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Research

Preservation, quality, chemical attributes and sheep acceptability of water hyacinth silage (*Eichhornia crassipes*, Mart.Solms-Laubach).

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Abstract

Availability of pasture during prolonged dry season is uncertain in Nigeria. Hence the need for pasture preservation during the period of lush growth. Silage making is one of the options available. Water hyacinth (WH) is readily available in the rivers, streams and lagoons in Nigeria. Nutritive value and coefficient of preference (COP) of ensiled WH was evaluated using agro-industrial by-products; namely, Dried brewer grain (DBG), Palm kernel cake (PKC) and Wheat offal (WO) as additives to prepare WH-based silages. Fermentation was for 42 days. Silages were fed to WAD sheep to determine preference. The WHS had a pH of 9.3, while other silages (those with additives) had a pH range of 4.3□4.7, a firm texture, pleasant odour and yellow-brown colour. The proximate composition of all four silages varied significantly and ranged: crude protein, 7.3□16.2; crude fibre, 12.4□24.4; ash, 9.00□26.8 and ether extract, 8.2□14.4 (g/ 100 g DM). Results of the COP for the silages ranged from 0.05□1.09 and could be ranked in order of preference as WHPKS>WHBDGS>WHWOS>WHS. The use of dried brewer's grain, palm kernel cake and wheat offal as additives resulted in properly fermented water hyacinth silages which were adequate in nutrients and highly accepted by sheep.

KEY WORDS: Chemical attributes, Coefficient of preference, Nutritive value, Silage, Water hyacinth

Introduction

One of the major problems of livestock production in Nigeria is nutrition. Shortage of feeds and fodders has generated interest in the use of unconventional plant materials in livestock feeding. A number of reasons, as observed by Khan et al. (2002), ranging from population pressure of man on land, feed scarcity and the need to match livestock production system with available resources for livestock feeding justify the use of non-conventional feed resources for livestock feeding. Feed costs the largest single expense in animal production, sometimes costing up to seventy percent of the total cost of production (Oluyemi and Roberts, 2000). This cost can be reduced by using water hyacinth (*Eichhornia crassipes*, Mart. Solms-Laubach) an aquatic plant that abounds in our rivers, streams, brooks and seas. Usage is, however, limited due to the lack of understanding of its nutritional details and how acceptable such would be to livestock in Nigeria. The need to evaluate this plant for nutritional adequacy calls for the study of its feeding value in ruminants.

Due to high water content of water hyacinth, its probable insufficiency to be fed fresh, this calls for a need to process it by wilting (Mako and Babayemi, 2008) before conversion into silage that could easily be fed during dry season period. The silage can be stored for several months without loss of quality and will probably obviate the need for a daily supply of the fresh plant as a fodder. The objective of this study was therefore to evaluate water hyacinth ensiled with three suitable agro-industrial waste additives. Criteria used were physical characteristics, chemical composition and sheep acceptability.

Material and methods

Harvesting of water hyacinth and silage making

Samples of water hyacinth were collected from a lagoon water body (Epe town in Lagos 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 (Plate 1). The material was then weighed and mixed in turn with each of the agro-industrial by-products namely dry brewer grain (DBG), palm kernel cake (PKC), and wheat offal (WO) at level 20% of the water hyacinth weight to be ensiled. Samples with no additive were also ensiled as control. All were replicated five times in a completely randomized design. Fermentation period was 42days as reported by Babayemi (2000). In all, four silage types were obtained namely: WHDBGS, WHPKCS, WHWOS (depending on type of additive used) and WHS (no additive used).

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 effected by placing a 25 kg sand-bag on top of the polythene bags after tying carefully and firmly (Plate 2).

Plate 1: Chopped water hyacinth plants on polythene sheets being wilted under shad

Plate 2: Fermentation, of chopped and wilted water hyacinth in mini silos.

