Indian Journal of Weed Science **51**(1): 67–71, 2019

Print ISSN 0253-8040 Online ISSN 0974-8164

Utilization of water hyacinth as livestock feed by ensiling with additives

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Article information

DOI: 10.5958/0974-8164.2019.00014.5

Type of article: Research article

Received : 14 December 2018
Revised : 9 February 2019
Accepted : 17 February 2019

Key words

Aquatic weeds

Water hyacinth

Utilization

Silage

Additives

Cassava powder

ABSTRACT

Water hyacinth (*Eichhornia crassipes* (Mart.) Solms) is one of the most productive plants on earth, but it is also considered as the world's worst aquatic weed. An experiment was carried out with the objective of utilizing it by converting to silage for its usage as animal feed. The quality and palatability of water hyacinth silage prepared with additives such as molasses, cassava powder, and rice bran were assessed. The completely randomized design (CRD) with 12 treatment combinations and 3 replications, was used. The treatments included: combination of wilted and fresh water hyacinth with or without rice straw or guinea grass and using any of the additives such as molasses, cassava flour and rice bran. Wilted water hyacinth plus cassava powder (10%), wilted water hyacinth plus rice straw (10%) plus cassava powder (10%), and wilted water hyacinth plus guinea grass (10%) plus cassava powder (10%) had good fodder quality due to low pH. The odour of these combinations was rated as either 'good' or 'very good'. The quality of rice bran added silages was low in terms of pH, odour and palatability; although its nutritional quality was high. Rice bran enhanced crude protein, crude fat and ash content of silages. Molasses ensured the quality of silage by lowering pH and enhancing intake. Cassava powder addition in general reduced the pH of the silage and enhanced the palatability of silage.

Most aquatic weeds interfere with the normal functioning of water bodies, besides causing several harms to the environment. Among the aquatic weeds, *Eichhornia crassipes* (Mart.) Solms, commonly known as water hyacinth is considered as the world's worst aquatic weed. It is estimated that 20-25 per cent of the total utilizable water in India is infested with water hyacinth alone (Varshney *et al.* 2008). Recognized by its lavender flowers and shinning bright leaves, water hyacinth is prolific in growth and is one of the most productive plants on earth. The plant can tolerate both fresh and saline water (AERF 2005); hence, its spread knows no boundaries. The plant is also a serious threat to biodiversity as it prevents the growth of other aquatic plants. It adversely affect water sources by blocking canals and motor pumps in irrigation projects (Jayan and Sathyanathan 2012), providing convenient breeding sites for mosquito, and interfering with fishing and fish culture.

In the past, several methods were tried to prevent its proliferation and spread (Bindu and Ramasamy 2005), but all these have not proved much because of its survival strategies. An alternate option is to utilize water hyacinth for various purposes such as fibre, animal feed, and manure (Jafari 2010). Silage for feeding animals is such an option. Livestocks are reluctant to eat water hyacinth in fresh form. Tham (2012) reported that improved silage could be made from water hyacinth by the use of additives such as molasses and rice bran. Molasses is a universal additive to silage but not easily available to common people. Lowilai *et al.* (1993) reported the use of cassava flour instead of molasses. Little bag silage in polythene bags is a viable option for small holders as traditional silos such as bunker, trench or tower silos are not feasible for them (Lane 2000). Having considered all the possible options, an experiment was designed and conducted to explore the possibility to utilize water hyacinth as a feed for ensiling, especially suited to small holders.

MATERIALS AND METHODS

The experiment was carried out at the College of Horticulture, Vellanikkara, Thrissur and University Livestock Farm and Fodder Research Station, KVASU, Mannuthy during August to October 2016. The experiment was done using completely randomized design (CRD) with 12 treatment combinations and 3 replications. The treatments included combination of wilted and fresh water hyacinth with or without rice straw or guinea grass and using any of the additives such as molasses, cassava flour and rice bran (**Table 1**).

Considering the ease and manoeuvrability, fresh water hyacinths were collected and piled up for some time to drain out dripping water. The petioles and leaves of these plants were chopped in to 4-5 cm pieces, spread on plastic sheets and allowed to wilt in shade for two days. Depending on treatments, grass, rice straw and additives were added and thoroughly mixed. Afterwards, these were filled in little bags made of polythene at the rate of 5 kg/cover. The mixtures were compressed by hand to remove as much air as possible. The covers were tightly tied and stored indoors. All the covers were opened after 45 days. The colour and smell of silages thus obtained were noted immediately after the experimental bags were opened by employing volunteers. Representative silage samples were taken for later analysis.

