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Research Article

Nutritive value of Damascus rose extraction residue ensiled with different effluent absorbents

Hassan FAZAELI*, Mojtaba ZAHEDIFAR
Animal Science Research Institute, P.O. Box 1483, 31585 Karaj, IRAN

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Abstract: Two experiments were conducted to study the silage characteristics and nutritive value of Damascus rose extraction residue (RER) which is a by-product remained after the extraction of rose water in some parts of Iran. In the first experiment, RER was ensiled together with different amounts of effluent absorbents, using a completely randomised design with 10 treatments and 4 replicates. In the second experiment, RER was ensiled together with dry sugar beet pulp, wheat straw, and limestone. The contents of OM, CP, CF, EE, and NFE were 94.4%, 11%, 24%, 24%, and 57.3%, respectively, in the initial samples of RER. The DM content of silages varied from 26.7% to 36.6%, pH-values ranged from 4.08 to 4.36, which denotes a significant difference ($P < 0.05$). In experiment 2, the DM and CP of silage were 25% and 9.7%, respectively, and the pH value was 4.6. The in vivo digestibility of DM and OM were 54.2% and 57.6%, respectively, and voluntary intake for DM and OM was 41.7 and 36.6 g/kgBW$^{0.75}$, respectively, in sheep. Total digestible nutrients were 52.1% and metabolisable energy was 7.87 MJ/kgDM. A linear relationship was observed between OM digestibility and TDN with in vitro gas production.

Key words: Rose extraction residue, silage, nutritive value

Introduction

Residues from crops and food processing plants constitute a vast amount of organic material that is not being used and has to be disposed. Disposal is both costly and environmentally polluting. Many such materials have nutritive value and may meet part of animal's nutrient requirements. The residues from Damascus rose is one such material.

The Damascus rose is cultivated in 14 provinces of Iran on 5420 hectares of land. The annual production of this flower is over 14,300 t from which, 8500 t of rose water and 600 L of essence are extracted (1). At the end of the extraction process, the residue that includes petal, sepal, and pistil is discarded. These residues should have some nutritive value but because of their high moisture content, it must be either dried or ensiled for storage and utilization.

Ensiling is one of the methods for the preserving feeds. Feeds high in moisture can be ensiled and kept for feeding of animals. However, ensiling rose residues is not simple due to their high moisture content. Absorbents can be used to adjust moisture content (2). Fazaeli and Mahdavi (3) used rice straw and molasses for berseem clover silage as an absorbent

* E-mail: hazaeli@gmail.com

and fermentation improver, respectively. Others have used cereal grains, rice bran, and sugar beet molasses for making silage (4,5). Brzoska et al. (6) used 65 kg of mixed barley grain with sugar beet pulp per ton of grass silage to increase dry matter from 23% to 33%. Straws can also be used for this purpose but its nutritive value of silage is lower (7). Use of an absorbent in silage can affect the animal performance, which can be measured through digestibility, intake, and the quantity of absorbed nutrients (8). Similar to other feeds, estimating energy value of silages is based on measuring digestibility together with developing of in vitro techniques. There have been some attempts to predict the digestibility via the index of cell wall constituents (9). However, in vivo methods give the most reliable information about the nutritive value of feed, especially the non-conventional feeds.

There has been considerable research work on estimating the nutritive value and voluntary intake of different feeds and different equations have been developed for estimating the nutritive value but it seems that for non-conventional feeds, such as residues of Damascus rose, in vivo method is necessary for assessing their nutritive value.

This research was conducted to study the silage characteristics and nutritive values of Damascus rose extraction ensiled with different effluent absorbents.

Materials and methods

First experiment: During the rose water processing season (May), fresh samples of rose extracted residue (RER) were collected from 3 factories. These samples were weighed and sun dried; the dry matter content was calculated as air dried. Dried samples were hammer milled through a 1 mm screen and chemical compositions were determined based on the AOAC (10). The cell wall constituents including NDF assayed without a heat stable amylase and inclusive of residual ash and ADF inclusive of residual ash were measured according to Van Soest et al. (11).

