Effect of Adding Different Levels of Dried Molasses Sugar Beet Pulp on the Silage Quality and *In Vitro* Digestibility of Wet Tomato Pomace Silage**

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Abstract: This study was aimed to investigate the effects of supplementation of dried molasses sugar beet pulp (3%, 5%, 7%, 10%, 15%, 20% and 25%, fresh material basis) on the silage quality, *in vitro* organic matter digestibility (IVOMD) and metabolisable energy (ME) content of wet tomato pomace (WTP) silage. All the treatments consisted of five replicate silos, and they were prepared in 1.5 L glass jar silos. The ensiling of WTP with dried molasses sugar beet pulp including molasses (DMSBP) had a significant effect on the chemical composition, ME and IVOMD of silages. Dry matter, crude ash, ME and IVOMD values of silages were increased with supplementation of DMSBP levels (P<0.001). Crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) contents of silages were decreased with increasing level of DMSBP (P<0.001). Ammonia nitrogen (NH_3-N) and lactic acid contents were decreased with increasing level of DMSBP (P<0.001). Propionic acid contents of silages were increased with increasing level of DMSBP (P<0.001). Butyric acid was not detected in any silage groups. As a result, tomato pomace can be ensiled with DMSBP without decreasing the quality criteria of silage.
Keywords: *Dried molasses sugar beet pulp, Silage, Wet tomato pomace.*

Yaş Domates Posasına Farklı Düzeylerde Melaslı Kuru Şeker Pancarı Posası İlavesinin Silaj Kalitesi ile *İn Vitro* Sindirim Üzerine Etkisinin Araştırılması

Özet: Bu çalışmanın amacı; melaslı kuru şeker pancarı posasının (MKŞPP) (%3, %5, %7, %10, %15, %20 ve %25) yaş domates posasına ilavesinin oluşacak silaj kalitesine, *in vitro* organik madde sindirimine (İVOMS) ve metabolik enerji (ME) değerine etkisini araştırmak amacıyla yapılmıştır. Çalışmada değerlendirilen silajlar 1.5 L cam kavanozlarda ağızları hava almayacak şekilde beşer tekerrür halinde silolanmışlardır. Melaslı kuru şeker pancarı posası ile domates posasının silolanması oluşan silajların kompozisyonu, *in vitro* organik madde sindirim derecesini ve metabolik enerji değerini önemli derecede etkilemiştir. Domates posasına MKŞPP ilave seviyesinin artışına bağlı olarak elde edilen silajların kuru madde (KM), ham kül (HK), metabolik enerji (ME) ve IVOMS değerleri artarken (P<0.001), ham protein (HP), asit deterjanda çözünmeyen lif (ADF) ve asit deterjanda çözünmeyen lif (NDF) değerleri azalmıştır (P<0.001). Domates posasına MKŞPP ilavesinin artışına bağlı olarak silaj pH değerlerinde genel olarak belirgin bir farklılık görülmezken, silaj amonyak azotu (NH_3-N) ve laktik asit değerlerinin azaldığı (P<0.001), propiyonik asit değerlerinin ise arttığı (P<0.001) görülmüştür. Bu çalışmada değerlendirilen silajlarda bütirik asit tespit edilmemiştir. Sonuç olarak, yaş domates posasının melaslı kuru pancar posası ilavesi ile silolanabileceği ve elde edilen silajların kaliteli silaj niteliği taşıdıkları sonucuna varılmıştır.
Anahtar Kelimeler: *Melaslı kuru şeker pancarı posası, Silaj, Yaş domates posası.*

Introduction

It is possible that apart from the planted forages, agricultural by products containing high water content and food industry by-products should be used as feedstuff to feed animals after drying or ensiling with various methods. These resources are also called alternative silage materials (FAO, 2013). It is possible to use sugar beet, tomato, pea and barley pulps for feeding animals with ensiling and indeed ensiling these resources is gradually becoming more common. As food industry by-products are products obtained seasonally, they have been used for a long time as a fresh roughage resource in family-type farms (Denek and Can, 2005). Tomato pomace consists of peel, seed and fibrous part remaining from processing of tomatoes for sauce production. According to the data obtained in 2013, approximately 150-200 thousand tons of fresh tomato pomace was produced in Turkey (TUIK, 2014). Tomato pomace has a high water content of 75-85% thus it is not possible to preserve it without spoiling when it gets contact with the air for a long time. Various methods can be used to decrease dry matter rate such as adding adsorbents such as cereals or straws during ensilage to protect from spoilage and nutrient loss for long storage periods (Denek and Can, 2005). It is possible to ensile tomato pomace without additives; however high dry matter containing additives are added to prevent nutrient losses via excessive water drainage during ensiling in addition to increment of silage fermentation quality.