Dry matter content of the ensiled water hyacinth was determined after oven- drying at 80 ± 5ÚC for 12 hours. Nitrogen content of silage was estimated by Micro Kjeldahl digestion and distillation method (Jackson, 1958). The nitrogen content thus obtained was multiplied by 6.25 to get the crude protein content of the plant samples. Crude fibre was estimated using acid-alkali digestion method (Sadasivam and Manickam 1992). The ether extract, ash content and silica content were analysed as described by AOAC (1990).The ether extract, which represents the crude fat fraction of the sample, was estimated by extracting the plant fat using petroleum benzene. The ash content in the samples was determined by igniting a known quantity of plant sample at 600ÚC for three hours. Nitrogen free extract was estimated by subtracting the crude protein, crude fibre, ether extract and ash content from 100. The palatability of silage was studied using 12 test animals. Silage treatments were fed as the first meal of the day and the feed intake was noted. The intake measurements consisted of two days for adaptation to the diets and three days for feed intake measurements. The animals were allowed to feed on a given weight of silage (W_1) and after 15 minutes the weight of left over feed (W_2) was noted. Then the percentage left over was worked out by the formula, percentage of left over feed = (W_2/W_1) x100.

RESULTS AND DISCUSSION

Physical quality parameters

In all the treatments, the silage was ready to use after 45 days. A main quality criteria of silage is pH, and based on pH, silage is generally classified as very good (pH 3.8 to 4.2), good (pH 4.2 to 4.5), and fair silage (pH >4.5) (Thomas 2008). In this experiment, wilted water hyacinth along with cassava powder (10%) seems to have good quality as it showed pH of 4.19 (**Table 1**). The odour of this silage was rated 'very good'. All the treatments with 10 per cent cassava powder showed low pH values. Quality wise, rice bran added silages were poor in terms of pH values, which were above 6.36. The results revealed that wilted water hyacinth plus cassava powder (10%), wilted water hyacinth plus rice straw (10%) plus cassava powder (10%), and wilted water hyacinth plus guinea grass (10%) plus cassava powder (10%) are almost equal in quality with respect to pH. The odour of these combinations was rated either 'good' or 'very good'. Rice bran added silages in general had bad odour. Among the fresh water hyacinth combinations, only those with rice straw (10%) and cassava powder (10%) proved good in terms of pH. The colour varied based on the ingredients used, mostly brownish green or grey.

Silage fermentation is affected mostly by water soluble carbohydrate content (Liu *et al.* 2011). Rice bran had 53 g water soluble carbohydrate per kilogram dry matter whereas molasses contains 700 g water soluble carbohydrate per kilogram dry matter (Lowilai *et al.* 1994; McDonald *et al.* 2011). Ngoan *et al.* (2000) stated that fermentation will be enhanced more by molasses than rice bran. As pH is a good indicator of fermentation, high pH of rice bran added silages may be due to the slower fermentation. Zanine *et al.* (2010) obtained low pH silage with cassava scrapings. Cassava scrapings (a by-product from the flour milling industry) at 7 per cent level improved the fermentation of elephant grass silage due to the high level of soluble carbohydrates and dry matter concentration and the pH of the silage was within the ideal range (3.8±0.12). Good quality silage has a characteristic yellowish green to brownish green colour (Gallaher and Pitman 2000) depending upon silage material and has pleasant, sour and sweet smell (Thomas 2008).

Chemical quality of the silage

The additives used influenced the chemical composition of water hyacinth silage (**Table 2**). Crude protein content gives an approximate value of protein content in forages. Among the treatments,

