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Laboratory Preparation and Quality Evaluation of Cabbage and Cauliflower Waste Silage

Bornalee Handique[1*], S. K. Saha[2], L. C. Choudhary[2] and Ajmal P Roshan[2]
[1] ICAR-Indian Agricultural Research Institute, Assam, India
[2] ICAR-Indian Veterinary Research Institute, Bareilly, Uttar Pradesh, India
*Correspondence: bornalee16@gmail.com

ABSTRACT

The experiment was conducted to evaluate the quality of cabbage and cauliflower waste silage and to study the *in vitro* parameters of cauliflower and cabbage waste silage ensiled with salt, urea and or molasses. Cabbage and cauliflower waste were collected from the local market and after cleaning cut into small pieces and kept in air tight container for 28 days. 5 different types silage were prepared from cabbage and cauliflower waste *viz.* I: Cabbage waste silage with 0.5% salt, 1% urea; II: Cauliflower waste silage with 0.5% salt, 1% urea; III: Cabbage and Cauliflower mixed (1:1) waste silage with 0.5% salt, 1% urea; IV: Cabbage waste silage with 0.5% salt, 1% urea and 5% molasses V: Cauliflower waste silage with 0.5% salt, 1% urea and 5% molasses and VI: Cabbage and Cauliflower mixed (1:1) waste silage with 0.5% salt, 1% urea and 5% molasses. The fermentation characteristics and nutritive values of silage were evaluated using representative fresh silage samples. Based on appearance and smell, all silage samples in this study were classified as high-quality. Similarly, the analysis of organic acid content confirmed that all silages were found to have good quality silage. The IVDMD (%) is significantly differ ($P<0.05$) among various cauliflower waste silage. From this experiment it can be concluded that incorporating 5% molasses into silage prepared from cabbage and cauliflower waste can uphold its high quality, as demonstrated by reduced pH and NH_3-N levels, coupled with increased lactic acid bacteria (LAB) content.

KEYWORDS: Cabbage waste, Cauliflower waste, Fermentation, *in vitro* quality, Silage

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INTRODUCTION

Globally, each year 2.5 billion ton of food is wasted and in India approximately one third of total production goes wasted or gets spoiled before it is eaten (FSSAI). This massive amount of food and vegetable waste biomass may contribute to the annual emission of about 3.3 billion tons of CO_2 equivalent greenhouse gases from dumping sites, leading to global warming (India Today, 2020). Fruit and vegetable waste is approximately 4.65-5.99 % of total food wastage. The declining fodder production has led to the search for alternative feed resources, providing an effective solution for the efficient disposal of vegetable waste. Cabbage and cauliflower, in particular, generate an average of 30–50% waste in the form of stems, stalks, and leaves (Das et al., 2018).

The cabbage and cauliflower waste can be utilized as silage and presents several benefits. Firstly, it addresses the issue of agricultural waste management, promoting a more sustainable and eco-friendly approach. Secondly, silage can serve as an alternative and cost-effective feed source for livestock, reducing reliance on traditional animal feeds. However, preserving cabbage and cauliflower as animal feed presents challenges due to their high moisture content (>80%) and perishability. Ensiling is a cost-effective preservation technique for these vegetables. High-quality vegetable waste silage (87.8% moisture) can be produced by incorporating wheat straw (29%) and wheat bran (9–20%) as absorbents (Ozkul et al., 2011). Additionally, applying molasses could enhance the vegetable waste ensiling process (Colombatto et al., 2003; Mtengeti et al., 2003). Considering these aspects the present study was carried out to study the quality of cabbage and cauliflower waste silage and *in vitro* evaluation of cauliflower waste silage.