In the second stage, a larger amount of fresh rose residues was obtained and immediately transported to the Animal Science Research Institute and ensiled together with the additives. To make the silage, specific amounts of chopped (2-3 cm) wheat straw, wheat bran, and dry non pellet sugar beet pulp were added to and mixed with the rose residues to obtain an acceptable amount of moisture content (Table 1). Silages were prepared in 6 L plastic containers, kept for 1 month, then opened and evaluated. The experiment was conducted using a balanced complete randomized design with 10 treatments and 4 replications. Analysis of variance procedure of SAS (12) was used to determine the effect of treatments on silage characteristics.

Table 1. Ratio (W/W) of ingredients in experimental silages (treatments).

Treatments	Ingredients				
	RER[#]	Wheat straw	Wheat bran	Sugar beet pulp	limestone
1	82.5	16.5	-	-	1
2	82.5	11.0	5.5	-	1
3	82.5	5.5	11.0	-	1
4	82.5	-	16.5	-	1
5	82.5	11.0	-	5.5	1
6	82.5	5.5	-	11.0	1
7	82.5	5.5	5.5	5.5	1
8	79.0	-	-	20.0	1
9	79.0	-	10.0	10.0	1
10	79.0	10.0	-	10.0	1

[#] Rose extracted residue as fresh (wet) weight

Second experiment: In the second experiment, 2 t of RER was obtained, mixed thoroughly with chopped wheat straw, dried sugar beet pulp (as flaked), and limestone in ratios of 81, 8, 10, and 1 (W/W), respectively, and ensiled. Silages were opened after 2 months and subjected to laboratory evaluations, and fed to animals. Samples were collected during the feeding trial for measuring the DM content and pH. Total tract digestibility of DM, OM, and energy digestibility and voluntary feed intake were measured using 8 small size sheep (Zel sheep) using a total faecal collection method during a 24 day experiment with a 14 day adaptation period. Fermentation of silage samples was measured using the in vitro gas production technique (13).

Relationships between produced gas and in vitro digestibility and total digestible nutrient content were estimated (14). Mean standard deviation and coefficient of variation were calculated.

Results

First experiment: Chemical composition of the samples is presented in Table 2. The dry matter content of RER was very low (8.8% to 15.2%). For the process of rose extraction, the raw material is dipped in water. After the drainage of residues, it still contains a high percentage of water. The dry matter figures, 8.8% and 9.1% (Table 2), were from the samples obtained immediately after emptying the rose residue; the sample containing 15.2% was after 5 h of drainage. To reduce the water content of the residue, the fresh residue was kept on a surface with a mild slope for 24 h before transporting it. Even then, the water content was not sufficiently low for ensiling. Therefore, absorbents mentioned earlier were tested. The contents of OM, CP, CF, NFE, and GE in the residue averaged 94.4%, 11.0%, 24.0%, 57.3% and 18.93 MJ/kg (DM basis), respectively, indicating some potential nutritive value.

Table 2. Dry mater and chemical composition (DM basis) of RER[#].

Measured items (g/kg)	Different locations 1	2	3	Mean of samples	CV[+] %
Dry matter	88*	91*	152**	-	-
Organic matter	944	944	944	944	0.05
Ash	56	55	56	56	0.85
Crude protein	102	109	119	110	6.3
Crude fiber	250	250	220	240	5.2
Ether extract	24	27	20	24	12.12
NFE	572	563	585	573	1.6
NDF	346	386	302	345	9.95
ADF	284	308	222	271	13.4
Hemicellulose	62	78	80	74	11
Gross Energy (KJ/g)	18.93	18.99	18.88	18.93	0.23

[#] Rose extracted residue

[+]Coefficient of variation

* sampled immediately after emptying

** sampled from the stored residue

Characteristics of experimental silages are reported in Table 3. Dry matter content of silage is important for assessing its quality. Dry matter ranged from 26.7% to 36.6%; the difference between the treatments was significant ($P < 0.05$). The pH value of silages varied from 4.36 (second treatment) to 4.08 (treatment 8), which is significantly different ($P < 0.05$). The pH values were lowest for treatments 8 and 9 (4.08 and 4.09, respectively). These treatments were higher in sugar beet pulp. The values showed significant ($P < 0.05$) differences between the treatments.

