

Effects of additives and wilting on the fermentation quality, microbial counts, chemical composition of Rumex silage (*Rumex patientia* L. × *Rumex tianschanicus* Losinsk.)

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ABSTRACT

Edible grass (*Rumex patientia* L. × *Rumex tianschanicus* Losinsk.) represents novel food and feed resources, distinguished by their elevated water content (exceeding 90%). Consequently, wilting or mixed silage is essential for moisture reduction. We examined the impact of wilting duration and additives on the silage quality of edible grass. The study employed a two-factor completely randomized experimental design, with factor 1 comprising wilting durations of 9, 12, and 15 h, and factor 2 including no treatment (A), a commercial lactic acid bacteria (LAB) additive (B), molasses (C), and cellulase (D), with a fermentation period of 60 d. After successful fermentation, the fermentation quality, nutrient content, and microbial data of edible grass silage were analyzed. The results showed that after wilting for 9, 12, and 15 h, DM content of edible grass increased significantly ($p < 0.01$). Edible grass wilted for 12 h using LAB, molasses, and cellulase could significantly increase the number of LAB and lactic acid production ($p < 0.05$), increase the crude protein (CP) content of edible grass ($p < 0.05$), reduce the neutral detergent fiber (NDF) content ($p < 0.05$), and increase the water-soluble carbohydrates (WSC) content of molasses and cellulase except for the LAB (B) group ($p < 0.05$). The primary indications revealed that CP rose by 5.45%-13.71%, while NDF declined by 3.67%-10.12%. Therefore, wilting is an important way to utilize high-moisture feed resources such as edible grass, and using LAB microbial additives supplemented with molasses and cellulase and other additives can significantly improve the silage quality of edible grass, providing preliminary data support for the application of edible grass silage in ruminants.

Key words: Edible grasses Rumex, lactic acid bacteria, silage, withering.

INTRODUCTION

One of the main things holding back the growth of China's ruminant business is the lack of high-quality forage. China bought 1.79 million tons of alfalfa hay from other countries in 2022. The total value of the imports was USD 926 million, which is a huge 36.2% rise from the previous year (Bai et al., 2025). As a result (Table 1), a lot of study has been done on new plants that can be used as feed, such as mulberry (Dong et al., 2019; Wang et al., 2019), ramie (Sun et al., 2019; Tian et al., 2022), broussonetia (Wen et al., 2022; Zheng et al., 2025), and moringa (Wang et al., 2018). The primary reason is that these resources exhibit great productivity, with annual fresh grass yields of 40-60 t ha⁻¹ and hay (DM) crude protein (CP) concentrations of 18%-25%, which are readily digested by ruminants $\geq 75\%$ (Zhang et al., 2019).

The edible grass from the Polygonaceae *Rumex* genus is a new resource food that has been reviewed and approved by Chinese management departments, after undergoing safety evaluation. According to some reports, this resource has a high crude protein (CP) content of up to 28% to 40% (Jiang et al., 2024). Its unique multiple cropping (repeated cutting)

mechanism also gives it the potential to produce yields that are comparable to or even exceed those of tree resources such as mulberry and moringa. At the same time, this resource has a wide environmental adaptability, with *Rumex* plants widely distributed in tropical, subtropical, and temperate regions (Li et al., 2022). Studies have shown that 3% to 6% of the dry powder of this grass can improve the antioxidant capacity of broilers and the volatile fatty acids in the cecum, increase the content of beneficial bacteria such as lactic acid bacteria in the cecum, and thereby improve the growth performance of broilers (Li et al., 2024). Another study has shown that this grass can completely replace alfalfa in lamb feed without affecting fattening performance and health, while also improving the deposition of n-3 polyunsaturated fatty acids (PUFA) in mutton (Zhang et al., 2024). Therefore, as a protein feed or forage, this grass has great prospects in livestock and poultry breeding (Li et al., 2024; Wang et al., 2025).

