kept in metabolism crates for seven days to acclimatize before data collection began. The rams were starved for twelve hours prior to experimental feeding to clear the gut of previous diets. They were also starved for another twelve hours at the end of the feeding period to ensure total collection of feces arising from the diet offered. Feces and urine were collected separately on a daily basis every morning (7:30–8:30 am). The feces were sun-dried and weighed daily to get constant weights. Urine was also collected three times (7:00 am, 12:00 noon, and 5:00 pm) daily in a labeled plastic container, with record of the total weight and volume. About 10% of each day's collection was stored in 10 mL of 10% sulfuric acid to prevent nitrogen losses by evaporation of ammonia and help keep the urine pH below 4. The urine was stored in a deep freezer until required for analysis. At the end of the seven-day collection period, feces from each replicate were mixed, ground, and representative samples taken for proximate composition determination. The urine from each replicate was also mixed together and representative samples were taken for nitrogen determination.

Note: The digestibility trial used only two rams per treatment (total n=8). This small sample size limits statistical power and generalizability. The results should be interpreted with caution, and future studies should include larger numbers of animals per treatment.

2.3 Composition of Supplementary and Basal Diets

The compositions of the diets were assigned at graded levels according to the treatment. The molasses was added at the rate of 5%, which was sprinkled on 20 kg of masakwa stover. The treatments were as follows:

- **T1 (Control):** Molasses-treated masakwa stover (0 g water hyacinth)
- **T2:** Molasses-treated masakwa stover + 100 g water hyacinth
- **T3:** Molasses-treated masakwa stover + 200 g water hyacinth
- **T4:** Molasses-treated masakwa stover + 300 g water hyacinth

2.4 Proximate Analysis of the Experimental Diet

The proximate composition of the experimental diets was determined using the proximate analysis according to the Association of Official Analytical Chemists (AOAC, 2004). The following were determined: crude protein (CP) by the Kjeldahl method, ash by burning in a furnace at 550°C for three (3) hours, crude fiber (CF), and ether extract by Soxhlet extraction according to standard methods. Neutral detergent fiber (NDF) was determined according to the method of Van Soest (1994).

2.5 Statistical Analysis

All data were subjected to SPSS version 16 to analyze the statistical data collected in this study. The NEWAY EXCEL package for processing data from feed degradability and in-vitro gas production was used to compute the data obtained in degradability (Chen and Gomes, 1992). Dry matter degradability of each sample for each incubation time was calculated from the disappearance of dry matter from the bag after incubation and washing according to the equation by Ørskov and McDonald (1979).

III. RESULTS

3.1 Proximate Composition of Masakwa Plant

The proximate composition of the masakwa plant over the 16-week growth period is presented in Table 1. The dry matter (DM) content of the masakwa plant increased progressively from 91.35% at week 4 to 92.43% at week 16, indicating a gradual loss of moisture as the plant matured. This increase in DM content is typical of plant maturation processes, where structural components accumulate and water content decreases.

The crude protein (CP) content showed a steady increase from 8.75% at week 4 to 10.60% at week 16, suggesting that protein accumulation continued throughout the growth period. The crude fiber (CF) content exhibited the most dramatic increase, rising from 9.35% at week 4 to 20.36% at week 16, reflecting the progressive lignification and structural development of the plant as it matured.

The ether extract (EE) content increased from 0.94% to 2.29% over the 16-week period, indicating a gradual accumulation of fats and oils in the plant tissues. The nitrogen-free extract (NFE), which represents the soluble carbohydrates, showed a marked decline from 76.93% at week 4 to 43.69% at week 16. This decline is consistent with the conversion of soluble carbohydrates into structural carbohydrates (cellulose and hemicellulose) as the plant matured. The ash content increased substantially from 4.03% at week 4 to 15.31% at week 16, reflecting the accumulation of mineral elements in the plant tissues over time.

These compositional changes indicate that the nutritional value of masakwa plant varies considerably with maturity, with younger plants having higher soluble carbohydrate content and lower fiber content, while mature plants have higher fiber and mineral content but lower soluble carbohydrate content.