Second experiment: The DM content of the prepared silage was 25.5%. Chemical composition for CP, Ash, EE, CF, NDF, ADF, Ca, and P were 9.7%, 13.4%, 3.2%, 25.6%, 39.0%, 30.2%, 2.2%, and 0.4% in DM, respectively. The GE of the silage was 17.80 MJ/kg DM basis and pH value was 4.6. The DM content is an important factor for assessing silage quality, in this study the DM of silage fall in an acceptable range (25.0 - 35.0 %).

Digestibility of DM and OM were averaged 54 ± 7.4%, and 57.6 ± 8.3%, respectively, and the total digestible nutrient content was 52.1 ± 6.7% (Table 4). Digestibility of CF, EE, NFE, and gross energy was relatively high. Among the nutrients listed in Table 4, digestibility of crude protein remained relatively low (34 ± 3.2%).

Voluntary feed intake of DM and OM were 716 ± 67 and 629 ± 62 g/d, respectively, when the silage fed to sheep (Table 4). Based on metabolic body weight, intake of DM and OM averaged 41.7 ± 5 and 36.6 ± 4.4 g/kg, respectively.

Volume of gas production at different hours of incubation is presented in Table 5. Production of gas from 12 to 48 h was relatively high. The highest gas production (10.9 mL) occurred between 12 and 24 h. Cumulative gas production continued up to 96 h after incubation.

Relationships between gas production and digestibility of OM and total digestible nutrients are illustrated in Figures 1-3, respectively. Organic matter digestibility was correlated linearly with gas production at 24 and 48 h, but the total digestible nutrients were most closely related to gas production at 48 h.

Table 3. Silages characteristics.

Parameters			Treatments
Score value	pH	DM (g/kg)	
9.13^{a}	4.31^{bc}	277^{bc}	1
7.0^{f}	4.36^{a}	285^{bc}	2
7.13^{f}	4.29^{ab}	286^{bc}	3
8.0^{bc}	4.18^{c}	290^{bc}	4
8.13^{b}	4.34^{a}	285^{bc}	5
7.9^{bcde}	4.17^{c}	267^{c}	6
7.0^{bcd}	4.23^{bc}	310^{bc}	7
7.4^{def}	4.08^{d}	297^{bc}	8
7.3^{ef}	4.09^{d}	320^{b}	9
7.5^{cdef}	4.27^{ab}	366^{a}	10
0.14	0.003	26.5	SEM

SEM = Standard error of mean.
Means with the different superscripts within a column are significantly ($P < 0.05$) different.

Table 4. Digestibility, voluntary intake, and energy value of silages.

Digestibility (coefficient)	Mean	SD#	+CV (%)
Dry matter	0.542	0.074	13.7
Organic matter	0.576	0.083	14.4
Crude protein	0.341	0.032	13.4
Crude fibre	0.585	0.062	10.6
Ether extract	0.685	0.048	7.0
Nitrogen free extract	0.578	0.069	12.0
Gross energy	0.547	0.075	13.7
TDN (g/kg)	521	67	11.6
Digestible energy (MJ/kg)*	9.71	-	-
Metabolisable energy (MJ/kg)**	7.87	-	-
Voluntary intake			
DM (g/d)	716	67	9.6
DM (g/kgW$^{0.75}$)	41.7	5.0	9.2
OM (g/d)	629	62	9.6
OM (g/kgW$^{0.75}$)	36.6	4.4	9.3

Standard deviation +Coefficient of variation
*DE = GE × digestibility of energy **ME = 0.81 × DE

Table 5. Mean* (± SD) of in vitro gas production of silages.