MATERIALS AND METHODS

Fresh cabbage and cauliflower waste were collected from Bareilly Sabji Mandi, India, cleaned, chopped, and stored in airtight containers for 28 days at 25 ± 5°C. 6 silage types were prepared *viz*. I: Cabbage waste silage with 0.5% salt, 1% urea; II: Cauliflower waste silage with 0.5% salt, 1% urea; III: Cabbage and Cauliflower mixed (1:1) waste silage with 0.5% salt, 1% urea; IV: Cabbage waste silage with 0.5% salt, 1% urea and 5% molasses V: Cauliflower waste silage with 0.5% salt, 1% urea and 5% molasses and VI: Cabbage and Cauliflower mixed (1:1) waste silage with 0.5% salt, 1% urea and 5% molasses. The chemical composition and bio-active components of silage materials before ensiling is depicted in Table 1.

The fermentation characteristics and nutritive values of silage were analyzed using representative fresh silage samples. Silage extract was prepared according to Kim et al., 2016. The pH was measured from fresh silage extract with a pH meter right after extraction. The sample was stored at – 20 ^{0} C for further analysis. NH3-N in the silage extract was assessed by the method of Weatherburn. (1967). Lactobacilli MRS agar was used for the isolation and enumeration of LAB. Volatile fatty acids were assessed using Nucon-5765 gas chromatograph.

The proximate principles were estimated by the method recommended by AOAC 2005. NDF and ADF was estimated by Van Soest method. (1991). Calcium and phosphorus were estimated as per the modified method of Talapatra et al. (1940).

Table 1. Formulation of concentrate portion for *in vitro* studies

Ingredients	0% CLS	10% CLS	20% CLS	30% CLS	40% CLS	50% CLS
Maize	37	23	30	27	24	21
Wheat bran	37	35	32	29	26	23
Soya bean meal	23	19	15	11	7	3
CLS	-	10	20	30	40	50
Mineral mixture	02	02	02	02	02	02
Salt	01	01	01	01	01	01
Total	100	100	100	100	100	100
% CP	18.93	19.07	19.04	19.00	18.98	18.95

Where, CLS: cauliflower waste silage

The *in vitro* gas production was run as per the technique of Menke and Steingass,1988. Formulation of concentrate portion with cauliflower waste silage for *in vitro* studies were presented in Table 2.

Table 2. Formulation of concentrate portion for *in vitro* studies

Ingredients	0% CLS	10% CLS	20% CLS	30% CLS	40% CLS	50% CLS
Maize	37	23	30	27	24	21
Wheat bran	37	35	32	29	26	23
Soyabean meal	23	19	15	11	7	3
CLS	-	10	20	30	40	50
Mineral mixture	02	02	02	02	02	02
Salt	01	01	01	01	01	01
Total	100	100	100	100	100	100
% CP	18.93	19.07	19.04	19.00	18.98	18.95

Where, CLS: cauliflower waste silage

The data generated from the study were analysed as per the standard statistical procedure Snedecor and Cochran using SPSS (Version 20.0) software.

RESULTS AND DISCUSSION

Chemical composition of cabbage and cauliflower waste before ensiling

The DM content for cabbage waste, cauliflower waste and mixed waste in the present experiment (Table 3) is higher than those reported by Ozkul et al. (2011) and lower than the values observed by Meneses et al. (2007). The CP content for cabbage waste, cauliflower waste and mixed waste surpasses the results reported by Ozkul et al. (2011). The higher NDF content reported in the present experiment might be attributed to the elevated cell wall content in cauliflower and cabbage, as noted by Wadhwa and Bakshi, (2013) and Meneses et al. (2007). The Ca and P content in cabbage waste, cauliflower waste and mixed waste resemble the findings of Bakshi and Wadhwa (2006). The higher TPC in cabbage waste compared to cauliflower waste might be cabbage waste have a greater potential for antioxidant applications. In the present experiment the TPC for cabbage waste, cauliflower waste and mixed waste is aligned with Das et al. (2024) and lower than the values observed by Oberoi et al. (2007). The slightly higher glucosinolate content observed in cabbage waste compared to cauliflower waste may result from genetic and environmental factors influencing the accumulation of these compounds in different Brassica vegetable (Cartea and Velasco, 2008). The greater flavonoid content found in cauliflower waste as compared to cabbage waste suggests that cauliflower waste may serve as a more abundant source of these beneficial compounds.