Table 1. Effect of additives on quality of water hyacinth silage

Treatment	pH	Colour	Odour
Wilted water hyacinth + molasses (5%)	4.53^{d*}	dark brown	good
Wilted water hyacinth + cassava powder (10%)	4.19^{d}	brownish green	very good
Wilted water hyacinth + rice bran (10%)	6.36^{b}	greenish brown	bad
Fresh water hyacinth + rice straw (10%) + molasses (5%)	5.44^{c}	golden yellow	very good
Fresh water hyacinth + rice straw (10%) + cassava powder (10%)	4.37^{d}	grey	good
Fresh water hyacinth + rice straw (10%) + rice bran (10%)	6.58^{b}	brown	bad
Wilted water hyacinth + rice straw (10%) + molasses (5%)	7.15^{b}	dark brown	bad
Wilted water hyacinth + rice straw (10%) + cassava powder (10%)	4.38^{d}	grey	good
Wilted water hyacinth + rice straw (10%) + rice bran (10%)	8.30^{a}	brown	good
Wilted water hyacinth + guinea grass (10%) + molasses (5%)	6.36^{b}	brownish green	good
Wilted water hyacinth + guinea grass (10%) + cassava powder (10%)	4.24^{d}	grey	very good
Wilted water hyacinth + guinea grass (10%) + rice bran (10%)	7.24^{b}	greenish brown	bad
LSD (p=0.05)	0.90		

*In a column, means with common letters do not differ significantly at 5% level in DMRT

Table 2. Effect of additives on the chemical composition of water hyacinth silage

Treatment	Crude protein (%)	Crude fibre (%)	Ether extract (%)	Nitrogen free extract (%)	Total ash (%)
Wilted water hyacinth + molasses (5%)	8.06^{d*}	16.81^{f}	0.53^{f}	54.77^{b}	19.84^{b}
Wilted water hyacinth + cassava powder (10%)	7.15^{e}	17.90^{e}	1.39^{c}	58.94^{a}	14.63^{e}
Wilted water hyacinth + rice bran (10%)	8.14^{d}	22.04^{bc}	1.81^{a}	47.33^{e}	20.68^{b}
Fresh water hyacinth + rice straw (10%) + molasses (5%)	5.43^{g}	20.86^{d}	0.72^{e}	52.53^{cd}	20.46^{b}
Fresh water hyacinth + rice straw (10%) + cassava powder (10%)	4.86^{g}	22.25^{b}	1.08^{d}	54.31^{b}	16.97^{d}
Fresh water hyacinth + rice straw (10%) + rice bran (10%)	9.72^{b}	25.35^{a}	1.62^{b}	41.06^{g}	22.79^{a}
Wilted water hyacinth + rice straw (10%) + molasses (5%)	6.56^{f}	20.98^{d}	0.55^{f}	53.56^{bc}	18.35^{c}
Wilted water hyacinth + rice straw (10%) + cassava powder (10%)	7.85^{d}	22.07^{bc}	1.04^{d}	54.84^{b}	14.20^{e}
Wilted water hyacinth + rice straw (10%) + rice bran (10%)	9.34^{bc}	24.62^{a}	1.54^{bc}	43.62^{f}	20.89^{b}
Wilted water hyacinth + guinea grass (10%) + molasses (5%)	9.14^{c}	20.61^{d}	0.58^{ef}	51.58^{d}	18.09^{cd}
Wilted water hyacinth + guinea grass (10%) + cassava powder (10%)	8.88^{c}	21.23^{cd}	1.09^{d}	54.20^{b}	14.60^{e}
Wilted water hyacinth + guinea grass (10%) + rice bran (10%)	10.45^{a}	22.87^{b}	1.65^{b}	44.64^{f}	20.39^{b}
LSD (p=0.05)	0.58	0.87	0.16	1.55	1.18

*In a column, means with common letters do not differ significantly at 5% level in DMRT

wilted water hyacinth + guinea grass (10%) + rice bran (10%) had the highest crude protein content (10.45%) followed by fresh water hyacinth + rice straw (10%) + rice bran (10%), and wilted water hyacinth + rice straw (10%) + rice bran (10%). Jones and Jones (1996) reported that absorbents rich in fibre such as straw reduce the nutritive quality during the ensiling process. Among the absorbents used, rice bran enhanced the crude protein significantly. As cassava contains low protein, those treatments with cassava powder showed the lowest crude protein content. Low crude protein and crude fibre content with the addition of cassava scrapings were reported by Zanine *et al.* (2010).