TABLE 1
PROXIMATE COMPOSITION OF MASAKWA PLANT OVER A 16-WEEK PERIOD (%)

Weeks	DM	CP	CF	EE	NFE	Ash
4	91.35	8.75	9.35	0.94	76.93	4.03
8	91.78	9.12	12.45	1.23	68.54	6.89
12	92.01	9.87	15.78	1.67	55.23	10.45
16	92.43	10.6	20.36	2.29	43.69	15.31
SEM	0.89	0.65	0.59	0.19	1.05	0.41

KEY: DM = Dry matter; CP = Crude protein; CF = Crude fiber; EE = Ether extract; NFE = Nitrogen-free extract; SEM = Standard error of the mean

3.2 Anti-Nutritive Factors of Masakwa Plant

The anti-nutritive factors of the masakwa plant at week 16 are presented in Table 2. The tannin content was 1.57%, saponin content was 1.81%, and alkaloid content was 2.18%. These values indicate the presence of potentially limiting factors that could affect feed intake and nutrient utilization if present in high concentrations.

The alkaloid content (2.18%) was notably higher than the levels considered safe for growing ruminants, suggesting that processing or treatment of masakwa stover may be necessary to reduce the concentration of these anti-nutritive factors before feeding to livestock. The tannin and saponin levels, while present, were within ranges that may not significantly impair digestibility at the levels recorded in this study.

TABLE 2
ANTI-NUTRITIVE FACTORS OF MASAKWA PLANT (%)

Weeks	Tannin	Saponin	Alkaloid
16	1.57	1.81	2.18
SEM	0.04	0.11	0.12

3.3 Nutrient Digestibility of Yankasa Rams Fed Molasses-Treated Masakwa Stover Supplemented with Different Levels of Water Hyacinth

The nutrient digestibility of Yankasa rams fed molasses-treated masakwa stover supplemented with graded levels of water hyacinth is presented in Table 3. The results showed significant ($p < 0.05$) differences among treatments for all parameters measured.

3.3.1 Dry Matter Digestibility (DMD)

Dry matter digestibility ranged from 51.46% (T2) to 60.72% (T4), with Treatment T4 (300 g water hyacinth) recording the highest value. Treatment T1 (control) recorded 55.13%, while Treatment T3 recorded 54.84%. The lowest value was observed in Treatment T2 (51.46%). The significantly higher DMD in Treatment T4 suggests that supplementation with 300 g of water hyacinth improved the overall digestibility of the diet, possibly due to enhanced microbial activity in the rumen.

3.3.2 Crude Protein Digestibility (CPD)

Crude protein digestibility ranged from 63.46% (T4) to 70.90% (T2). Treatment T2 (100 g water hyacinth) recorded the highest CPD (70.90%), followed by Treatment T3 (67.76%), Treatment T1 (66.49%), and Treatment T4 (63.46%). The higher CPD values in Treatments T2 and T3 suggest that moderate levels of water hyacinth supplementation enhanced protein utilization, while the highest level of supplementation (300 g) may have resulted in a dilution effect or altered rumen fermentation patterns.

3.3.3 Crude Fiber Digestibility (CFD)

Crude fiber digestibility ranged from 70.66% (T1) to 79.28% (T4). Treatment T4 recorded the highest CFD (79.28%), followed by Treatment T3 (73.80%), Treatment T2 (70.76%), and Treatment T1 (70.66%). The significantly higher CFD in Treatment T4 indicates that supplementation with 300 g of water hyacinth enhanced the utilization of fibrous components of the diet, likely through improved microbial fermentation in the rumen.

3.3.4 Ether Extract Digestibility (EED)

Ether extract digestibility ranged from 79.55% (T1) to 87.27% (T4). Treatments T3 and T4 recorded the highest EED values (87.16% and 87.27%, respectively), which were significantly higher than T1 (79.55%) and T2 (80.96%). The improved EED in treatments with higher water hyacinth supplementation suggests that the fat content of water hyacinth was well utilized by the rams.

3.3.5 Nitrogen-Free Extract Digestibility (NFE)

Nitrogen-free extract digestibility ranged from 65.03% (T2) to 71.01% (T4). Treatment T4 recorded the highest NFE digestibility (71.01%), followed by Treatment T1 (66.79%), Treatment T3 (66.66%), and Treatment T2 (65.03%). The higher NFE digestibility in Treatment T4 indicates improved utilization of soluble carbohydrates when supplemented with 300 g of water hyacinth.

3.3.6 Acid Detergent Fiber Digestibility (ADF)

Acid detergent fiber digestibility ranged from 52.02% (T1) to 60.45% (T4). Treatments T3 and T4 recorded significantly higher ADF digestibility (60.14% and 60.45%, respectively) compared to T1 (52.02%) and T2 (56.05%). The improved ADF digestibility in treatments with higher water hyacinth supplementation indicates enhanced breakdown of lignified fiber components, likely due to improved rumen microbial activity.