Determination of silage quality

The study was carried out at the Teaching and Research farm of the University of Ibadan in May 2010, co-ordinate of this location being 7˚, 27' and 3˚, 45' at an altitude of 200□300 m above sea level. The average annual rainfall was about 1250mm with a mean temperature of 25□29˚ C (Babayemi, 2009). Fermentation was terminated after 42 days adopting the duration also suggested by Babayemi (2009). Assessed quality features were colour, odour, texture, temperature and pH. Immediately the silage was opened, a thermometer (laboratory type) was inserted to determine the temperature. Subsamples from different depths were taken and mixed together for dry matter determination by oven drying at 65˚ C to constant weight. These samples were later milled and stored in air tight containers for subsequent chemical analysis. The pH of sub-sampled silage was done following the procedure of AOAC (1995). About 100g of fresh and mixed of each silage sample was put in a beaker and 100 ml distilled water added. Contents were boiled for 5 minutes and decanted. The supernatant was cooled to room temperature. Following this, pH of the supernatant was determined using a pH glass electrode. Colour of silage was undertaken by visual observation using colour charts. Texture of silage was determined on the basis of wet or firm. Odour of silage was assessed on the basis of pleasant or unpleasant to olfactory stimulation.

Acceptability of silage by sheep

Eight West African dwarf rams weighing 16.50 ± 1.20 kg and about 12–15 months old were used to evaluate the free-choice intake of ensiled WH. Animals were purchased from local markets around Oyo town. The animals were placed on prophylactic treatment by giving a long-acting antibiotic administration. Animals were also treated against ectoparasites and endoparasites using levamisol and diasuntol. During the adaptation period, rams were fed only feedstuffs they were accustomed to in addition to wheat bran and cassava peels. The animals were housed in a group pen in the sheep unit of the University of Ibadan designed to accommodate 10–15 matured rams. The floor was made of concrete and there were wood shavings on the floor to act as beddings to absorb urine and faeces. Ten (10) kg each of the four silages was introduced on a cafeteria basis to the animals in four different wooden feed troughs measuring 2m x 5m so that each animal had free access to each of the silages in the troughs. The positioning of silage in a trough was changed daily to prevent bias by an animal from sticking permanently to a trough. Consumption was monitored for 8 h per day. The intake was measured by deducting the orts from the amount of feed offered. Daily samples of each ensiled WH were taken during the 14-day trial for DM content determination. Silage preference was determined from the coefficient of preference (COP) value, calculated from the ratio between intake of each individual silage divided by the average intake of the four silage types (Bamikole et al. 2004; Babayemi et al.2009). Silage was inferred to be relatively acceptable provided the COP was greater than unity.

Chemical and statistical analysis

Crude protein (CP), crude fibres (CF), ether extract (EE) and ash contents of the silages were determined in triplicates as described by AOAC (1995) and the amount of crude protein was calculated (N x 6.25). The fibre fraction comprising of neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined as described by Van Soest et al. (1991). Data were analysed using analysis of variance procedure of SAS (SAS, 2002). Significant means were separated by Duncan (1955) multiple range test. The model for the analysis was:

$$Y_{ij} = \mu + T_j + \epsilon_{ij}$$

Where Y_{ij} is the parameter studied, μ is the general mean (i.e. the population mean of all possible similar experiments), T_j is the effect of additive type on silage produced and ϵ_{ij} is the experimental error containing all uncontrolled sources of variation.

Results

Proximate compositions of the four silages prepared from water hyacinth (i.e. WHS, WHDBGS, WHPKCS and WHWOS) are presented in Table 1.The organic matter (OM) content was high and almost similar in additive-containing silages (WHDBGS, WHPKCS, WHWOS) with mean values ranging from 87.00 to 91.00 g/100g DM while the value that without an additive (WHS) is 73.20 g/100g DM. The dry mater (DM) content followed a similar trend, with mean values ranged from 19.60 to 22.39g/100g DM in additive-containing silages which contrasted sharply with the 6.75g/100g DM in the WHS silage.

Crude protein (CP) was highest in WHDBGS (16.23 g/100g DM), followed by WHWOS, WHPKCS and least in WHS (7.26 g/100g DM). The component of ether extract (EE) followed the same trend as CP while crude fibre (CF) content showed a reverse trend, being highest in WHS and lowest in WHDBGS, WHPKCS and WHWOS respectively. Ash content obtained was also highest in WHS and lowest in WHBGDS, WHPKCS and WHWOS.

