

Effect of different processing methods on the biochemical composition of water hyacinth and acceptability by WAD goats

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Abstract

The limiting factor in the use of water hyacinth (WH) as a fodder is the high moisture content. Subjecting this water weed to various processing methods might reduce the moisture content to an appreciable level that will be tolerated by animals. Fresh samples of water hyacinth harvested from lagoon water body in Ogun State were processed into wilted, ensiled, sun-cured. Two experiments were conducted. Experiment I involved the determination of nutrient composition (Dry matter, Crude protein, Crude fibre Ash, Neutral detergent fibre and Acid detergent fibre), mineral content (macro and micro minerals) and secondary metabolites (spot test analysis of (saponin, phenol and steroid) of fresh and processed WH. In experiment II, the fresh and processed WH were fed to eight WAD goats in a cefetaria feeding trial to determine the Coefficient of Preference (COP) of all forms of water hyacinth. Results revealed that, the nutrient composition was influenced by processing methods except for the ash content. The sun-cured WH contained more dry matter (89.30 g/100g DM), while the lowest dry matter (8.22 g/100g DM) was recorded for fresh WH. However, ensiled WH contained more crude protein (16.23 g/100g DM) than other forms of WH, the lowest CP (10.42 g/100gDM) was recorded for fresh WH (DBG has some protein in it and it added to the water hyacinth, hence the raised CP content of ensiled WH). However, the neutral detergent fibre ranged from 55.20 to 66.25 g/100g DM in ensiled and sun-cured respectively. The mineral content of all forms of WH were similar. Qualitative evaluation of saponin, phenol and steroid showed that all forms of WH contained tannins and steroids; saponin was found but declared negative due to height of the form. The result of COP, showed that the fresh WH (0.74) was rejected, while all processed WH were acceptable to the animals. However, the ensiled WH (1.40) was most preferred. It is concluded that processing methods can improve the nutrient composition of WH and also the preference by animals.

Key words: Acceptability, mineral content, nutrient composition, secondary metabolites, water hyacinth

Introduction

The shortage of conventional feed resources is one of the major constraints for increased productivity of livestock in Nigeria. Due to high population density, there is no scope for increasing the area under fodder cultivation and importation of feed is not sustainable for economic reasons. One way to alleviate this shortage would be the development of new

technology for the utilization of aquatic plants as livestock feed. In Nigeria, water hyacinth grows abundantly throughout the year in rivers, ponds, lakes, ditches and low lying paddy fields without agronomic care. Moreover, they do not compete with other useful vegetation for growing space. It has high reproductive rate, doubling itself in 6-18 days (Hansen and Chakrabarty, 2009). This plant frequently cause blockage of

navigable waters and irrigation ditches. In this situation, utilization of water hyacinth as feed for livestock may offset the cost of removal. The nutrient composition of water hyacinth suggests that they can be acceptable animal feeds and that they have more minerals and protein and less fibre than most terrestrial forages. (Mako and Akinwande, 2012). The high moisture content of the plant might be a limiting factor in feeding the plant on a fresh basis, since animals would eat more of the plant materials to enable it get adequate amount of nutrient for body metabolism. Unfortunately, this might not be attainable since the level of feed intake in ruminant is also controlled by the capacity of the digestive tract, particularly, the rumen, with the animal ceasing to eat when a certain degree of 'fill' has been attained. However, it has been confirmed that the high amount of water in the plant can be reduced by dehydrating the harvested plant materials under the sun as wilted (Mako and Babayemi, 2008), ensiled (Akinwande *et al*, 2011) and hay (Mako, 2013).

The nutritive value of forage may be assessed by its nutrient composition, acceptability and digestibility. Nutrient composition is a factor associated with the plant and its environment. The rate of consumption of forage is related to the readiness with which it is degraded and it is a function of the fiber mass generated during digestion and quantity of forage available to animals (Barro and Ribeiro, 1983).

This study was therefore, designed to evaluate the effect of different processing methods on the nutrient composition, mineral content, secondary metabolites and acceptability of water hyacinth by WAD goats.

Materials and methods

Processing of water hyacinth

Samples of water hyacinth were collected from a lagoon water body (Odogbolu town in Ogun State). Samples were collected in batches of about 100kg fresh weights. Ensiling was carried out near a ferry point where wilting and storage were done. After harvesting, fresh plant shoots were lacerated and separated from the roots. Lacerated samples were later chopped using knives to about 3-5 cm pieces and then wilted under shade for 48 hours on polythene sheets {Lacerated samples are water hyacinth stems that were split open. The shoots (leaves and stems) were washed and cut into pieces, Roots were discarded}.