Table 1. Nutritional composition of foliage from edible grass, alfalfa, mulberry, ramie, broussonetia and moringa. DM: Dry matter; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; Ash: ash; WSC: water soluble carbohydrates. The calculation of DM is based on fresh weight, and other components are based on a DM basis.

[illegible]

In these studies, and earlier ones, we found that this grass has a very high-water content (over 88%, Table 1). The elevated expense of drying may influence the utilization, harvesting, and storage of this resource. Silage is a prevalent method for preserving fresh forage or crops. During silage, lactic acid bacteria (LAB) convert water-soluble carbohydrates (WSC) into organic acids, primarily lactic acid, thereby establishing an acidic environment that inhibits the proliferation of dangerous germs (Dehghani et al., 2012; Cáceres et al., 2024). The WSC level in edible grass and mulberry leaves is comparatively low, resulting in subpar natural silage quality (Trabi et al., 2017). To enhance fermentation quality, a range of biological and chemical additions has been formulated, including LAB, molasses, and cellulase. The incorporation of homofermentative LAB enhances lactic acid generation and accelerates the pH reduction during the initial phases of silage. The incorporation of cellulase may facilitate the degradation of cell walls to liberate fermentable substrates for LAB proliferation. Besides additives, wilting is typically advised to inhibit the proliferation of clostridia and the hydrolysis of proteins (Zheng et al., 2018). Molasses can directly compensate for the deficiency of water-soluble carbohydrates to enhance fermentation (Wu and Nishino, 2016). Despite numerous research evaluating the effects of these additions and wilting on enhancing feed fermentation quality, there remains a paucity of information regarding the silage quality of kenaf and *Rumex* plants.

This study seeks to assess the impact of commercial lactic acid bacteria inoculants, cellulase, molasses, or wilting on the fermentation quality and nutrient composition of edible grass silage, while offering comprehensive insights into edible grass silage.

MATERIALS AND METHODS

Forage collection and silage production

On 15 April 2021, at the Teaching and Experimental Field of the Yuelu Mountain Chinese Medicinal Materials Seed Innovation Center, Hunan Agricultural University, Changsha (28.18° N, 113.09° E; 48.9 m a.s.l.), Hunan Province, China. Average temperature in April 14 to 21 °C, average yearly precipitation 197 mm.

Experimental design

Following the harvest of the planted edible grass, it was promptly severed into segments of 2-3 cm utilizing a forage chopper 40C (Liuling Machinery and Electricity, Zhejiang, China). These treatments were succeeded by the incorporation of chemicals subsequent to wilting for 9, 12, and 15 h. Selected newly cut fragments of edible grass (*Rumex patientia* L. × *Rumex tianschanicus* Losinsk.) were analyzed for nutritious components at 0 h, and this portion was excluded from silage production due to its elevated moisture content of 89.78%. The silage addition treatments (A-D) were determined by fresh weight: Control group with no additives (A); a commercial microbial inoculant FC, where the final concentration was 0.002% (SiloSolve FC, Novonesis, Hørsholm, Denmark) (B). The inoculant powder was combined with sterile distilled water to create a pre-solution (1 g powder to 500 g water), and 1 g this pre-solution was incorporated into every 100 g fresh edible grass. Addition of molasses, 15 g molasses (TH226, Lifalong Chemical Technology, Tianjin, China) added per 1 kg fresh edible grass (C). Inclusion of cellulase, 5 g cellulase (FDG-2225, Xiaseng Enzyme Biotechnology, Cangzhou, China) added to every 1 kg fresh edible grass (D). To guarantee that each group received only the required additives, the materials in groups A, C, and D were subjected to the same treatment as group B, with 1 g distilled water incorporated into every 100 g fresh edible grass.

Sterile gloves were replaced between several silage treatments to avert bacterial contamination. The treated edible grass (150 g) was placed into a plastic bag of 20×30 cm, and the air was extracted using a vacuum machine (FKJ-9600, Pukemeng Ao Technology, Wenzhou, China). The finished randomized experimental design involved three replicates of the experiment. The plastic bags were evaluated in a constant temperature incubator (HWS-250F, Binglin Electronic Technology, Shanghai, China) at 25 °C and 55% humidity. The duration of the test was 60 d. Table 1 presents the fundamental chemical and microbiological properties of the edible grass samples prior to silage.