Table 1: Dry matter and Proximate (g/100g DM) composition of water hyacinth ensiled with or without additives.

Nutrients	WHS	WHDBGS	WHPKCS	WHWOS	SEM
Dry matter	6.75	22.39^a	19.60	21.75	0.81
Organic matter	73.20^c	87.00^b	91.00^a	89.80^a	0.43
Crude protein	7.26^c	16.23^a	10.76^b	10.86^b	0.22
Crude fibre	24.40^a	13.00^c	21.40b	12.40^c	0.58
Ash	26.80^a	13.00^c	9.00^c	10.20^c	0.42
Ether extract	8.20^c	14.40^a	12.40^b	11.80^b	0.35
Nitrogen free extract	33.34^d	43.37^c	46.44^b	54.77^a	0.85

[a, b, c, d]= Means on the same row differently superscripted are significantly different (P<0.05), WHS= Water hyacinth silage(no additive), WHDBGS= Water hyacinth dry brewer grain silage, WHPKCS= Water hyacinth palm kernel cake silage, WHWOS= Water hyacinth wheat offal silage, SEM= Standard error of mean, NFE= Nitrogen free extract.

Table 2: The cell wall contents (g/100g DM) in water hyacinth ensiled with or without additives.

Nutrients	WHS	WHDBGS	WHPKCS	WHWOS	SEM
Neutral detergent fibre	56.40^{b}	51.20^{c}	67.60^{a}	43.20^{d}	1.06
Acid detergent fibre	29.20^{b}	24.00^{c}	39.00^{a}	18.80^{d}	1.25
Acid detergent lignin	10.60^{b}	6.60^{c}	15.20^{a}	4.40^{d}	0.67
Hemicellulose	27.20^{a}	27.20^{a}	28.60^{a}	24.40^{b}	1.52
Cellulose	18.60^{b}	17.40^{b}	23.80^{a}	14.40^{c}	0.76

[a, b, c, d]= Means on the same row differently superscripted are significantly different (P<0.05), WHS= Water hyacinth silage(no additive), WHDBGS= Water hyacinth dry brewer grain silage, WHPKCS= Water hyacinth palm kernel cake silage, WHWOS= Water hyacinth wheat offal silage, SEM= Standard error of mean, NFE= Nitrogen free extract.

The cell wall fractions of the silage types are presented in Table 2. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were highest in WHPKCS, followed by WHS, then WHDBGS and lowest in WHWOS. Hemicellulose level was similar in the silages except in WHWOS. Cellulose was highest (23.80 g/100 g DM) in WHPKCS, similar in WHDBGS and WHS and lowest (4.40 g/ 100g DM) in WHWOS. The NDF values ranged from 67.60 g/100g DM in WHPKCS being the highest to 43.20 g/100g DM in WHWOS being the lowest.

The quality of the ensiled water hyacinth with regard to colour, texture and odour/smell are shown in Table 3. Also depicted in figures 1 and 2 are pH and temperature of the silages respectively. Colour of the silages ranged from dark green (in the WHS) to yellow/khaki brown in the WHDBGS, WHPKCS and WHWOS. Only the silage WHS (silage without additive) exhibited wet-and-slimy texture while the others were firm in texture. The same trend was observed in terms of odour/smell. While the silage WHS manifested an unpleasant odour, the other group exhibited a pleasant alcoholic smell.

Table 3: Quality characteristics (colour, texture, odour) of ensiled water hyacinth

Silage	Quality indicators		
	Colour	Texture	Odour/ smell
WHS	Dark green	Wet and slimy	Unpleasant
WHBDGS	Yellowish brown	Firm	Alcoholic and pleasant
WHPKCS	Khaki brown	Firm	Alcoholic and pleasant
WHWOS	Yellowish brown	Firm	Alcoholic and pleasant

WHS = Water hyacinth silage (no additive), WHDBGS = Water hyacinth dry brewer grain silage, WHPKCS = Water hyacinth palm kernel cake silage, WHWOS = Water hyacinth wheat offal silage.