Crude fibre content was the highest in silages added with rice straw and guinea grass. Rice bran addition also enhanced the crude fibre content. The highest crude fibre content of 25.35% was recorded in the treatment, *viz.* fresh water hyacinth + rice straw (10%) + rice bran (10%) which was on par with wilted water hyacinth + rice straw (10%) + rice bran (10%) with a crude fibre content of 24.62 per cent. The lowest crude fibre content was observed in the treatment wilted water hyacinth + molasses (5%). Rice bran addition positively influenced the crude fat content of the silage. Wilted water hyacinth + rice bran (10%) had the highest crude fat content (1.81%) followed by wilted water hyacinth + guinea grass (10%) + rice bran (10%) and fresh water hyacinth + rice straw (10%) + rice bran (10%). Li *et al.* (2007) reported higher crude protein and crude fat by the addition of wheat bran.

Nitrogen free extract represents the digestible carbohydrate content. As cassava tubers are rich in carbohydrate content, it gave significantly high nitrogen free extract. Maximum NFE of 58.94 per cent was noted in the treatment, *viz.* wilted water hyacinth + cassava powder (10%). Ash content

Table 3. Palatability of silage

Treatment	Left over feed (%)		
	1st day	2nd day	3rd day
Wilted water hyacinth + molasses (5%)	55.24	0.00	0.00
Wilted water hyacinth + cassava powder (10%)	49.81	0.00	0.00
Wilted water hyacinth + rice bran (10%)	99.62	46.61	0.00
Fresh water hyacinth + rice straw (10%) + molasses (5%)	56.20	25.76	0.00
Fresh water hyacinth + rice straw (10%) + cassava powder (10%)	89.39	72.98	76.77
Fresh water hyacinth + rice straw (10%) + rice bran (10%)	96.71	95.02	87.35
Wilted water hyacinth + rice straw (10%) + molasses (5%)	85.66	78.95	61.89
Wilted water hyacinth + rice straw (10%) + cassava powder (10%)	0.00	0.00	0.00
Wilted water hyacinth + rice straw (10%) + rice bran (10%)	88.45	79.86	72.30
Wilted water hyacinth + guinea grass (10%) + molasses (5%)	87.35	54.75	0.00
Wilted water hyacinth + guinea grass (10%) + cassava powder (10%)	96.97	0.00	0.00
Wilted water hyacinth + guinea grass (10%) + rice bran (10%)	99.62	38.64	29.28

represents the mineral content of the silage. Rice bran addition significantly increased the ash content of the silage.

Palatability of silage

When considering the quality of silage, palatability of the product is an important criterion. Estimated palatability of silage as percentage of left over feed is given in **Table 3**. The silage combinations with low pH values were preserved well and had high palatability values. Rice bran addition reduced the palatability although its nutritional content was high. Cassava powder added silages have shown high palatability. On the first day of trial, there was only one treatment, *viz.*, wilted water hyacinth + rice straw (10%) + cassava powder (10%) with zero per cent feed left over. From the second day onwards the palatability of the silage treatments improved. On the second day, treatments with zero per cent left over feed were wilted water hyacinth + molasses (5%), wilted water hyacinth + cassava powder (10%), wilted water hyacinth + rice straw (10%) + cassava powder (10%), and wilted water hyacinth + guinea grass (10%) + cassava powder (10%).

The treatment with the least preference by the animals was fresh water hyacinth + rice straw (10%) + rice bran (10%). On the third day too, the least preferred silage treatment was fresh water hyacinth + rice straw (10%) + rice bran (10%). Baldwin *et al.* (1975) reported that there is positive correlation between preservative level, pH and the acceptability of silage to cattle. Woomer *et al.* (2000) reported that without additives, the pH of water hyacinth silage alone was 7.33 suggesting poor quality while addition of 15 per cent maize bran or molasses result in silage of pH 4.1 and 4.2 respectively and was readily accepted by goats and young steers.

From the results, it can be concluded that palatable silage can be made from wilted water hyacinth using additives such as molasses and cassava powder. Both molasses and cassava powder ensured the quality of silage by lowering pH and enhancing animal intake. The quality of rice bran added silages was low in terms of pH, odour and palatability; although its nutritional quality was high. Based on the quality parameters, wilted water hyacinth along with molasses (5%) or cassava flour (10%) and wilted water hyacinth along with cassava powder (10%) plus rice straw (10%) or guinea grass (10%) are the best options for utilizing water hyacinth as silage for feeding animals.

ACKNOWLEDGEMENT

The authors are grateful to the Kerala Agricultural University and Kerala Veterinary and Animal Sciences University for the research grant and facilities provided for undertaking the study.

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