Measurement indicators and methods

Analytical chemistry of nutritional constituents. The edible grass and silage samples of edible grass were desiccated to a consistent weight at 65 °C when the bag was opened. Following pulverization by a grinder (100C, Jiaying Jiasound Technology, Zhejiang, China) and subsequent passage through a 40-mesh screen, samples were preserved for future application. The desiccated samples were examined for DM, crude ash content, crude protein (CP computed as total N (TN) multiplied by 6.25 using a 2300 automatic Kjeldahl nitrogen analyzer, FOSS, Denmark), and crude fat using the AOAC procedure (AOAC, 1995). The determination of neutral detergent fiber (NDF) and acid detergent fiber (ADF) was conducted using the methodology outlined by Van Soest et al. (1991), using amylase and anhydrous sodium sulfite in the study. The concentration of water-soluble carbohydrates (WSC) was assessed using the anthrone-sulfuric acid colorimetric technique (Murphy, 1958).

Lactic acid bacteria count. Following the methodology of Cai et al. (1999), 10 g forage prior to ensiling and silage were collected and combined with 90 mL sterile water, thereafter undergoing continuous dilution from 10^{-1} to 10^{-5} in sterile distilled water. The live lactic acid bacteria (LAB) were cultivated and enumerated using the plate count method on MRS agar within an anaerobic chamber (LB620, LOOBO, Shandong, China) at 28 °C for 48 h.

Fermentation characteristics. Upon opening the bags, 10 g each silage sample was promptly homogenized with 90 mL distilled water in a mixer for 1 min, subsequently filtered through four layers of coarse cotton cloth and three layers of filter paper, and the pH of the filtrate was assessed using a pH meter (FiveEasy 20 K; Mettler-Toledo International, Greifensee, Switzerland). The $\text{NH}_3\text{-N}$ concentration was evaluated via the phenol-hypochlorite method (Broderick and Kang, 1980). The organic acid content in the filtrate, encompassing lactic acid, acetic acid, propionic acid, and butyric acid, was quantified according to Playne (1985) and analyzed using gas chromatography. In summary, 1.5 mL supernatant was combined with 300 μL 25% metaphosphoric acid (at a ratio of 5:1) and incubated at ambient temperature for 30 min. After centrifugation to remove the precipitate, 1 μL sample was injected into a gas chromatograph (model 2010-Plus, Shimadzu, Tokyo, Japan) equipped with a capillary column packed with a volatile fatty acid-specific column (DB-Wax, Agilent, California, USA). A flame ionization detector (FID) was used, with an oven temperature of 120 °C, a detector temperature of 250 °C, and a program duration of 15 min for the determination of acetate, propionate, butyrate, and lactate concentrations. The detection limit for all volatile fatty acids (VFAs) was 0.1 mmol L^{-1} .

Data analysis

A general linear one-way analysis was performed to evaluate the effects of silage additives (ADD), wilting time (WT), and their interaction ADD×WT. On the chemical composition and fermentation products of edible grass silage. The means were subsequently compared with the significance established by Duncan's multiple range test. All statistical analyses were conducted utilizing the general linear model process of SPSS Statistics 25 (IBM, Armonk, New York, USA). The significance level is $0.01 < p < 0.05$, while extreme significance is indicated by $p < 0.01$.

RESULTS

Nutritional component content of edible grass before silage at different wilting times

The results in Table 2 show that DM content of the edible grass without wilting is significantly lower than that of the other groups, and the WSC content is significantly higher than that of the other groups ($p < 0.01$).

Table 2. Nutritional component content of edible grass before silage at different wilting times. SEM: Standard error of the mean; DM: Dry matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ADF: acid detergent fiber; Ash: ash; WSC: water soluble carbohydrates. The calculation of DM is based on fresh weight, and other components are based on a DM basis. Data with different lowercase letters in the same row indicate significant differences among treatment groups with different wilting time ($p < 0.05$).

