Original article

Effect of Dried Molassed Sugar Beet Pulp and Molasses on Silage Quality of Forage Turnip (*Brassica rapa L.*)

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Summary. This study aimed to determine the effect of different levels of dried molassed sugar beet pulp (DMSBP) and molasses (M) addition of on the fermentation quality of forage turnip (*Brassica rapa L.*) silages. Forage turnip was ensilaged with DMSBP (0, 7, 10 and 15%) and M (0, 1, 2 and 3%). The addition of DMSBP and M improved the silage quality and fermentation parameters of forage turnip silages. *In vitro* organic matter digestibility (IVOMD) and metabolizable energy (ME) values of forage turnip silages increased with addition of DMSBP (P<0.01). The pH and ammonia nitrogen (NH_3-N/TN) values decreased with addition of DMSBP and M and aerobic stability values increased (via decreased CO_2 values) with addition of DMSBP (P<0.01). The lactic, propionic and butyric acid values of silages decreased with addition of DMSBP, but acetic acid values increased (P<0.01). The lactic and acetic values increased with addition of M, while propionic and butyric acid values of silages decreased with addition of M (P<0.01). As a result, forage turnip (*Brassica rapa L.*) can be ensilaged no additives or addition different levels of DMSBP and M, but the silages prepared with 7% DMSBP and 3% M additive had high aerobic stability and low silage ammonia nitrogen values. However, these results should be supported with *in vivo* feeding studies.

Key words: Forage turnip (*Brassica rapa L.*), silage, dried molassed sugar beet pulp, molasses.

Introduction

Brassica species are among the alternative forage crops that are widely produced and used in order to supply forage requirement during limited forage production in different regions of the world (1). *Brassica* species forages can be used for ruminants by silage or grazing (2). In the recent years, as being called as lenox in Turkey, a variety of forage turnip (*Brassica rapa L.*) it is encouraged to increase of production, cultivation and using as forage source for ruminant nutrition. Since the forage turnip (*Brassica rapa L.*) plant is a legume group of plants, it has high buffer capacity (BC) and crude protein (CP) with low dry matter (DM) and water-soluble carbohydrates (WSC) content causes these plants to be ensilaged with difficulties (3). Forage turnip, due to its low fibre content, it is not recommended to use more than 75% in ration in order to keep proper rumen activity (4). Koch and Karakaya (5) reported that the forage turnip will cause significant nutrient losses after harvesting due to the high-water content and that it can only be used in animal feeding as silage. Although the dry matter (DM) content of most *Brassica* species is low than 16-19%, the yield of DM per unit area is high. Although it varies depending on the environmental factors at the time of harvest, 8-10 tons of fresh material can be obtained per decare on average (6). There are a limited number of studies on ensiling of forage turnip (*Brassica rapa L.*) plant and these studies have reported that forage turnip can be ensilaged no additives or together with straw, grains and molasses and these silages have been reported as having high quality silage characteristics (7-9). However, no detailed studies investigating about the forage turnip silage quality was found. Molasses (M) and dried molassed sugar beet pulp (DMSBP) are the important fermentation stimulating sources for silage fermentation (10,11). In this study as silage additives high DM content DMSBP and high WSC content M were used. Thus, it has been thought that DMSBP and M could be added to the silage to increase the DM content of the forage turnip and to eliminate the deficiency of the WSC and improve the silage quality. The aim of this study the addition of at the different levels of dried molassed sugar beet pulp (DMSBP) and molasses (M) was to the determine the effects on the fermentation quality of forage turnip silage.

Materials and Methods

Forage turnip was harvested at full flowering and full encapsulation period. The DMSBP and M were used to increase the dry matter and water-soluble carbohydrate (WSC) contents of the silages. Experiment was designed 4x4 factorial design, DMSBP (0, 7, 10 and 15%) and M (0, 1, 2 and 3%) were added to forage turnip on a fresh basis and homogeneously mixed and total 16 silage group prepared. The mixtures were packed tightly in 1.5 L glass jars with five replicates per treatment. The chemical composition of forage turnip, DMSBP and M used as silage material are given in Table 1.