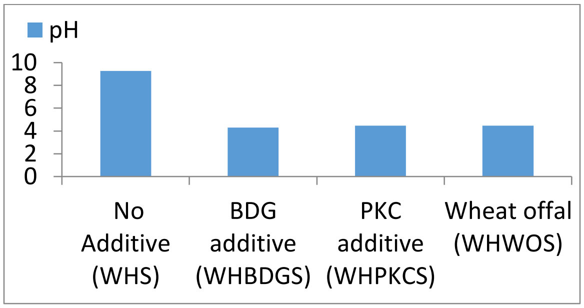

Fig. 1: Effects of additives on pH of ensiled water hyacinth

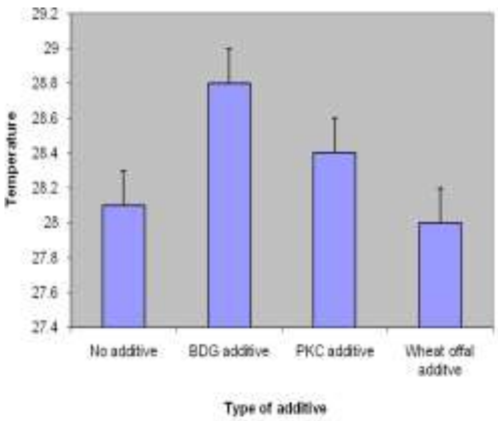

Fig. 2. Effects of additive on the temperature of water hyacinth silages fed to WAD sheep

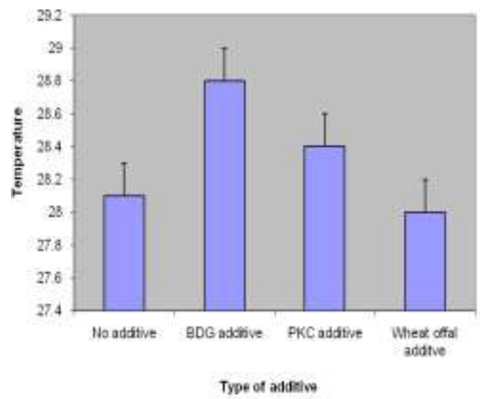

Fig. 2. Effects of additive on the temperature of water hyacinth silages fed to WAD sheep

The pH value (9.26)was highest in WHS, while the lowest pH valuewas obtained from water hyacinth silages with additives, it ranged from 4.20 to 4.66 for WHBDGS and WHWOS respectively.

The dry matter (DM) intake and coefficient of preference (COP) of sheep fed ensiled water hyacinth types are shown in Table 4. The DM intake (g/DM) ranged from 38.57 (WHS) to 1543.60 (WHWOS). The COP ranged from 0.05 in WHS to 1.90 in WHWOS.

Table 4: Dry matter intake and coefficient of preference of WAD sheep fed water hyacinth ensiled with or without additives.

Silage type	Mean daily consumption of all animals (g/DM)	Coefficient of preference
WHS	38.57	0.05
WHDBGS	892.82	1.10
WHPKCS	968.07	1.19
WHWOS	1543.60	1.90

WHS= Water hyacinth silage(no additive), WHDBGS= Water hyacinth dry brewer grain silage, WHPKCS= Water hyacinth palm kernel cake silage, WHWOS= Water hyacinth wheat offal silage.

Discussion

Chemical composition

The trend observed in the values of organic matter and dry matter in this study was expected as additives added to silages WHDBGS, WHPKCS and WHWOS would have contributed to the OM and DM. Also since the agro-industrial by-products used as additives appeared powdery and absorbent, they must have drastically reduced effluent loss, and by implication, potential nutrients loss in silages WHDBGS, WHPKCS and WHWOS. The DM content of additives-containing silages here is consistent with the 20.00g/100g DM obtained by Woomer et al. (2000) though lower than value (36.82g/100g DM) obtained by Shimizu and Kinjo (1980).