Table 3. Chemical composition (%) of cabbage and cauliflower waste before ensiling

Parameters	Cabbage waste	Cauliflower waste	Mixed waste
Dry matter	28.88	22.97	26.21
Organic matter	89.5	85	87.25
Total ash	10.5	15	12.75
Acid insoluble ash	2.54	2.14	2.34
Crude protein	20	24.60	22.30
Ether extract	1.53	2.46	2.00
Neutral detergent fibre	45	36	41
Acid detergent fibre	28	22	25
Acid detergent lignin	9	11	10
Cellulose	19	11	15
Hemicellulose	17	14	15.50
Calcium	2.50	2.25	2.25
Phosphorus	0.72	0.52	0.62
Total phenols (mg of GAE/g)	3.85	3.10	3.48
Condensed tannins	0.37	0.42	0.39
Glucosinolates	0.054	0.030	0.042
Total Flavonoid mgQE/g)	1.63	2.02	1.83

Mixed waste: Cabbage waste + cauliflower waste (1:1)

Physical characteristics of cabbage and cauliflower waste silage

The colour of cabbage waste and cauliflower waste was ranging from greenish-yellow to olive green in this experiment. The smell of cabbage and cauliflower waste, without molasses, was acidic; however, the addition of 5% molasses for ensiling resulted in a sweet and acidic odour. The structure of all the silage samples was firm and easily separable. Upon opening the silage, there was no evidence of mould growth. In all the silage, the greenish colour was retained and the odour and structure were well-preserved, following the approach outlined by Breirem and Ulvesli, (1960). In terms of appearance and smell, all the silage in this experiment demonstrated qualities of good silage.

Chemical composition (%) of cabbage and cauliflower waste silage

The chemical composition of cabbage and cauliflower waste silage are presented in Table 4. In this experiment DM content of silages are notably lower compared to those observed by Alcicek et al. (2000), Meneses et al. (2007) and Ozkul et al. (2011).

Table 4. Chemical composition of cabbage and cauliflower waste silage

Parameters	I	II	III	IV	V	VI
Proximate principles (%)						
Dry matter	19.03	17.32	21.43	20.92	19.96	22.05
Total ash	22	26	32	20	22	28
Organic matter	78	74	68	80	78	72
Acid insoluble ash	4	4	2	3	2	3
Crude protein	21.88	24	23.50	20	22.60	21.03
Ether extract	2.87	3.62	2.63	2.60	3.35	2.44
Cell wall components (%)						
Neutral detergent fibre	35.68	29.40	27.53	36.12	30	28.25
Acid detergent fibre	22.64	18.30	17.46	22.01	17.85	18
Acid detergent lignin	08	06	06	07	05	04
Cellulose	14.64	12.30	11.46	15.01	12.85	14
Hemicellulose	13.04	11,10	10.07	14.11	12.15	10.25
Minerals (%)						
Calcium	2.50	2.25	2.50	2.25	2.50	2.50
Phosphorus	0.65	0.48	0.40	0.68	0.52	0.69
Bioactive components (%)						
Condensed tannin	0.49	0.51	0.33	0.45	0.46	0.31

Chen et al. (2004) also reported higher DM levels in corn silage while supplemented with 3% molasses. The CP content of cauliflower silage surpasses the values reported by Bakshi et al. (2006). The improvement in CP and EE levels in cabbage waste and cauliflower waste silage in this experiment supports the notion that ensilage is a convenient method for preserving the nutritive values of feeds (Kilic, 2005; Khorsed et al., 2006). In this experiment the NDF content is comparable to Bakshi et al. (2006) (31.5%) and it is lower than the values observed by Alcicek et al. (2000) and Meneses et al. (2007).