Gas production (mL)	Time of incubation (h)								
	2	4	6	8	12	24	48	72	96
at the interval of two subsequent times	6.1 (0.48)	4.8 (0.25)	4.4 (0.4)	4.3 (0.33)	8.0 (1.6)	10.9 (0.17)	7.1 (0.25)	1.9 (0.5)	4.6 (0.9)
Cumulative production	6.1 (1.45)	10.9 (1.37)	15.4 (1.3)	19.6 (1.47)	27.6 (1.6)	38.5 (1.6)	45.6 (1.0)	47.5 (1.4)	52.1 (0.9)

* Mean of 16 samples

Discussion

In the first experiment from the chemical composition point of view, the rose residue is comparable with cereal hay and it can be classified as roughage (15).

The original dry matter of RER, 15.2%, was increased to an acceptable level (36.6%) by adding 10% wheat straw and 10% sugar beet pulp before ensiling. Previous studies (3,16) have shown that chopped straw and sugar beet pulp absorb water and prevent silage effluent. The recommended dry matter of forages for making silage is about 35% (7). However, the range in ideal dry matter depends on other characteristics, such as concentration of soluble carbohydrates, CP, minerals (especially cation and anion), the physical structure of cell wall, and the water holding capacity. Suitable moisture ranges from 25% to 40% (17).

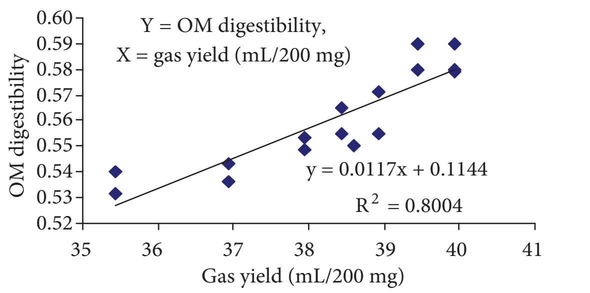

Figure 1. Relationship between 24 h in vitro gas production and digestibility of organic matter.

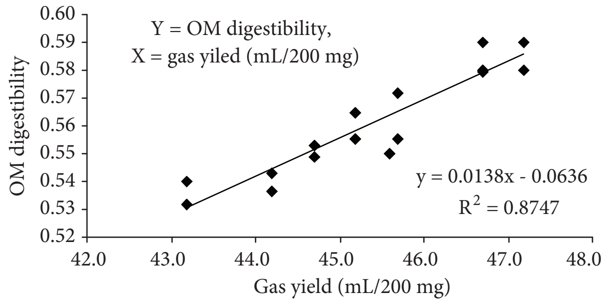

Figure 2. Relationship between 48 h in vitro gas production and digestibility of organic matter.

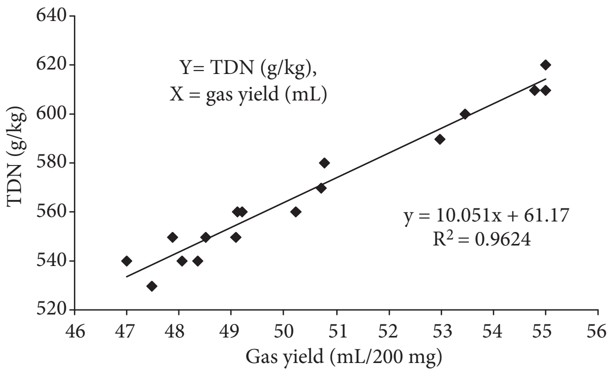

Figure 3. Relationship between 48 h in vitro gas production and total digestible nutrients.

The possibility of making good silage can be attributed to suitable levels of soluble carbohydrates and nitrogen, and appropriate physical characteristics, such as particle size and texture, which gives it good compression property (2,16). According to Done and Appleton (17) addition of sugar beet pulp to grass silage reduced the amount of acid production in the silage. However, Hameleers et al. (16) reported that lactic acid was increased in maize silage containing 18% beet pulp. Tatlı et al. (18) reported pH values of 4, 4.92, and 4.15 for silages of corn, alfalfa, and sugar beet pulp with dry matter content of 28.7%, 31.4%, and 16.7%, respectively. When sugar beet pulp was used as absorbent in ensiling of grass, the dry matter content was increased from 23% to 32% and pH rose from 4.18 to 4.60 (2). However, at all dry matter content of silages in this trial (26.7%-36.6%) pH value of treatments (4.08-4.36) ranged in an acceptable level.