Many researchers reported that dry matter values of fresh tomato pomace ranged from 14.2 to 26.04% (Caluya and Siar, 1995; Çapçı et al., 1995; Denek and Can, 2005; Hadjipanayiotou, 1994; Karabulut et al., 1999; Weiss et al., 1997). The differences between dry matter values may be derived from differences in applied methods and type processing of tomato pomace production (Denek and Can, 2005). Crude protein (CP) content of fresh tomato pomace were determined in range of 18.1 and 23.5% of DM (Denek and Can, 2005; Gasa et al., 1989; Hadjipanayiotou, 1994; Karabulut et al., 1999; Weiss et al., 1997). These CP variations of tomato pomace were attributed to differences in the amount of seeds rather than the amount of peels in the pomace (Bradowski and Geisman, 1980; Ensminger et al., 1990; Haşimoğlu et al., 1979). Mendez-Llorent et al. (2014) revealed that tomato pomace could be stored for a long time without spoilage and nutrient loss. They reported that the DM, ash, crude protein, ether extract, ADF and NDF values in the silages following 70 days ensilage period were 24.0%, 10.5%, 22.0%, 3.9%, 14.4% and 22.2%, respectively. Ventura et al. (2009) reported that metabolisable energy content of fresh tomato pomace was 2.59 Mcal/kg and no negative effect was observed up to 1.5 kg/day of the pomace given to goats. In contrast, Abbeddou et al. (2015) indicated that inclusion of tomato at the rate of 30% to the sheep ration during lactation period decreased milk yield and milk protein content whereas unsaturated fatty acid and total fat content of the milk increased with pomace addition.

This study was aimed to investigate the effects of supplementation of dried molasses sugar beet pulp (3%, 5%, 7%, 10%, 15%, 20% and 25%) on the silage quality, *in vitro* organic matter digestibility (IVOMD) and metabolisable energy (ME) content of wet tomato pomace (WTP) silage.

Material and Methods

Wet tomato pomace (WTP) material was obtained from private tomato paste factory in Bursa city, dried molasses sugar beet pulp (DMSBP) as a silage additive was provided from Balikesir-Bursa Beetroot Cooperative. Wet tomato pomace, DMSBP and the silage samples were dried and grounded through 1 mm screen in laboratory mill (Wiley mill) for subsequent analysis. Dry matter (DM), ash and crude protein (CP) content of WTP, DMSBP and the silage samples were analyzed by AOAC (2005). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) content of WTP, DMSBP and the silage samples were analyzed according to method described by Van Soest et al. (1991). Water soluble carbohydrate (WSC) content of silage material and silage additive were analyzed according to methods described by Dubois et al. (1956). Experimental silage treatments consisted of five replicates for each treatment, including control WTP silage and silages supplemented with DMSBP at the ratio of 3%, 5%, 7%, 10%, 15%, 20%, and 25% at fresh material basis. Silages were prepared in the 1.5 L glass jars. The jars were stored for 60 days at room temperature and were opened after 60 days of ensiling. The pH (Polan et al. 1998) values and dry matter (AOAC, 2005) contents of the silages were immediately measured. After pH determined, 10 ml filtrate was acidified with 0.1 ml 1 M HCI (v/v) and stored at -18 °C for silage ammonia nitrogen (NH_3-N) analysis. The NH_3-N contents of the t silage samples were analyzed according to the Kjeldahl method described by Broderick and Kang (1980). Other 10 ml filtrate was acidified with 0.25 ml of 25% metaphosphoric acid. Volatile fatty acids and lactic acid were determined by high-performance liquid chromatography according to the method reported by Suzuki and Lund (1980). The gas production values of the silages, WTP (as silage fresh material) and DMSBP (as silage additive) were determined through the method described by Menke and Steingass (1988) using four glass syringe replicates for each. The *in vitro* organic matter digestibility (IVOMD, % OM) and metabolizable energy (ME) (MJ/kg DM) of silages were calculated using equations reported by Menke et al. (1979). Rumen fluid inoculum for the *in vitro* study was obtained from slaughtered animals. The data obtained in the current study was subjected to one-way analysis of variance using SPSS program (1991). Duncan multiple mean comparison test was used for determination the differences among treatment groups.