The material was then weighed and mixed in turn with the additive (dry brewer grain) at 20% of the water hyacinth weight to be ensiled (i.e. 20kg of DBG to 80kg of WH). DBG as an additive is needed to enhance fermentation during silage making. Usually materials below 30 % DM is prone to the risk of poor fermentation (bearing in mind that the dry matter of water hyacinth is 8.22 g/100g DM which is very low), therefore the DBG was used as an additive to reduce the pH fast, using the least amount of sugar, this will reduce DM losses and protein breakdown. Other common additives that are used in ensiling are molasses, honey, wheat offals etc. DBG was not added to other processing methods as it is only needed to make silage.

This was replicated five times in a completely randomized design. Fermentation period was 42 days as reported by Babayemi (2009).

Experimental silos

Polythene bags each capable of holding at least 30 kg wilted water hyacinth were used as silos. Each bag was placed inside a 65 litre capacity plastic basin for

reinforcement and ease of fermentation. Ensiling was by rapid compaction of the material into the silos to displace the air until the polythene bags were filled. Sealing of the silo was done by placing a 25 kg sand-bag on top of the polythene bags after tying carefully and firmly.

Wilting and Sun-curing

Harvested samples were wilted under a shed for five days as wilted samples; also harvested samples were spread under the sun to dry completely as sun-cured samples.

Acceptability study

Experimental site

The study of the relative acceptability of different forms of water hyacinth was carried out at the Sheep and Goat Unit of the Department of Agricultural Production and Management Science, Tai Solarin University of Education, Ijebu-Ode, which is situated in the low rainfall area of Ogun-State. The location is 7° 21' N and 3° 45' S at an altitude of between 200m and 300m above sea level. The mean temperature is 25-29 °C with an average rainfall of about 1250mm. The surrounding of the sheep and goat house was sprayed with broad spectrum insecticide, acaricides and larvicides (diasuntol), while the inside of the pen was fumigated at 3 days interval before the arrival of the goats. The feed and water troughs were washed thoroughly to get rid of any pathogens present. The laboratory analysis was carried out at the Ruminant Nutrition Laboratory of Animal Science Department, University of Ibadan.

Experimental goats

Eight (8) female WAD goats previously certified fit by the University veterinarian was subjected to free choice feeding to evaluate the acceptability of different forms of water hyacinth in a cafeteria feed preference study (Mako and Babayemi 2008). The pre experimental weight and age of the goats used were between 12.50 –

12.65 kg and 12 to 18 months respectively. They were housed together in a pen within the sheep and goat house which was constructed to achieve good ventilation. The floor of the house was made of concrete and covered with wood shavings for easy cleaning of the pen.

Feeding of animals

The feed preference study lasted for 2 weeks including a week for the animals' adaptation to the forage. Water hyacinth processed into different forms (wilted, sun-cured, ensiled and fresh) were reserved to the goats daily. The processing for wilted WH was strategic, such that 5 days old water hyacinth were used each day; the fresh samples were harvested daily; ensiled and sun-cured WH were available each day. Each form of WH was placed in separate feeding troughs in triplicates and were strategically placed in the pen in form of cafeteria feeding (Mako and Babayemi, 2008). The wooden feeder (150 cm x 60 cm) was used to enable the eight (8) goats feed simultaneously in a convenient situation, each animal had free access to each of the differently processed water hyacinth in the feeding troughs. Position of feeders were changed every day to prevent adaptation of the animal to a particular forage. The feeding was allowed from 0800 to 1600 hr daily. The feed consumed was determined by deducting the feed refusal from the quantity offered. Dried samples (about 200 g) of each form of water hyacinth taken during the 14-day acceptability trial were used to determine the Dry matter content. The forage preferred was assessed from the coefficient of preference (COP) value calculated from the ratio between the intakes of each individual forage divided by the average intake of the forage (Mako and Babayemi, 2008). Thus, the plant was concluded to be acceptable provided the

COP was greater than unit

Chemical analyses of feeds

Dry matter (DM), crude protein (CP), crude fibres (CF), ether extract (EE) and ash contents of fresh and differently processed WH were determined in triplicates as described by AOAC (2012) The fibre fraction comprising of neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined as described by Van Soest *et al.* (1991).