3.3.7 Neutral Detergent Fiber Digestibility (NDF)

Neutral detergent fiber digestibility ranged from 70.12% (T1) to 79.12% (T4). Treatment T4 recorded the highest NDF digestibility (79.12%), followed by Treatment T3 (78.23%), Treatment T2 (70.56%), and Treatment T1 (70.12%). The significantly higher NDF digestibility in Treatments T3 and T4 indicates that water hyacinth supplementation enhanced the utilization of hemicellulose and cellulose components of the diet.

TABLE 3
NUTRIENT DIGESTIBILITY OF YANKASA RAMS FED MOLASSES-TREATED MASAKWA STOVER SUPPLEMENTED WITH DIFFERENT LEVELS OF WATER HYACINTH

Parameter	T1 (0 g control)	T2 (100 g)	T3 (200 g)	T4 (300 g)	SEM
DM (%)	55.13b	51.46d	54.84c	60.72a	1.19**
CP (%)	66.49c	70.90a	67.76b	63.46d	1.62**
CF (%)	70.66b	70.76b	73.80b	79.28a	1.28**
EE (%)	79.55c	80.96c	87.16a	87.27a	1.90**
NFE (%)	66.79b	65.03c	66.66b	71.01a	0.96**
ADF (%)	52.02c	56.05b	60.14a	60.45a	0.51**
NDF (%)	70.12d	70.56c	78.23b	79.12a	0.42**

KEY: DM = Dry matter; CP = Crude protein; CF = Crude fiber; EE = Ether extract; NFE = Nitrogen-free extract; ADF = Acid detergent fiber; NDF = Neutral detergent fiber; SEM = Standard error of the mean
Values with different superscripts within the same row are significantly different ($p < 0.05$); ** = significant at $p < 0.05$

3.4 Summary of Digestibility Findings

Overall, the digestibility results showed a general trend of improved nutrient utilization with increasing levels of water hyacinth supplementation. Treatment T4 (300 g water hyacinth) consistently recorded the highest digestibility values for most parameters, including DM (60.72%), CF (79.28%), EE (87.27%), NFE (71.01%), ADF (60.45%), and NDF (79.12%). The only exception was crude protein digestibility, where Treatment T2 (100 g water hyacinth) recorded the highest value (70.90%).

These findings suggest that water hyacinth supplementation at levels of up to 300 g per ram per day can significantly improve the digestibility of molasses-treated masakwa stover, with the most pronounced improvements observed in fiber fractions (CF, ADF, NDF) and ether extract. The improved digestibility is likely attributable to enhanced rumen microbial activity resulting from the additional nutrients provided by water hyacinth.

IV. DISCUSSION

4.1 Biomass and Nutritive Value of Masakwa Plant

The height of the masakwa plant recorded in the experiment was 150.70 cm, lower than the 193 cm reported by Adamu and Dauda (2008), while it was higher than the 140 cm reported by Gapili et al. (2019). The differences in plant height might be attributed to seed varieties, soil types, and time of harvest (Kyriazakis and Oldham, 2007). Plant height was generally slow from week one to three, which might be as a result of shock experienced by the plants when they were uprooted from the nursery where regular water supply was given (Tabo et al., 2002). Farmers select sites for masakwa sorghum production on the basis of soil types, availability of land, and the amount of water stored during the wet season (Tabo et al., 2002). Sandy, clay loams, and clay soils are most commonly preferred, but in this case, clay soil was used because of its high water-holding capacity, as reported by Masresha and Belay (2020).

4.2 Proximate Composition and Anti-Nutritive Factors of Masakwa Stover

The dry matter (DM) of the masakwa plant (93.17%) was lower than the 96.50% reported by Medugu et al. (2012), which could be attributed to environment, seed variety, type of soil, climate, and time of harvest. The crude protein (CP) was 19.72%, similar to the 20.25% reported by Medugu et al. (2012). The crude fiber (CF) and ether extract (EE) of masakwa were 30.89% and 2.05%, respectively, which were less than the 32.00% CF and higher than the 1.00% EE reported by Jibril et al. (2018). Similarly, the ash, acid detergent fiber (ADF), and neutral detergent fiber (NDF) of masakwa were 21.73%, 38.22%, and 48.83%, respectively. The values were higher than the 9.17% (ash) and 36.20% (ADF) reported by Akhtar et al. (2021) but less than the 72.23% (NDF) reported by the same authors, and similar to the 51.20% reported by Getachew and Mohamadou (2014). The differences might be attributed to environment, variation in soil, and climate.