The jars were stored for 60 days at room temperature (22 °C) and then they were opened after 60 days of ensiling. The pH values of the silages were immediately measured (12). Volatile fatty acid and lactic acid analysis were determined by high-performance liquid chromatography according to procedure of Suzuki and Lund (13). Ammonia nitrogen rate in total nitrogen (NH_3-N/TN, %) content was determined according to the procedure described by AOAC (14) and silages were subjected to aerobic stability test (determination for CO_2 production values) for 5 days in a system developed by Ashbell *et al*. (15). Buffering capacity (BC) of forage turnip was determined according to the method of Playne and McDonald (16). WSC value was determined according to the procedure described by Dubois *et al*. (17). Dry matter (DM), Crude ash (CA) and crude protein (CP) contents of forage turnip material, DMSBP, M and all silages were determined by procedure of AOAC (18).

NDF and ADF contents were measured according to the procedure of Van Soest *et al.* (19). The *in vitro* gas production technique (20) was used to determine *in vitro* organic matter digestibility (IVOMD) values and metabolizable energy (ME) values were calculated using the equations by Menke *et al*. (21).

$$ME\ (MJ/kg\ DM) = 2.20+0.136\ GP+0.057\ CP+0.0029\ CP^2$$

$$OMD\ (\%) = 14.88+0.889\ GP+0.45\ CP+XA$$

Where, GP is 24 h net gas production (ml/200 mg),

CP = Crude protein (%)

XA = Ash content (%)

Treatments were arranged as a 4×4 factorial, treatment sum of squares were separated into main effects (dried molassed sugar beet pulp and molasses level) and their interactions. The means were compared using Duncan Multiple Comparison test (22).

Results

The chemical composition of forage turnip (*Brassica rapa L.*)**,** DMSBP and M used as silage material and additives were presented in Table 1.

Table 1. Nutrient composition of sialge materials used in preparation of forage turnip (*Brassica rapa L.*) silages.

	DM	CA	CP	ADF	NDF	IVOMD	ME
FT	18.06	8.81	10.35	38.71	42.14	56.24	8.67
DMSBP	95.55	4.76	10.65	26.54	38.99	83.49	12.85
M	77.86	10.84	10.24	-	-	81.75	12.54

DM: Dry matter, %; **CA:** Crude ash, % DM; **CP:** Crude protein, % DM; **ADF:** Acid detergent fiber, % DM; **NDF:** Neutral detergent fiber, % DM; **IVOMD:** *In vitro* organic matter digestion, %; **ME**: Metabolisable energy, MJ/kg DM; **FT:** Forage turnip plant; **DMSBP:** Dried molassed sugar beet pulp; **M:** Molasses.

BC and WSC values of forage turnip plant used as silage material were determined as 184 meq/kg DM and 81.6 g/kg DM, respectively.

The effect of DMSBP and M supplementation on the chemical composition of the resultant turnip silages were presented in Table 2.

Supplementation of DMSBP and M increased DM and CP content of resultant the silages (P<0.01). But ADF and NDF values of the silages decreased with addition of DMSBP and M (P<0.01). IVOMD and ME values of the silages increased with addition of DMSBP (P<0.01), whereas supplementation of M did not change IVOMD and ME values of the silages (P>0.01). The pH, NH_3-N/TN, CO_2 and organic acids (acetic, propionic, lactic and butyric acid) of the forage turnip silages were presented in Table 3.

Compared with control, pH and NH_3-N/TN values of the silages decreased with addition of DMSBP and M (P<0.01). The CO_2 values of the silages decreased with addition of DMSBP (P<0.01), while increased with addition of M (P>0.01). The lactic, propionic and butyric acid values of silages decreased with addition of DMSBP, but acetic acid values were increased (P<0.01). The lactic and acetic values increased with addition of M, while propionic and butyric acid values of silages decreased with addition of M (P<0.01).

Discussion

In this study, DM values of forage turnip silages preapared with DMSBP and M were higher than control silage. The differences of DM content of silages were probably due to higher DM content of the DMSBP and M than silage material (23). Increasing DMSBP and M levels increased the CP content of forage turnip silages this result can be associated with the fact that plant proteins could be protected from proteolysis due to WSC source provided to silages with addition of DMSBP and M (24). ADF and NDF values of forage turnip silages were decreased with addition of DMSBP and M, this result may be due to increased ADF, NDF and CF degradation as a result of lactic acid fermentation (25). In this study, pH values of silages prepared by adding different levels of DMSBP and M were found within the acceptable pH values (4.0-5.0) for legume silages (26). The decreased of pH and increased of lactic acid values with addition of M were considered to be due to the

Table 2. The effect of dried sugar beet pulp and molasses on chemical composition of forage turnip (*Brassica rapa L.*) silages.