Qualitative determination of saponin, phenols and steroids

Saponin, phenols and steroids were determined as reported by Babayemiet *al.* (2004). Briefly, 2g of dried samples were extracted with 30 ml of petroleum ether (PE) and 25ml of methanol water (M/W, 9/1. V/V). The mixture was shaken at 250 revolutions per minute for 1hr.30mins, filtered and separated by a funnel. The lower (M/W) and upper (PE) layers were emptied into 50ml volumetric flask. From the M/W fraction, 1.67ml was dispensed into 9ml distilled water, and out of it, 1ml was taken to a test tube. The test tube was shaken for 30 secs and left to stand for 15 mins. Saponin content was evaluated from the height of the layer as (< 5 mm) negligible, (5-9 mm) low, (10-14 mm) medium and (>15 mm) high. For phenol analysis, 1 ml from the M/W fraction was dispensed into five bottles with 1% FeCl₃ added at different levels (0.2, 0.4, 0.6, 0.8 and 1ml respectively). Phenol form complexes with ferric iron, resulting in a blue solution and hence, their presence was scored as : no phenol (no colour change), hydrolysable (dark blue) and condensed tannin (dark-green). For steroids, 10 ml from the PE fraction was evaporated in a water bath at 45°C and 0.5ml chloroform, 0.25 ml acetic anhydride and 0.125 ml conc. H₂S04 were added. The mixture was agitated briefly and the colour reaction was

accessed being steroids (blue or green), triterpenoids (red, pink or purple) or saturated steroids (light yellow)

Mineral Analyses of samples

A total of ten minerals were analysed. Each sample was digested with HNO₃ / HClO₃ mixtures (nitric acid and perchloric acid) (20:5 v/v). The digest was made up to 100 ml in standard volumetric flask with deionized water. Ca, Na, K, Fe, Cu, Zn, Mn, Mg and Pb in the digest were determined with the atomic absorption spectrophotometer model 420. (Gallenkemp and Co. Ltd). Phosphorus in the digest was estimated with vanadomolybdate solution. The colour so developed was read with spectrophotometer at 420 nm.

Statistical analysis

Data obtained were analyzed and subjected to analysis of variance procedure (ANOVA) of SAS (2003). Significant means were separated by Duncan's (1955) Multiple Range Test.

Results

Table 1 is the chemical composition of fresh and processed water hyacinth. It was observed that processing had significant variations on the nutrient composition of the water weed which did not follow a particular pattern. The dry matter ranged from 8.22 to 89.30g/100g DM in fresh and sun-cured WH respectively. The crude protein ranged from 10.42 to 16.23g/100g DM in fresh and ensiled WH respectively. The CP for ensiled WH The NDF ranged from 55.20 to 66.25g/100g DM in ensiled and sun-cured WH respectively. The ash content of the fresh and processed WH was similar. The macro and micro mineral contents of fresh and processed WH is presented in Table 2. No significant variation occurred among the minerals in fresh and processed WH.

Table 1: Chemical composition (g/100g DM) of fresh and processed WH

Parameters	Fresh	Wilted	Ensiled	Sun-cured	S E M
Dry matter	8.22 ^d	13.49 ^c	22.39 ^b	89.30 ^a	2.55
Crude Protein	10.42 ^c	11.73 ^b	16.23 ^a	11.64 ^b	0.05
Ether extract	1.56 ^c	1.76 ^b	14.40 ^a	1.27 ^d	0.01
Ash	19.47	23.88	13.00	18.24	2.10
Neural detergent fibre	56.29 ^c	62.03 ^b	55.20 ^c	66.25 ^a	0.15
Acid detergent fibre	35.60 ^c	43.04 ^b	24.00 ^d	47.55 ^a	0.11

Table 3 reveals the qualitative content of anti-nutrients in WH as affected by processing methods. It was observed that processing reduced the level of saponin judging by the height of the foam (3mm) in fresh WH. All forms of WH contained tannin and steroids.

The forage preference by the animals fed fresh and processed water hyacinth is presented in Table 4. Based on their coefficient of preference (COP) values (1.20; 1.00 and 1.40) of more than unity for wilted, sun-cured and ensiled WH respectively, all the processed water

hyacinth except the fresh sample were accepted by the animals, but the ensiled water hyacinth was most preferred.