The anti-nutritive factors of the masakwa plant were 0.82% (tannin), which is lower than the 2.40% reported by Adedeji (2020). The saponin content was 1.06%, which corresponds with the 1.05% reported by Adedeji (2020). The alkaloid content of the masakwa plant was 2.16%, which is higher than the value required by growing ruminants (Diarra et al., 2016). This may likely affect growth rate and other production parameters. It also showed that as the plants grow, their toxicity level increases, which agrees with Amodu et al. (2004).

4.3 Chemical Composition of Water Hyacinth

The crude protein (CP) of water hyacinth was 19.72%, which is higher than the value of 10.42% (CP) reported by Mako et al. (2011) and 14.00% (CP) reported by Emran et al. (2015). The leafy parts of water hyacinth from nutrient-enriched wastewater usually contain 25–35% crude protein on a dry weight basis. The level of CP in the whole plant without root is higher than the critical level of 7.0 g/100 g DM, below which feed intake will be depressed; this was as a result of absorbing waste material present in the body of water (Mengistu et al., 2017). Murillo et al. (2012) emphasized that due to good nutrient profile, water hyacinth can be used to supplement the low nutrient value of tropical grasses, and also that all of the essential amino acids were present at high levels in the leaf protein isolate. The neutral detergent fiber (NDF) content of water hyacinth leaves and the entire plant in this study were (48.83%), higher than the value of 48.30% NDF reported by Aboud et al. (2005) and Jafari (2010). Some parts of the feed were only partially digestible by any species of animals, but can be used to a greater extent by ruminants, which depend on microbial digestion for utilization of most fibrous plant components.

4.4 Nutrient Digestibility of Molasses-Treated Masakwa Stover Supplemented with Graded Levels of Water Hyacinth

Nutrient digestibility of Yankasa rams fed molasses-treated masakwa stover supplemented with graded levels of water hyacinth showed significant ($p < 0.05$) differences. The digestibility was significantly ($p < 0.05$) influenced by the water hyacinth supplementation. The dry matter digestibility ranged from 51.46% to 60.72%, higher than the 42.88% to 57.98% reported by Kalio et al. (2013) when the authors fed West African Dwarf (WAD) sheep with cassava, yam, and sweet potato peels. The result of crude fiber and organic matter digestibility showed a significant ($p < 0.05$) difference, with values ranging from 58.95% to 79.28%, higher than the 43.66% to 57.69% reported by Ahamefule et al. (2002). Treatment T4, supplemented with 300 g water hyacinth, had the highest crude fiber and organic matter digestibility (79.28% and 58.98%, respectively), while Treatment T1 (0 g water hyacinth) had the lowest crude fiber digestibility (70.66%). The crude fiber and organic matter digestibility values obtained in this study were higher than the values (43.66–57.69%) reported by Adeshina and Okunlola (2000). Thus, the 300 g supplemented diet recorded in this study contained a higher percentage of crude protein (CP), which resulted in higher palatability and better utilization of nutrients by the rams. This observation agrees with earlier reports (Oddoye et al., 2005) that for rumen microbial flora to perform at optimum level, the presence of nitrogen source and soluble carbohydrate had to be synchronized.

V. CONCLUSION

The study concluded that supplementation of molasses-treated masakwa stover with increasing levels of water hyacinth significantly improves the digestibility of the diets for Yankasa rams, and no adverse effects were recorded. The highest digestibility values were generally observed in the treatment with 300 g water hyacinth supplementation (T4), indicating a positive effect on nutrient utilization.

Recommendations:

1) Farmers in the region should consider incorporating water hyacinth into the diets of Yankasa rams at levels of up to 300 g per animal per day to improve feed intake and nutrient utilization.
2) Further research should be conducted to evaluate the long-term effects of water hyacinth supplementation on ram productivity, health, and meat quality.
3) Research should also investigate the palatability of higher levels of water hyacinth supplementation and determine if higher levels will adversely affect other nutritional factors or animal performance.
4) Future studies should include larger sample sizes (more than 2 animals per treatment) to improve statistical power and generalizability of the findings.
5) The utilization of water hyacinth as a feed resource should be promoted as a sustainable strategy for managing this invasive aquatic weed while providing a nutritious feed supplement for ruminants.

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CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the publication of this manuscript.

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