Results

Chemical composition, ME, IVOMD and water soluble carbohydrates (WSC) of wet tomato pomace (WTP) and DMSBP are presented in Table 1. Effects of different levels of DMSBP on WTP silage nutrient composition are presented in Table 2. Effect of different levels of DMSBP on pH, ammonia nitrogen (NH_3-N) content and organic acids of WTP silages are presented in Table 3.

Table 1. Chemical composition, metabolisable energy, *In vitro* organic matter digestibility and water soluble carbohydrates of wet tomato pomace and dried molasses sugar beet pulp

Silage Material	DM	Ash	CP	ADF	NDF	IVOMS	ME	WSC
WTP	20.08	5.00	16.32	43.44	45.53	60.04	9.64	16.92
DMSBP	93.65	5.80	10.24	27.21	38.99	70.89	10.89	25.48

WTP: Wet tomato pomace; **DMSBP:** Dried molasses sugar beet pulp; **DM:** Dry matter, %; **Ash:** crude ash, % DM; **CP:** crude protein, % DM; **ADF:** Acid detergent fiber, % DM; **NDF:** Neutral detergent fiber, % DM; **IVOMD:** *In vitro* organic matter digestibility, % OM; **ME:** Metabolisable energy, MJ/kg DM; **WSC:** Water soluble carbohydrates, % DM.

Table 2. Effect of dried molasses sugar beet pulp on wet tomato pomace silage composition and metabolisable energy and *in vitro* organic matter digestibility

Group	DM	Ash	CP	ADF	NDF	IVOMD	ME
Control	21.48^{h}	4.82^{d}	17.51^{a}	49.29^{a}	55.72^{a}	58.23^{d}	9.47^{c}
3% DMSBP	22.72^{g}	5.01^{bc}	17.43^{a}	45.76^{b}	53.73^{b}	59.83^{cd}	9.70^{bc}
5% DMSBP	24.23^{f}	5.01^{bc}	16.62^{b}	44.61^{bc}	53.01^{bc}	62.48^{bc}	10.04^{ab}
7% DMSBP	25.43^{e}	5.04^{b}	16.15^{bc}	43.63^{cd}	51.66^{c}	63.14^{ab}	10.10^{ab}
10% DMSBP	26.96^{d}	5.19^{ab}	15.40^{c}	42.18^{de}	51.86^{c}	62.67^{abc}	9.97^{ab}
15% DMSBP	29.69^{c}	5.27^{a}	14.54^{d}	42.11^{de}	52.69^{bc}	65.83^{a}	10.38^{a}
20% DMSBP	31.90^{b}	5.32^{a}	14.21^{d}	41.75^{e}	51.63^{c}	65.15^{ab}	10.26^{a}
25% DMSBP	35.10^{a}	5.33^{a}	14.11^{d}	40.85^{e}	51.73^{c}	65.22^{ab}	10.26^{a}
SEM	0.709	0.030	0.213	0.425	0.230	0.444	0.055
Significance	***	***	***	***	***	***	***

$^{a-f}$ Values in the same column without a common superscript letter are significantly different (P<0.001). **DMSBP:** Dried molasses sugar beet pulp; **DM:** dry matter, %; **Ash:** Crude ash, % DM; **CP:** Crude protein, % DM; **ADF:** Acid detergent fiber, % DM; **NDF:** Neutral detergent fiber, % DM; **IVOMD:** *In vitro* organic matter digestibility, % OM; **ME:** Metabolisable energy, MJ/kg DM; *****:** P<0.001.

Table 3. Effect of different levels of dried molasses sugar beet pulp on pH, ammonia nitrogen content and organic acids of wet tomato pomace silages

Group	pH	NH_3-N	LA	AA	PA	BA
Control	3.43^{ab}	6.31^{a}	51.25^{a}	16.87^{bc}	0.00^{g}	ND
3% DMSBP	3.45^{a}	6.36^{a}	49.08^{a}	20.38^{a}	0.00^{g}	ND
5% DMSBP	3.42^{ab}	6.19^{ab}	40.97^{b}	17.98^{b}	0.32^{f}	ND
7% DMSBP	3.40^{b}	6.09^{abc}	35.48^{c}	15.44^{cd}	0.57^{e}	ND
10% DMSBP	3.40^{b}	5.87^{abc}	32.08^{c}	15.89^{bcd}	0.73^{d}	ND
15% DMSBP	3.43^{ab}	5.74^{abc}	26.48^{d}	$15.18d^{cd}$	1.00^{c}	ND
20% DMSBP	3.42^{ab}	5.61^{bc}	24.10^{de}	$15.14d^{cd}$	1.19^{b}	ND
25% DMSBP	3.43^{ab}	5.49^{c}	22.52^{f}	14.35^{d}	1.35^{a}	ND
SEM	0.004	0.079	1.668	0.338	0.491	-
Significance	***	***	***	***	***	-

$^{a-g}$Values in the same column without a common superscript letter are significantly different (P<0.001). **DMSBP:** Dried molasses sugar beet pulp; **pH:** pH value; **NH3-N:** Ammonia nitrogen, NH3-N/TN; **LA:** Lactic acid, g/kg KM; **AA:** Acetic acid,g/kg DM; **PA:** Propionic acid, g/kg DM; **BA:** Butyric acid, g/kg DM; **ND:** Not detected; *****:** P<0.001.