Discussion

The values of dry matter and nutrient contents obtained for processed WH increased greatly. The crude protein content was higher than 7% CP recommended as the minimum requirement for ruminants (NRC, 1981). The CP content of the fresh and processed also fell within the range of the minimum protein requirement of 10 – 12% for ruminants by ARC (1985) and that of 10% recommended for growth and

Table 2: Mineral contents (g/100g DM) of fresh and processed WH

M P	g / 100 g DM															
	C	a	P	K	N	a	M	g	F	e	Z	n	C	u	M	n
Fresh	0.60	0.14	0.34	0.22	0.16	523.69	51.86	12.19	678.0							
Wilted	0.62	0.16	0.35	0.25	0.17	521.70	52.19	11.85	682.4							
Sun-cured	0.67	0.22	0.42	0.26	0.19	527.00	52.98	13.00	689.2							
Ensiled	0.81	0.43	0.60	0.43	0.27	712.00	68.23	15.54	776.5							
S E M	0.02	0.03	0.02	0.03	0.02	10.93	1.11	0.35	9.30							

Table 3. Qualitative contents of Saponin, Phenols and Steroids of fresh and processed WH

Processed WH	S a p o n i n		P h e n o l		S t e r o i d	
	Foam (mm)	Comment	Colour change	Comment	Colour change	comment
Fresh	3	Negative	Dark green	Con. Tan	Light green	Steroid
Wilted	2	Negative	Dark green	Con. Tan	Light green	Steroid
Sun-cured	2	Negative	Dark green	Con. Tan	Light green	Steroid
Ensiled	1	Negative	Dark green	Con. Tan	Light green	Steroid

Con. tan = condensed tannin

Table 4: Mean daily dry matter intake and Coefficient of preference of WAD goats fed different forms of Water hyacinth

Water hyacinth	Mean daily (Kg DM) Consumption of all animals	Coefficient of preference
F r e s h	9	10
W i l t e d	4	61
S u n - c u r e d	2	31
E n s i l e d	6	71

maintenance in dairy goats (Ranjah, 1981), but the limiting factor is the high moisture content of the fresh which will not allow the animals to obtain enough dry matter. The NDF also increased and it is in agreement with the value of 72.90 g/100g DM reported by Baldwin *et al.* (1975) in a water hyacinth study. It fell within the value range of 55-60 g/100g DM that can limit feed intake as reported by Meissner *et al.* 1991, The ADF range obtained also increased, but the reason for decrease in ADF of ensiled WH was not known.

The values of macro and micro minerals obtained are lower than the values reported elsewhere (Khan *et al.* 2002). However the values are within the recommended requirements for grazing animals (NRC, 2001). This is an indication that water hyacinth will supply required minerals for livestock throughout the year.

Qualitative analysis of secondary metabolites in WH showed that all water hyacinth contained low saponin. Saponin has been identified as the active compound in depression of methanogenesis (Hess *et al.*, 2003). The low content of saponin in all the processed water hyacinth is advantageous because, high saponin alone would retard feed intake of ruminants (Onwuka 1983). The tannin content present in all processed water hyacinth is also an added advantage as a natural additive in the diet of ruminants. Tannin form complexes with protein in the rumen as protection

against massive proteolysis, thereby diminishing rumen protein digestibility (Barry and McNabb, 1999).

A number of factors may influence acceptability of feed by ruminants. Provenza and Cinocotta (1994) reported that the physical structure and chemical composition of the plant are the most vital factors that influence preference for feed. It can then be inferred that the high moisture content of the fresh water hyacinth made it to be rejected, while the high CP content of the ensiled WH made it to be most preferred.

Conclusion

The result of the nutrient composition of processed water hyacinth confirmed that it can ameliorate the problem of moisture content in using water hyacinth as fodder. All processed WH were accepted by the animals, it can then be concluded that processing WH will enhance its potential to alleviate the scarcity of feed for ruminants especially during the dry season.

References

- Akinwande, V.O, Mako, A.A and Babayemi, O. J. 2011.** Silage quality, voluntary feed intake (VFI), nutrient digestibility and nitrogen balance in WAD sheep fed ensiled water hyacinth in Nigeria. Proceedings of the 36th Annual Conference of the *Nigerian Society for Animal Production* (NSAP). Pg. 509 – 512