Fermentation characteristics of silage

The fermentation indices of cabbage and cauliflower waste silage are presented in Table 5. The silage exhibited an acidic pH, with the presence of acetic acid, while no butyric acid was detected. The lower pH levels in molasses-added silage may be attributed to the additional water-soluble carbohydrates from molasses, which facilitated lactic acid production by lactic acid bacteria (LAB) (Colombatto et al., 2003; Mtengeti et al., 2013). Additionally, the reduced NH3-N levels in molasses-treated silages could be due to lower proteolysis. as molasses restricts proteolysis by reducing silage pH (Colombatto et al., 2003; Mtengeti et al., 2013).

Table 5: Fermentation indices of cabbage and cauliflower waste silage

Parameters	I	II	III	IV	V	VI
pH	4.50	4.00	4.50	4.10	3.50	3.88
NH_3-N g/kg DM	2.43	2.24	2.02	1.58	1.20	1.13
LAB Log_{10} cfu/g	8.62	8.84	8.79	8.96	9.00	9.05
Lactic acid (%)	2.64	2.41	2.73	3.20	3.16	3.27
Acetic acid (Mm/L)	3.56	3.30	3.24	3.81	3.56	3.83
Butyric acid (%)	ND	ND	ND	ND	ND	ND

The higher LAB count observed in the latter three silages (IV, V, and VI) in this study was associated with the addition of molasses, which provided water-soluble carbohydrates as nutrients for LAB. This finding is consistent with the results of Chen et al. (2014). The highest lactic acid content was recorded in silage VI, while the lowest was found in cauliflower waste silage without molasses. These values align with the findings of Kinh et al. (2010).

***In vitro* evaluation of cabbage and cauliflower waste silage**

in vitro DM digestibility (IVDMD), total gas and methane production of cabbage and cauliflower waste-based silage was presented in Table 6. The IVDMD (%) is significantly differ among various cauliflower waste silage ($P<0.05$). However non-significant difference was observed in cabbage waste silage. The percent total gas production and methane production in both cabbage and cauliflower waste silage is non-significant ($P>0.05$). The IVDMD (%) is significantly differ ($P<0.05$) among various cauliflower waste silage. The ensiling cauliflower waste resulted in depression in gas production and *in vitro* digestibility of dry matter, which could be because of the very low dry matter content. Similar results also reported by Bakshi et al. (2006). The high gas production observed in cabbage suggests its strong potential for rumen fermentation. The low NDF content in vegetable wastes contributed to the increased in vitro gas production and digestibility. Mekasha et al. (2002) reported comparable in vitro dry matter digestibility (IVDMD) values of 80.4% for cabbage waste. High IVDMD values indicate a lower presence of cell wall constituents, aligning with the low ADF and high NDF content.

Table 6. *in vitro* digestibility and total gas production of cauliflower waste silage

Silages	IVDMD (%)	Total gas (ml/g DM)	Methane (ml/g DM)
0% CBS	71.36	146.34	21.95
10% CBS	69.63	135.34	15.12
20% CBS	63.01	122.91	17.38
30% CBS	62.73	129.40	14.09
40% CBS	60.25	120.37	15.07
50% CBS	58.82	117.16	12.72
SEM	3.22	7.15	3.34
P value	0.091	0.918	0.988
0% CLS	77.03^{b}	130.34	24.12
10% CLS	63.01^{a}	129.16	20.07
20% CLS	62.98^{a}	122.91	17.09
30% CLS	61.36^{a}	126.40	15.72
40% CLS	59.63^{a}	120.37	13.30
50% CLS	57.82^{a}	119.82	12.95
SEM	2.13	6.77	2.32
P value	0.021	0.788	0.870

CBS: Cabbage waste silage; CLS: Cauliflower waste silage
Values bearing different superscripts a, b in a row differ significantly ($P<0.05$)

CONCLUSION

This study suggests that incorporating 5% molasses into cabbage and cauliflower silage significantly improves fermentation stability and nutritional value, making it a viable livestock feed alternative. Future studies should focus on long-term feeding trials to validate its effectiveness in animal diets.

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