Items	Wilted time				SEM	p-value
	0 h	9 h	12 h	15 h		
	g kg ⁻¹					
DM	102.10 ^d	346.10 ^c	412.40 ^b	465.30 ^a	45.30	< 0.001
CP	295.50	295.80	300.90	283.90	3.30	0.302
EE	36.50	34.10	32.10	40.10	6.60	0.190
NDF	418.50	449.50	447.70	433.60	13.40	0.186
ADF	256.70	275.70	274.10	234.10	5.40	0.230
Ash	112.90	108.30	109.30	112.20	4.80	0.124
WSC	60.23 ^a	58.34 ^b	59.25 ^b	59.14 ^b	1.56	0.003

Effects of wilting and additives on the lactic acid bacteria in edible grass silage

The results in Table 3 reveal that the wilting time had nonsignificant effect on the LAB in the edible grass silage ($p > 0.05$). In comparison to the blank control group, the incorporation of molasses markedly enhanced the LAB in the 9 and 12 h edible grass silage ($p < 0.05$). The incorporation of microbial additions and cellulase could markedly enhance the LAB population in the 9, 12, and 15 h edible grass silage.

Table 3. Impact of wilting time (WT) and additives (ADD) on the lactic acid bacteria count in edible grass silage (fresh materials). SEM: Standard error of the mean; A: no treatment; B: commercial microbial additive; C: molasses; D: cellulase. Data in the same row with different letters indicate significant differences among the four additive groups ($p < 0.05$).

Items	Additives	Wilted time			SEM	p-value		
		9 h	12 h	15 h		ADD	WT	ADD×WT
		log cfu g ⁻¹						
Lactic acid bacteria	A	3.48 ^B	4.78 ^C	5.01 ^B	0.03	0.001	0.069	0.368
	B	7.05 ^A	8.73 ^A	7.27 ^A	0.17			
	C	5.43 ^A	5.73 ^{BC}	5.29 ^B	0.05			
	D	7.10 ^A	7.26 ^{AB}	6.79 ^A	0.14			

Effects of wilting time and additives on the nutritional composition of edible grass silage

Table 4 indicates that varying wilting durations significantly influence DM content of edible grass silage ($p < 0.01$), with DM content ranked as follows: 15 h, 12 h, 9 h. Various additions exert a significantly significant influence on the CP, NDF, and WSC of edible grass silage ($p < 0.01$). For the silage of edible grass with a withering duration of 9 h, additives can considerably enhance the protein content ($p < 0.05$), with groups B and D exhibiting more pronounced benefits. Additives can markedly diminish the NDF concentration of consumable grass silage ($p < 0.05$). Group D exhibits a markedly elevated WSC level compared to the other groups, whereas Group B has the lowest WSC concentration ($p < 0.05$).

Table 4. Impact of wilting time (WT) and additives (ADD) on the nutritional components of edible grass silage after fermentation (DM). SEM: standard error of the mean; DM: dry matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ADF: acid detergent fiber; Ash: ash; WSC: water soluble carbohydrates; A: no treatment; B: commercial microbial additive; C: molasses; D: cellulase. Data in the same row with different capital letters indicate significant differences among the four additive groups ($p < 0.05$). Data in the same row with different lowercase letters indicate significant differences among the three wilting groups ($p < 0.05$).