Silages with treatments 7, 8, 9, and 10 had better scores but the treatments 8 and 9 had lower pH values (4.08 and 4.09, respectively) and their DM content was 29.7% and 32%, respectively (Table 3). These treatments (8 and 9) were considered superior compared to other ones so that they could be classified as good silage. The silage score is related to the type of forage and ensiling conditions. For pH, treatments 8 and 9 were classified as first grade while treatments 7 and 10 were second grade. Regarding the relationship between pH and DM, and considering the point that increasing DM increases pH, the aforementioned treatments would fall in the same grade. The preferred superior treatment at the farm level could be selected from any of these 4 treatments based on forage availability, cost, and convenience of operation.

In the second experiment based on chemical composition, this feed can be classified as forage and should meet the energy and protein requirements for maintenance of ruminants. The dry matter content of the fresh residue was between 10% and 15%, but after ensiling, due to the addition of straw, percentage of cell walls increased and crude protein decreased. The pH value of this silage at 4.6 was higher than those obtained in the first experiment (4.08-4.36). This can be attributed to differences in ensiling conditions (19). This silage was prepared under farm conditions while the first experiment was conducted on laboratory scale and well controlled. Considering its DM content, this silage was expected to have a pH lower than 4.5 while its average pH was 4.6. Brzoska et al. (2) documented that appropriate DM and pH depends upon various characteristics of ensiled materials including concentration of soluble carbohydrates, CP, content of ash, particularly cation and anion, physical structure, and water holding capacity of forage so that DM can vary between 25 to 40 g/kg and pH from 3.8 to 5.5.

The digestibility of nutrients in silage RER was comparable with grass silage (2) and other forage silages. For example, digestibility of Kenaf forage ensiled with 10% sugar beet pulp was reported to be 56% (20). Among the nutrients listed in Table 4, digestibility of crude protein remained relatively low. With a 9.7% crude protein diet, protein digestibility of above 50% would be expected but it was observed around 34%. This is very likely due to the formation of indigestible compounds formed during boiling of rose flower. The extraction process continues for 3 h, and heating of proteins with carbohydrates may lead to formation of compounds that are unavailable for both rumen microbes and the host animal (21).

Findings of voluntary intake in this study match results of Tatli and Cerci (22) who reported that DM intake of grass hay silage in sheep was 38 g/kgW$^{0.75}$, but intakes were lower than for a mixture of clover and leguminous hay silage of 48 g/kgW$^{0.75}$ (7). These results imply that the quality of RER silage is similar to forage silage reported in NRC (15). In the literature, voluntary feed intake of grass silage containing 21%-37.6% DM and 10%-12% crude protein for 29 kg sheep was 732 to 986 g/d, or 25 to 34g/kg body weight. Intake of ensiled feeds depends on the type of feed, nutritive value, and silage quality (5). Tatlı et al. (18) reported that the intake of corn silage by 30 kg lambs was 1033 g/d while, the intake of alfalfa was 552 g/d. When the 2 silages were mixed together, intake increased to 833 g/d. Voluntary intake of grass silages in growing lambs appears lower compared to dried hays (22).

The relatively higher gas production between 12 and 24 h (Table 5) indicated that this silage could have a considerable fermentable carbohydrate. Meanwhile cumulative gas production continued up to 96 h of incubation. This could imply that this feed would have a relatively low ruminal outflow rate and long retention time in the rumen (23). A low outflow rate would be expected because wheat straw was part of the silage.

The volume of produced gas has been used as an index for predicting digestibility (14). Gas production depends mainly on fermentation of feed to volatile fatty acid; protein and EE content are not relatively fermented (13,23). Therefore, the gas production procedure is more reliable for the feeds containing lower levels of CP and EE as would apply to silages investigated in this study.

In conclusion, Rose extract residues can be ensiled with chopped wheat straw and sugar beet pulp and fed to animal to prevent or postpone environmental pollution. Such silage can meet the maintenance requirements of breeding sheep. Based on digestibility and voluntary feed intake measurements, it can be classified as medium quality forage. More research can elucidate additional nutritional aspects of this feed.

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