DMSBP Level, %	DM	CP	ADF	NDF	IVOMD	ME
0	19.10[d]	10.35[c]	45.29[a]	47.41[a]	54.54[c]	8.37[c]
7	21.62[c]	11.38[a]	40.70[b]	45.12[b]	61.79[b]	9.54[b]
10	22.76[b]	11.27[ab]	40.69[b]	44.67[bc]	63.06[a]	9.73[a]
15	25.72[a]	11.20[b]	38.70[c]	44.17[c]	63.48[a]	9.79[a]
M Level, %						
0	21.61[d]	10.72[c]	43.36[a]	47.27[a]	60.94	9.38
1	22.19[c]	11.15[ab]	41.38[b]	45.41[b]	60.61	9.35
2	22.52[b]	11.07[b]	40.62[c]	44.69[c]	60.88	9.38
3	22.90[a]	11.25[a]	40.02[c]	44.00[d]	60.44	9.32
SEM	0.278	0.066	0.346	0.242	0.454	0.072
Effects						
DMSBP	**	**	**	**	**	**
M	**	**	**	**	NS	NS
İnteraction	NS	**	**	**	**	**

[a-d]**:** Values with different letters were found different in each column (**: P<0.01, NS: Not Significant); **DMSBP:** Dried molassed sugar beet pulp; **M:** Molasses; **DM:** Dry matter, %; **CP:** Crude protein, % DM; **ADF:** Acid detergent fiber, % DM; **NDF:** Neutral detergent fiber, % DM; **IVOMD:** *In vitro* organic matter digestibility, %; **ME:** Metabolisable energy, MJ/kg; **SEM:** Standard error of means.

Table 3. The effect of dried sugar beet pulp and molasses on fermentation characteristics of forage turnip (*Brassica rapa L.*) silages.

DMSBP Level, %	pH	NH_3-N/TN	CO_2	LA	AA	PA	BA
0	4.35[a]	11.57[a]	7.70[a]	57.00[a]	34.47[b]	0.12[a]	1.01[a]
7	4.29[b]	7.92[b]	7.51[a]	42.91[b]	45.11[a]	0.00[b]	0.49[b]
10	4.24[c]	7.31[c]	6.63[b]	39.49[c]	43.46[a]	0.00[b]	0.31[c]
15	4.23[c]	6.92[c]	6.99[b]	35.47[d]	44.33[b]	0.00[b]	0.57[b]
M Level, %							
0	4.31[a]	9.38[a]	5.52[b]	35.39[d]	30.95[c]	0.11[a]	0.76[a]
1	4.28[ab]	8.43[b]	7.68[a]	39.86[c]	37.80[b]	0.00[b]	0.67[ab]
2	4.28[ab]	8.26[b]	7.91[a]	48.84[b]	45.58[a]	0.00[b]	0.56[b]
3	4.26[b]	7.65[c]	7.71[a]	50.78[a]	43.05[a]	0.00[b]	0.38[c]
SEM	0.008	0.240	0.172	1.221	1.096	0.012	0.044
Effects							
DMSBP	**	**	**	**	**	**	**
M	**	**	**	**	**	**	**
İnteraction	**	**	**	**	*	**	**

[a-d]**:** Values with different letters were found different in each column (*: $P<0.05$; **: $P<0.01$); **DMSBP:** Dried molassed sugar beet pulp; **M:** Molasses; **NH_3-N/TN:** Ammonia nitrogen rate in total nitrogen (TN) content % NH_3-N/TN; **CO_2:** Carbon dioxide formation, g/kg DM**; LA:** Lactic acid, g/kg DM; **AA:** Acetic acid, g/kg DM; **PA:** Propionic acid, g/kg DM; **BA:** Butyric acid, g/kg DM; **SEM:** Standard error of means.