Discussion and Conclusion:

In this study, DM content of control silage (21.48%) was found higher than dry matter content of WTP (20.08%). This difference is thought to be caused by losses in the form of silo effluents. The DM values of the silages obtained from the our study was lower (23.04-34.64%) than the values obtained in other studies (Weiss et al., 1997; Di Blasi et al., 1997; Çapçı et al., 2002; Denek and Can, 2006; Mirzaei et al., 2008; Orosz et al., 2012; Mendez-Llorente et al., 2014; Wu et al., 2014). These differences in DM contents of tomato pomace may be associated with the differences in production technologies implemented during the process of producing tomato pomace (Denek and Can, 2006). In the present study, the DM values of the silages increase with inclusion level of DMSBP addition, and the DM value of 25% DMSBP addition had highest DM content (35.10%) which is generally desirable DM value for high quality silages. The DM values of all the silages obtained in this study (21.48-%35.10%) were found closer to DM values accepted for good quality silage (20-35%) (Ergül, 1993). Crude protein content of WTB was determined 16.32% while the CP value of the control silage was found 17.51%. In the present study, DMSBP addition diminished CP content with increasing rate of DMSBP addition. The difference in the CP values was depending on the amount of seeds than the peels content involved in the tomato pomace (Bradowski and Geisman, 1980; Ensminger et al., 1990; Haşimoğlu et al., 1979) Increment of DMSBP level lowered CP value of silages due to low CP content of DMSBP than the that of tomato pomace. In this study CP value (17.51%) of control silage was found lower than previous studies values (Weiss et al., 1997; Çapçı et al., 2002; Denek and Can, 2006; Mirzaei et al., 2008; Shabtay et al., 2008; Orosz et al., 2012; Mendez-Llorente et al., 2014; Wu et al., 2014). In the study conducted by Denek and Can (2006), tomato pomace silage CP values prepared with addition of 10%, 15% and 20% wheat straw were lower than the CP values of current study. This difference might be from the fact that researchers used wheat straw as an adsorbent with a very low content of CP to improve the level of silage DM. Whereas the ADF and NDF values of the silage material WTP in this study were found 43.44% and 45.53%, respectively. The ADF and NDF values of the control silage were found 49.29% and 55.72. While these values were similar to some previous researches (Çapçı et al., 2002; Tahmasbi et. al. 2003; Denek and Can, 2006; Wu et. al. 2014), higher than the values (14.4%-22.2%) reported by Mendez-Llorente et al. (2014). These differences may be attributed to different production technologies WTP. Type and harvest time of the tomato due to geographical differences can be other factors effecting CP content. ADF and NDF values of silages decreased by adding DMSBP compared with control silage. Inclusion of DMSBP to WTP were lowered ADF and NDF values of silages because of poor ADF and NDF content of DMSBP The *in vitro* organic matter digestibility (IVOMD) value (58.23) obtained from the control silage in this study were similar to the IVOMD value of previous studies (53.74- 57.34%) reported by Çapçı et al. (2002) and Denek and Can (2006).. Depending on the DMSBP additions, IVOMD and ME values were increased compared to the control silage values. IVOMD and ME values were decreased depending on the increment of ADF and NDF values of silages.