Significant differences among the three wilting groups ($p < 0.05$).								
Items	Additives	Wilted time			SEM	p -value		
		9 h	12 h	15 h		ADD	WT	ADD×WT
g kg ⁻¹								
DM	A	354.1 ^c	423.3 ^b	459.5 ^a	1.56	0.920	< 0.001	0.812
	B	350.0 ^c	416.5 ^b	460.6 ^a	1.66			
	C	346.3 ^c	420.2 ^b	466.7 ^a	1.75			
	D	348.8	426.2	459.3	1.65			
OM	A	863.7	868.2	863.7	1.78	0.397	0.832	0.037
	B	873.9	859.4	872.6	3.47			
	C	866.8	878.7	867.5	2.12			
	D	870.1	863.4	872.9	2.46			
CP	A	264.3 ^C	267.5 ^C	273.1	2.54	< 0.001	0.779	0.326
	B	295.7 ^{AB}	304.2 ^A	299.9	3.42			
	C	279.6 ^{BC}	298.1 ^A	288.2	4.79			
	D	300.3 ^A	282.1 ^B	291.4	5.33			
EE	A	33.4	30.0	35.5	2.38	0.545	0.323	0.076
	B	30.8	38.4	36.6	1.93			
	C	37.5	33.6	30.6	1.69			
	D	45.5	29.7	35.7	2.10			
NDF	A	421.7 ^A	429.6 ^A	427.7 ^A	4.12	< 0.001	0.964	0.403
	B	381.7 ^C	390.1 ^B	390.2 ^C	5.64			
	C	419.0 ^{AB}	414.4 ^{AB}	398.7 ^{BC}	4.74			
	D	407.4 ^B	401.7 ^{AB}	417.7 ^{AB}	4.02			
ADF	A	287.0	292.3	295.0	2.55	0.379	0.402	0.787
	B	290.4	292.6	277.5	3.80			
	C	298.8	296.9	289.8	5.26			
	D	285.3	290.6	286.4	3.01			
WSC	A	52.2	55.2 ^{AB}	55.1	1.22	0.003	0.511	0.954
	B	52.5	51.5 ^B	50.3	0.79			
	C	57.9	59.0 ^{AB}	57.0	1.95			
	D	59.1	62.8 ^A	59.3	1.94			

Impact of wilting time and additives on the fermentation quality of edible grass silage

As shown in Table 5, in terms of wilting time, the pH of 12 h wilting was significantly lower than that of 9 and 15 h wilting ($p < 0.05$); the lactic acid content of 12 h wilting was significantly higher than that of 9 and 15 h wilting ($p < 0.05$); the acetic acid content of 9 h wilting was significantly lower than that of 12 and 15 h wilting ($p < 0.05$). Concerning additives, the lactic acid concentration in group B was markedly higher than in the other groups ($p < 0.05$); the lactic acid to acetic acid ratio in each additive group was significantly elevated compared

to group A. The ammonia N levels in groups B and C were markedly lower than those in groups A and D ($p < 0.05$). A significant interaction was observed between wilting time and additions for pH, lactic acid, and ammonia N concentration ($p < 0.01$).

Table 5. the impact of wilting time (WT) and additives (ADD) on the fermentation quality of edible grass silage. Lactic acid, acetic acid, and propionic acid are determined based on the fresh silage materials, while $\text{NH}_3\text{-N}$ is calculated based on total N. SEM: Standard error of the mean; A: no treatment; B: commercial microbial additive; C: molasses; D: cellulase. Data in the same row with different capital letters indicate significant differences among the four additive groups ($p < 0.05$). Data in the same row with different lowercase letters indicate significant differences among the three wilting groups ($p < 0.05$).