high WSC content of M (27). In this study, the findings that the silages assessed had high lactic and acetic acid values, low pH and acceptable NH_3-N/TN values demonstrated that desired silage fermentation occurred (28). Silage NH_3-N/TN value of good quality silages is expected to be lower than 11% (29). The NH_3-N/TN values determined from all the silages in the present study were found lower the upper limit reported by Carpintero *et al.* (29). When silage is opened, anaerobic conditions converts to aerobic conditions and some microorganisms which cannot grow within the optimal silage fermentation process start to grow and cause silage to spoil (30,31). In this period, undesirable microorganisms consume WSC and lactic acid and cause DM and nutrient losses (32). As a result, silage starts to spoil due to CO_2, temperature and water increase in silo (33). Increase of CO_2 production negatively affects aerobic stability of the silage (31). In this study, CO_2 values increased with addition of M, this result can be due to high WSC content of M, which is a nutritional source for mold and yeasts. The lactic acid value of silages decreased with DMSBP addition, but it was increased with M addition. The most important source of energy used by lactic acid bacteria during silage fermentation period is WSC and therefore addition of M level increases lactic acid value of silages (30). In this study, high level of acetic acid values was determined in the forage turnip silages. This result may be due to the low DM content of the silages in which heterofermentative bacteria were more active (34). Some studies have reported that acetic acid inhibits the formation of yeasts and fungi and increases aerobic stability after opening of silage (35). In this study, butyric acid decreased with addition of DMSBP and M. The butyric acid bacteria generally cannot grow in the environment where the pH value is below 4.5 and while lactic acid bacteria are dominant within pH range of 3.80-4.20 and proliferation and activity of the bacteria producing butyric acid becomes impossible in this case (36). The pH value should be in the range of 4.30-4.50, lactic acid content should be at 6-8%, acetic acid should be at 2-3% and propionic and butyric acid should be lower than 0.5% of DM and NH_3-N/TN value should be approximately 10-15% of for the good quality legume silages (37). The silages prepared in this study, the pH, NH_3-N/TN, lactic acid, acetic acid, propionic acid and butyric acid values were generally compatible with the reports of Kung *et al*. (37).

As a result, forage turnip (*Brassica rapa L.*) can be ensilaged no additives or addition different levels of DMSBP and M, but the silages prepared with 7%

DMSBP and 3% M additive had high aerobic stability and low silage ammonia nitrogen values. However, these results should be supported with *in viv*o feeding studies.