The pH value (3.43) obtained from the WTP control silage in the present study was found lower than pH values (3.89, 3.92, 3.99, 4.01, 4.35) reported in former studies (Çapçı et al., 2002; Denek and Can, 2006; Orosz et al., 2012; Tahmasbi et al., 2003; Weiss et al., 1997). pH values of silage is an important parameter for determining the silage fermentation quality. pH values (3.40-3.45) of the control silage and DMSBP including were found closer to pH value range (3.5-4.2) for value of good quality silages (Açıkgöz et al., 2002; Kılıç, 2006). Ammonia nitrogen (NH_3-N/TN) level obtained in the control silage (6.31% NH_3-N/TN) in this study was found lower than silage with NH_3-N level (10.32% NH_3-N/TN) reported by Weiss et al. (1979) and higher than value (3.11% NH_3-N/TN) indicated by Tahmasbi et al. (2003), and similar to value (6.18% NH_3-N/TN) obtained by Savrunlu and Denek (2016). The NH_3-N values of the tomato pomace silages prepared by adding different levels of DMSBP were found in the range of 5.49 and 6.36%, in this study. NH_3-N level decreased depending on the increase in DMSBP addition. Silage NH_3-N values, which is one of the most important criteria in determining the silage fermentation quality, occur as a result of degradation of the proteins in the silage by clostridial microorganisms and it depends on high protein low DM content of ensilage material (Kung, 2010). Inclusion of DMSBP addition to the TPS decreased CP content and increased DM levels, therefore DMSBP decreased in NH_3-N levels of the silages. Plant protease enzymes in the silage are a main a factor for ammonia nitrogen production and low pH reduces the degradation of proteins via inactivating the undesirable anaerobic micro-organisms such as enterobacteria and clostridia (Kung, 2010). The pH values (3.40-3.45) of all silages in this study were might be reason for low NH_3-N values. Degradation of proteins into NH_3-N through degradation is undesirable in quality silages. Hence, NH_3-N/TN value of good quality silages is expected to be lower than 11% (Carpintero et al., 1979). The NH_3-N/TN values (5.49-6.36% NH_3-N/TN) derived from all the silages in the present study were found to be lower than the upper limit (11% NH_3-N/TN) reported by Carpintero et al. (1979). Silage lactic acid content at the level of 65-70% of the total silage acids shows good silage fermentation (Kung, 2010). In this study, the rate of lactic acid content in the control silage and 3, 5, 7 and 10% DMSBP added silages was determined above (75.2% and 65.87%) the stated rate (i.e. 65-72%) while the lactic acid level values obtained from the 15, 20 and 25% DMSBP additions were closer to the rates (65-72%) reported by Kung (2010). The existence, type and number of bacteria on the silage product considerably affect the silage fermentation quality (Kung, 2010). While the homofermentative lactic acid bacteria present in the environment during silage fermentation produce lactic acid from the sugar as the primary product, the hetero-fermentative lactic acid bacteria also produce secondary products including ethyl alcohol, acetic acid, diacetyl and carbon dioxide apart from lactic acid (Blandino et al., 2003; Holzapfel and Wood, 1995; Kung, 2008). It has been reported that increased silage acetic acid concentration inhibits mold formation and increases silage aerobic stability (Sucu ve Filya, 2006). In this study, high acetic acid level was measured due to low dry matter of the tomato pomace. High nitrogen amount and heterofermentative bacteria existence probably caused high buffer capacity and lead to fermentation continuity (Kung, 2010). Acetic acid level increased in the silages with 3 and 5% additions DMSBP whereas it decreased in the silages with 7, 10, 15, 20 and 25% addition of it. The acetic acid contents (14.35 and 20.38 g/kg DM) of the silages in the present study were determined lower than the reported 30 g/kg DM value for good quality silages (Kung, 2010). Propionic acid was not detected in the control silage and the silage prepared by adding 3% DMSBP. The propionic acid content was found 0.32-1.35 g/kg range on DM dry matter basis. Gradually increment (5, 7, 10, 15, 20 and 25%) of DMSBP raised propionic acid content of silages. . The propionic acid contents of the present study were found to be lower than the values reported by Carpintero et al. (1979). Even though propionic acid bacteria, which are not resistant to low pH, could produce propionic acid from lactic acid and glucose, it was considered doubtful that propionic acid may or not produced in good fermented silages (Kung, 2010). The propionic acid, which the last product of some types of clostridial bacteria is commonly observed at the level of >3-5 g/kg DM in poor fermented silages (Kung, 2008; Kung, 2010). In the present study, butyric acid was not detected in any silage. In addition, bad smell, spoilage, yeast and mold development were not observed. It was documented that short-chain volatile fatty acids such as acetic, propionic and butyric acids prevents aerobic spoilage in the silages by particularly suppressing yeast and mold development (McDonald et al., 1991).

It was concluded that wet tomato pomace could be ensiled without adding any additive; however, it could be ensiled with dried sugar beet pulp including molasses due to its high water retention capacity and dry matter content. Moreover, the present study demonstrates that all the silages obtained by addition of DMSBP dried molasses sugar beet pulp can be considered as quality silage. The wet tomato pomace silages including 10-15% dried sugar beet pulp could be used as a quality roughage resource for ruminants because of its high dry matter content and contribution to fermentation quality in addition to both the environmental and economic benefits.

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