Items	Additives	Wilted time			SEM	<i>p</i> -value		
		9 h	12 h	15 h		ADD	WT	ADD×WT
pH	A	4.64 ^{Bb}	4.36 ^{Ac}	4.83 ^{Aa}	0.07	< 0.001	< 0.001	< 0.001
	B	4.20 ^C	4.15 ^B	4.15 ^B	0.02			
	C	4.30 ^{Bb}	4.36 ^{Ab}	4.76 ^{Aa}	0.07			
	D	4.72 ^{Ab}	4.25 ^{ABa}	4.82 ^{Aa}	0.01			
Lactic acid, g kg ⁻¹	A	7.31 ^C	7.94 ^C	7.40 ^D	0.17	< 0.001	< 0.001	< 0.001
	B	12.14 ^{Ab}	17.49 ^{Aa}	12.96 ^{Ab}	0.89			
	C	11.72 ^A	12.10 ^B	11.82 ^B	0.27			
	D	9.62 ^B	9.63 ^C	9.34 ^C	0.12			
Acetic acid, g kg ⁻¹	A	0.84	0.84	0.84	0.03	0.065	0.046	0.068
	B	0.62 ^b	0.94 ^a	0.88 ^a	0.05			
	C	0.75	0.88	0.78	0.04			
	D	0.71	0.67	0.76	0.04			
Propionic acid, g kg ⁻¹	A	0.54	0.50	0.48	0.04	0.986	0.271	0.265
	B	0.59	0.46	0.44	0.03			
	C	0.48	0.53	0.51	0.02			
	D	0.50	0.54	0.49	0.02			
Lactic acid/acid/acetic	A	8.74 ^C	9.57 ^C	8.89 ^B	0.35	< 0.001	0.183	0.196
	B	19.59 ^{Aa}	18.62 ^{Aa}	14.76 ^{Ab}	0.83			
	C	15.99 ^B	13.79 ^B	15.58 ^A	0.85			
	D	13.72 ^B	14.73 ^B	12.76 ^{AB}	0.83			
$\text{NH}_3\text{-N}$, g kg ⁻¹	A	67.29 ^{Aa}	76.44 ^{Aa}	52.80 ^{ABb}	3.75	< 0.001	0.033	0.007
	B	53.51 ^{Ba}	42.95 ^{Cb}	39.54 ^{Bb}	2.36			
	C	48.11 ^B	46.91 ^C	51.77 ^{AB}	2.21			
	D	70.86 ^A	59.67 ^B	65.06 ^A	3.11			

DISCUSSION

Edible grass is an innovative food resource characterized by high protein content and yield, therefore garnering interest from professionals in the food and feed industries. To secure an adequate protein yield, this forage is harvested during the nutritional growth phase when its height exceeds 50 cm, and this procedure can be repeated (Jiang et al., 2024). The duration of wilting time controls the final DM content of the silage, and DM content will directly affect the fermentation process and final quality of the silage (Salo et al., 2014). Generally speaking, DM content of forage raw materials is significantly depending on the degree of wilting. For plants like edible grass, mulberry leaves, broussonetia, and ramie, which utilize fresh leaves or fresh stems and leaves, wilting to eliminate excess moisture is an essential procedure for producing quality silage (Borreani et al., 2018). Especially for high-moisture materials like edible grass. The research results of Liao et al. (2023) show that different moisture contents will significantly affect the fermentation quality and microbial community of high-moisture water hyacinth silage, with higher DM content resulting in higher lactic acid and crude protein, and lower ammonia N content. The results of this study show that wilting for 12 h, with a DM content of 42%, results

in higher lactic acid bacteria content, crude protein content, and lower ammonia N levels in edible grass. This is consistent with our research results. Therefore, controlling the wilting time to make edible grass silage is crucial for the quality and composition of the product.

The resource of edible grass is gaining attention, but there is a lack of effective application methods. Silage is an ideal means of preservation and quality improvement. However, there is currently a lack of targeted research. Unless the moisture content of edible grass is controlled by wilting and other means. Special additives are also widely used in the preparation of forage silage, mainly including microbial agents, molasses, enzymes, and buffering acids (Soundharajan et al., 2021; Menezes et al., 2022). The enhancement of silage quality primarily occurs through the stimulation of helpful bacterial proliferation and the suppression of detrimental bacterial growth (Okoye et al., 2023). The microbial agent of SiloSolve FC mostly consists of two lactic acid bacteria (LAB): *Lactobacillus buchneri* LB 1819 and *Lactococcus lactis* LL O224. The application of such agents will enhance the proliferation of LAB in silage while inhibiting the growth of putrefactive microorganisms due to increased lactic acid production and the benefits of the bacterial community (Okoye et al., 2023).