The nutrient profile reported here is within the values (in g/100g DM) reported for by-products currently utilised for livestock feeding such as cowpea shell (CP, 6.0; CF, 23.1; Ash, 2.0), maize starch residue (CP, 13.0; CF, 11.6; Ash, 1.6), cassava peel (CP, 5.1; CF, 15.7; Ash, 6.1) (Longe and Adetola, 1983), palm oil sludge (CP, 31.80; Ash, 8.50) (Malau-Aduli et al. cited by Bamikole and Babayemi, 2008). The CP constituent of three of the silages (WHBDGS, WHPKCS and WHWOS) are considered adequate for ruminant livestock feeding when juxtaposed with the recommended critical CP level of 70g/kg (or ammonia level, 70m/g N/d) to support optimum ruminal microbial activity; lower values are associated with decreased microbial activity (digestion) and are indicative of nitrogen deficiency (Norton, 2010).

The range of NDF obtained here is in agreement with that (72.90 g/100g DM) reported by Baldwin et al. (1975) in a water hyacinth study. However it is lower than the value (54.30 g/100g DM) obtained by Aboud et al. (2005). The ADF range obtained was lower than 43.20, 20.00 and 30.80 g/100g DM respectively reported by Baldwin et al. (1975), Woomer (2000) and Aboud et al.(2005). The NDF contents of WHBDGS (51.20 g/100g DM) and WHWOS (43.20 g/100g DM) were below the value 55-60 g/100g DM that can limit feed intake as reported by Meissner et al. 1991, cited by Bamikole and Babayemi (2008). Higher proportion of cell wall in WHPKCS and WHS could therefore result in decreased feed intake.

Quality characteristics

Kung and Shaver (2002), cited by Babayemi (2009) posited that pleasant smell is accepted for a good or well-made silage. The yellowish-brown-khaki colour of silages WHBDGS, WHPKCS and WHWOS were indicative of the original colour of fresh water hyacinth suggesting well preserved silages. In the opinion of Kung and Shaver (2002), when a green forage ensiled produce a yellow colour, such can be classified as a well-made silage. The khaki brown colour developed in the silages was probably caused by the action of organic acids on chlorophyll of water hyacinth which was converted into the magnesium-free pigment, phaeophytin. The temperature of the silages was below 28.8˚C indicating well preserved silages. Temperature is one of the variables that can affect silage colour and the lower the temperature during silage making, the less will be the colour change (Babayemi, 2009).

pH values

The result obtained for pH value (4.20 4.66) for WH silage with additives can be compared to 4.10‒4.20 obtained by Woomer et al. (2000) and 4.20‒5.00 obtained by Babayemi (2009) in their respective studies of water hyacinth and Guinea grass silages. Kung and Shavers (2002) stated that a good quality grass and legumes silage pH values in the tropics range from 4.3‒4.7.The low pH range in silage reported in this study is indicative of proper fermentation and good qualities. This observation further confirms that additives are needed to make good silages. This is because many of the additives are rich in readily available water soluble carbohydrates. These together with sources of nitrogen, sulphur and phosphorus are needed by the microbial agents of fermentation.

Acceptability

There are many ways of accessing the nutritive value of feeds for ruminants; the direct intake (*in-vivo*) by the animal is about the best. In recent times, cafeteria techniques have been used to assess the acceptability of some aquatic weeds and some forages (Bamikoleet al. 2004, Babayemiet al. 2006 and Babayemi (2007). In this study, the mean DM intake and COP by sheep placed on water hyacinth silages (with or without additives) are indicated. The COP varied from 0.05 to 1.90 DM/day. Silages WHPKCS, WHDBGS and WHWOS with COP ranging above unity were well accepted or preferred by WAD sheep. Conversely, WHS (silage without an additive) with a COP value of 0.05 was not accepted. Provenza and Cincotta, 1994, cited by Babayemi et al. 2009) had posited that among number of factors that may influence acceptability of feed by small ruminants, the plant physical structure and chemical composition are the most vital that influence preference for food. The unpleasant flavour imposed on the WHS silage by inadequate fermentation, elucidated already, probably caused a shift in acceptability by sheep. The converse was true for the other silages, hence their acceptability.

Conclusion

Results obtained from this study indicate that well fermented silage can be obtained from water hyacinth by making use of suitable additives such as DBG, PKC and WO. From the chemical and physical characterisation of the silage, it can be judged to have good potential as a feed resource for small ruminants. Coefficient of preference showed that all silages containing additives were fully accepted by sheep while the one without an additive was rejected.

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