- AOAC 2012.** Official methods of Analysis, 19th ed. (Association of Official Analytical Chemists, Arlington, VA) Pp. 69-88.
- ARC 1985.** Agricultural Research Council. The nutrient requirements of farm animals. No 2 Ruminants: Tech. Rev. and Summanes. ARC, London.
- Babayemi, O. J. 2009.** Silage quality, dry matter intake and digestibility by West African dwarf sheep of Guinea grass (*Panicum maximum* cv Ntchisi) harvested at 4 and 12 week regrowths, *African J. Biotech.* 8: 3983-3988.
- Baldwin, J. A, Hentges, J. F, Bagnal, L. O. and Shirley, R. L, 1975.** Comparison of Pangolagrass and water hyacinth silages as diets for sheep, *J. Animal Sci.*, 40: 968-971.
- Barro, C and Ribeiro, A 1983.** The study of Clitoraltermatea L. Hay as a forage alternative in tropical countries. Evolution of the Chemical Composition at four different growth stages. *Journal of the Science of Food Agriculture*, 34: 780–782.
- Barry, T. N. and McNabb, W. C. 1999.** The implication of condensed tannins on the nutrition value of temperate forages fed to ruminant. *Br. J. Nutri.* 18: 263-272.
- Hasan, M. R and Chakrabarty, R 2009.** Floating aquatic macrophytes: water hyacinths. In: Hasan, M. R and Chakrabarty, R. (Eds). Use of algae and aquatic macrophytes as feed in small scale aquaculture – a review. FAO Fisheries and Aquaculture Technical Paper. No. 531. Rome, FAO. 123P
- Hess, H. D., Monslave, L. M., Lascano, C. E., Carcilla, J. E. Diaz, T. E. and Kreuzer, M. 2003.** Supplementation of tropical grass diet with forage legumes and sapindus sponaria fruits; effect on in vitro ruminal nitrogen turn over and methanogenesis. *Australian Journal of Agricultural Research*, 54, 703-713
- Khan, M. J., Steingass, H. and Drochner, W. 2002.** Nutrition evaluation of some aquatic plants for animal feeding. *Bangladesh Journal of Agricultural Science.* 29 (2): 317-324.
- Mako, A. A. and Babayemi, O. J., 2008.** Nutritional evaluation of water hyacinth as ruminant feed to curtail its environmental menace in Nigeria. *African Journal of Livestock Extension.* 6: 48–53
- Mako, A. A. and Akinwande V. O. 2012.** Potential of water hyacinth (*Eichhornia crassipes* Mart. Solms - Laubach) in ruminant production to curtail its environmental hazards on Nigerian water ways. *Journal of Solid Waste Technology and Management.* 38, NO.2 134-142
- Mako A. A., Banjo O. S., and Akinwande. V. O. 2012.** Nutritive evaluation and acceptability of two aquatic weeds (*Eichhornia crassipes* and *Acrocerazanioides*) by West African Dwarf Goats. *African Journal of Agricultural Research.* 7 (19) 3007–3013.
- Mako, A. A. 2013** Performance of West African Dwarf goats fed graded levels of sun-cured water hyacinth (*Eichhornia crassipes* Mart. Solms-Laubach) replacing Guinea grass. *Livestock Research for Rural Development.* 25 (7) 2013.
- Meissner, H. H., Viljoen, M. O., and Van Niekerk, W. A. 1991.** Intake and digestibility by sheep of Antephora, Panicum, Rodes and Smuts finger grass pastures In: Proceedings of the

- IVth international Rangeland Congress, September 1991. Montpellier, France. 648-649.
- NRC 2001.** Nutrient requirements for dairy cattle Seventh revised edition. National Research Council. National Academy of Science Press. Washington DC, US
- Onwuka, C. F. I. 1983.** Nutritional Evaluation of some Nigerian browse plants in the humid tropics. Ph. D Thesis, University of Ibadan.
- Provenza, F. D. and Cincotta, R. P. 1994.** Forage as a self organisational learning process; accepting adaptability at the expense of predictability In. Hughes, R. N. (ed) Diet selection. Blackwell Scientific publications. Oxford Pp 79 – 101.
- Ranjah, S. K. 1981.** Animal nutrition in Tropics 2nd Rev. ed. New Delhi Vikas Publishing House Put. Ltd. Pp 31 – 35.
- SAS (2003).** Statistical Analytical Systems, user's guide, version 8 ed., SAS Institute, Carry, North Carolina, USA.
- Sculthorpe, C. D. 1977.** Biology of Aquatic Vascular Plants. St. Martin's Press, New York.
- Westerdahl, H.E. and Getsinger, K. D. 1988.** Aquatic plant identification and herbicide use of Guide, vol. 11. Aquatic plants and susceptibility to herbicides. Technical Report A- 88 – 89. Department of the Army water ways Experiment station, Corps of Engineers, Vicksburg, MS
- Van Soest, P. J., Robertson, J. B. and Lewis, B. A. 1991.** Methods for dietary fibre, neutral detergent fibre, and non- starch polysaccharides in relation to animal nutrition, *J. Dairy Sci.* 74:3583-3597.

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