Silage is commenced by LAB during fermentation, wherein LAB utilize water-soluble carbohydrates (WSC) as their energy and C source. Literature indicates that the advised concentration of WSC is 60 to 70 g kg⁻¹ DM, which generates adequate acidity for the preservation of silage (Zhang et al., 2016). In this investigation, WSC concentration levels of edible grass after 9, 12, and 15 h wilting were 58.34, 59.25, and 59.14 g kg⁻¹, respectively, which are near the prescribed minimum concentration level. Consequently, the preservation of WSC is essential throughout the silage process. The incorporation of molasses elevated the WSC concentration in edible grass silage post-fermentation, and the reduced NH₃-N concentration in the fermented edible grass suggests that molasses usage can mitigate N loss during the silage process.

The research conducted by Jiang et al. (2021) demonstrated that an increase in molasses addition resulted in elevated levels of DM, crude protein, and lactic acid in hybrid Broussonetia silage, while there was a linear decrease in neutral detergent fiber (NDF), acid detergent fiber (ADF), pH value, butyric acid content, and ammonia N/total N ratios. This outcome aligns with our research findings; we discovered that the edible grass subjected to 12 h wilting exhibits a reduced NH₃-N concentration. This contrasts with the findings of Luo et al. (2021), which indicated that the addition of molasses enhanced the fermentation quality and flavor of alfalfa silage, with the 3% group achieving an optimal pH value (below 4.5) and the most favorable circumstances for prolonged storage. Nonetheless, the concentration of NH₃-N did rise. This may pertain to the varying fermentation conditions during the silage process in different locations, including pH value, temperature, and moisture content, all of which can influence the production of ammonia N. Compared to silage treated with molasses, edible grass silage treated with cellulase for 12 h has a greater WSC level. Although they contain little monosaccharides, legumes—such as alfalfa, clover, and even stable grass—are generally thought to have a high buffering capacity. This considerably slows down the quick pH drop needed for premium silage. The pH of these plant sources can be raised by adding 2%-5% molasses. Lactic acid bacteria multiply quickly during fermentation, causing the pH to drop quickly (Mordenti et al., 2021). Singh et al. (1985) used 5%-10% molasses in green berseem (*Trifolium alexandrinum* L.) to increase the WSC content after ensiling. According to Wang et al. (2017), mixed silage made of alfalfa, rice straw, and broccoli shavings contained 2.5% to 15% molasses. At day 30 following fermentation, the 2.5% molasses concentration did not differ substantially from the control, and the WSC content only increased by 1.8%. Similarly, after 203 d fermentation, adding 1% to 3% sugarcane molasses did not raise the WSC of alfalfa silage; instead, the 1% addition had a lower WSC than the control. In this study, we choose to incorporate only 1.5% molasses due to financial constraints, which may primarily account for the minimal enhancement in WSC. Consequently, additional research is required to ascertain the optimal quantity of molasses to enhance fermentation outcomes and reduce expenses.

The external application of cellulase can decompose plant cell walls, liberate additional fermentable substrates, and enhance the proliferation and fermentation of LAB. Li et al. (2018) discovered that the use of cellulase alone in alfalfa silage did not significantly impact fiber breakdown. Nonetheless, the research conducted by Zhao et al. (2021) demonstrated that the application of cellulase alone may markedly diminish the NDF and ADF content of corn-soybean residue mixed silage in comparison to the control group. This aligns with our research findings; the application of cellulase can diminish the NDF level of edible grass post-wilting.

CONCLUSIONS

Consequently, various indicators from this study demonstrate that edible grass can serve as a superior meal. Following a 12 h wilting period, the use of lactic acid bacteria (LAB) additives, molasses, and cellulase can enhance the nutritional quality of fermented edible grass, augment the population of LAB and lactic acid concentration, while diminishing neutral detergent fiber content and NH₃-N generation.

Author contributions

Conceptualization: M.C., W.L. Methodology: M.C., W.L. Sample collection: M.C. Software: X.L. Investigation: M.C. Resources: M.C. Data curation: M.C., X.L. Writing-original draft: M.C., Q.Z. Writing-review & editing: J.Z. Supervision: T.J. Project administration: M.C. All co-authors reviewed the final version and approved the manuscript before submission.

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