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References

1. Ayres L, Clements B. Forage brassicas quality crops for livestock production. Agfact P2, 2002; 1(13): 1-3.
2. Fernandes GM, Possenti RA, Teixeira de Mattos W, Schammass EA and Junior EF. *In situ* degradability and selected ruminal constituents of sheep fed with peanut forage hay. Archives of animal nutrition 2013; 67(5):393-405.
3. Davies DR, Merry RJ, Williams AP, Bakewell EL, Leemans DK, Tweed JKS. Proteolysis during ensilage of forages varying in soluble sugar content. Journal of Dairy Science 1998;81: 444-453.
4. Marvin HH, Jung J. Use of brassica crops to extend the grazing season. The Pennsylvania State University, Agronomy Facts 2008;33:1-4. https://extension.psu.edu/use-of-brassicacrops-to-extend-the-grazing-season? (Accessed 14 May 2020).
5. Koch DW, Karakaya A. Extending the grazing season with turnips and other brassicas. Wyoming co-operative Extension Service Bull. 1998; B-1051.
6. Rao SC, Horn FP. Planting season and harvest date effects on dry matter production and nutritional value of brassica spp. in the southern great plains. Agronomy Journal 1986; 78(2): 327-333.
7. Cetin I, Duru Arslan A. Determination of some quality properties of ensiled forage turnip (*Brassica rapa L.*) with different additives. Fresenius Environmental Bulletin 2020; 29: 2766-2771.
8. Gumus H, Oguz Karakas F, Oguz N, Bugdaycı KE, Kuter E. The effects of different additives on the fermentation and physical characteristics of lenox silage. Journal of Faculty of Veterinary Medicine, Erciyes University 2020;17(1): 39-44.
9. Hart SP, Horn FP. Ensiling characteristics and digestibility of combinations of turnips and wheat straw. Journal of Animal Science 1987; 64(6): 1790-1800.
10. Kaiser AG 2004. Silage additives. Chapter 7 in Successful Silage. Kaiser AG, Piltz JW, Burns HM, Griffiths NW. (eds). Dairy Australia and New South Wales Department of Primary Industries. New South Wales, Australia.
11. Şakalar B, Kamalak A. The use of dried molasses sugar beet pulp in the silo of the alfalfa plant. Anadolu Agriculture Science Journal 2016; 31:157-164.
12. Polan CE, Stieve DE, Garrett JL. Protein preservation and ruminal degradation of ensiled forage treated with heat, formic acid, ammonia or microbial inoculant. Journal of Dairy Science 1998; 81:765-776.
13. Suzuki M, Lund CW. Improved gas liquid chromatography for simultaneous determination of volatile fatty acids and lactic acid in silage. Journal of Agricultural and Food Chemistry 1980;28: 1040-1041.
14. AOAC, 1990. Official method of analysis. Association of official analytical chemistry pp.66-88. 15th.edition. Washington, DC. USA.
15. Ashbell G, Weinberg ZG, Azrieli A, Hen Y, Horev B. A Simple System to Study the Aerobic Determination of Silages. Canadian Agricultural Engineering 1991; 34: 171-175.
16. Playne MJ, McDonald P. The buffering constituents of herbage and of silage. Journal of the Science of Food and Agriculture 1966; 17(6): 264-268.
17. Dubois M, Giles KA, Hamilton JK, Rebes PA, Smith F. Colorimetric method for determination of sugars and related substances. Analytical Chemistry 1956; 28: 350-356.
18. AOAC, 2005. International, 18th ed. Association of official analytical chemists, Washington DC, USA.
19. Van Soest PJ, Robertson JB, Lewis BA. Methods of dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 1991; 74: 3583-3597.
20. Menke KH, Raab L, Salewski A, Steingass H, Fritz D, Schneider W. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. Animal Research and Development 1988; 28:7-55.
21. Menke KH, Raab L, Salewski A, Steingass H, Fritz D, Schneider W. The Estimation of the digestibility and metabolizable energy content of ruminant feeding stuffs from the gas production when they are incubated with rumen liquor *in vitro*. Journal of Agricultural Science 1979; 93(1): 217-222.
22. SPPS, 2008. Inc, SPSS Statistics for Windows, Version, Chicago.
23. Sibanda S, Jingura RM, Topps JH. The effect of level of inclusion of the legume desmodium uncinatum and the use of molasses or ground maize as additives on the chemical composition of grass and maize legume silages. Animal Feed Science and Technology 1997; 68: 295-305.
24. Slottner D, Bertilsson J. Effect of ensiling technology on protein degradation during ensilage. Animal Feed Science and Technology 2006; 127(1–2): 101-111.
25. Bolsen KK, Ashbell G, Weinberg ZG. Silage fermentation and silage additives review. Asian-Australasian Journal of Animal Sciences 1996; 9(5): 483-494.
26. Rondahl T, Bertilsson J, Martinsson K. Effects of maturity stage, wilting and acid treatment on crude protein fractions and chemical composition of whole crop pea silages (*Pisum sativum L.*). Animal Feed Science and Technology 2011;163, 11-19.
27. Sing R, Kamra DN, Jakhmola RC. Ensiling of leguminous green forages in combination with different dry roughages and molasses. Animal Feed Science and Technology 1985; 12; 133-139.
28. Nadeau EM, Buxton DR, Russell JR, Alliso MJ, Young JW. Enzyme, bacterial inoculant and formic acid effects on silage composition of orchardgrass and alfalfa. Journal of Dairy Science 2000;83: 1487-1502.

29. Carpintero MC, Holding AC, Mcdonald P. Fermentation studies on lucerne. Journal of The Science of Food and Agriculture 1969;20; 677-681.
30. McDonald P, Henderson AR, Heron SJE. The biochemistry of silage. Second Edition. Chalcombe Publication, Marlow, UK. England. 1991. p. 340.
31. Wilkinson JM, Davies DR. The aerobic stability of silage: key findings and recent developments. Grass and Forage Science 2012;68: 1-19.
32. Woolford MK. The detrimental effects of air on silage. Journal of Applied. Bacteriology 1990; 68:101-116.
33. Jatkauskas J, Vrotniakiene V, Ohlsson C, Lund B. The effects of three silage inoculants on aerobic stability in grass, clover-grass, lucerne and maize silages. Agricultural and Food Science 2013; 22(1): 137-144.
34. Kung JRL. 2010: Understanding the biology of silage preservation maximize quality and protect the enviroment. In Proceeding California Alfalfa and Forage Symposium, Visalia, 41-54.
35. Danner H, Holzer M, Mayrhuber E, Braun R. Acetic acid increases stability of silages under aerobic conditions. Journal of Applied and Environmental Microbiology 2003; 69: 562–567.
36. McDonald P. 1981. The biochemistry of silage. John Wiley and Sons. Ltd.
37. Kung JRL, Shaver RD, Grant RJ, Schmidt RJ. (2018). Silage review: Interpretation of chemical, microbial, and organoleptic components of silages. Journal of Dairy Science 2018; 101(5): 4020-4033.

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