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Determination of Chemical, Nutritional and Fermentation Properties of Citrus Pulp Silages

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ABSTRACT

This study was carried out to investigate the possibilities of making silage from fruit juice industry waste.For this purpose, orange, lemon and tangerine pulp silage quality have been determined by comparing silage with maize and beet pulp silage.Treatment groups; 1) orange, 2) tangerine, 3) lemon, 4) maize and 5) sugar beet pulp. The silages were evaluated after 2 months from ensiling in the following areas: subjective evaluation, pH, dry matter, organic matter, crude protein, acid detergent fiber, neutral detergent fiber, ether extract and energy values (metabolizable energy) and net energy for lactation were calculated. As a result, it was determined that fruit juice industry residues were lower in terms of dry matter, but they contained higher energy due to their high organic matter content, digestibility and low cellulose content. In addition, it was determined that citrus pulp was evaluated as silage without any contribution.

Türk Tarım – Gıda Bilim ve Teknoloji Dergisi, 6(12): 1833-1837, 2018

Narenciye Grubu Meyve Posası Silajlarının Kimyasal, Besinsel ve Fermantasyon Özelliklerinin Belirlenmesi

MAKALE BİLGİSİ

Araştırma Makalesi

Geliş 24 Eylül 2018
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Anahtar Kelimeler:
Portakal
Mandalina
Limon
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ÖZ

Bu çalışma meyve suyu sanayi artıklarından silaj yapılabilme imkanlarını araştırmak amacıyla yapılmıştır. Bu amaçla meyve suyu fabrikasından temin edilen portakal, limon ve mandalina posaları; silaj yapımı yaygınlaşan mısır ve pancar posası silajı ile karşılaştırılarak silaj kaliteleri belirlenmiştir. Muamele grupları; her biri üçer tekerrür olmak üzere 1) portakal, 2) mandalina, 3) limon 4) mısır hasılı ve 5) pancar posasıdır. İki ay silolama sonrası açılan silajlarda: subjektif değerlendirme, pH, kuru madde, organik madde, ham protein, ADF, NDF, ham yağ, gaz üretimleri, organik madde sindirilebilirlikleri ve enerji değerleri hesaplanmıştır. Araştırma sonuçları incelendiğinde, meyve suyu sanayi artıklarının kuru madde bakımından daha düşük olduğu ancak organik madde, sindirilebilirlik ve selüloz içeriklerinin düşük olmasına bağlı olarak daha yüksek enerji içerdiği tespit edilmiştir. Ayrıca narenciye posalarının herhangi bir katkı katılmaksızın silolanarak değerlendirilmesinin mümkün olduğu tespit edilmiştir.

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Introduction

Silage feeds are an important alternative to meet the roughage needs of ruminant animals. Silage can be done successfully from many plant materials, which fruit pulps are one of these. In Turkey, maize is generally used as a silage feed crop, and other crops suitable for silage such as wheat, meadow grass, food industry by-products (pulps etc.), which are alternative forage feed sources that cannot be utilized sufficiently (Özen et al., 2005). In the previous studies, alternative feed sources have been determined to increase the profitability by lowering the feed input costs. For this reason, fruit juices, a by-product obtained after fruit juice production, are an important alternative source of forage feed that can be used in ruminant nutrition (Filya et al., 2006, Duru and Kaya, 2015). Studies on the use of fruit pulp silages in animal nutrition (Ashbell, 1994; Yalçınkaya et al., 2012; Canbolat et al., 2014) showed large differences in the quantities of these materials. Generally, food factory residues such as apples, oranges, lemons, tomatoes and grape pulps are used for silage production (Yalçınkaya et al., 2012). Some of these fruits are rich in antioxidants, carotenoids, anthocyanins, pectins, fatty acids, flavonoids and phenolic acids and some vitamins and minerals (Velioglu et al., 1998) may also be important contributors to silage quality (Ülger et al., 2015).

Citrus fruits are a group of plants which include such as orange, tangerine, grapefruit and lemon tree. Total world citrus production is average 69.4 million tonnes/year and about 3% of the total production of citrus fruits (orange (*Citrus sinensis*), tangerine (*Citrus reticulata*) and lemon (*Citrus lemon*)) is provided by Turkey. Low quality or non-consumable fruits and its waste products cause both environmental pollution and serious economic losses. The waste products can easily spoil due to the high-water content during their storage. For this reason, an amount of waste productsis evaluated by feeding of the animals as freshly in the nearby fruit juice factories, but an important part of these products may not evaluated. It is possible that the citrus pulps can be preserved for a longer time by making silages and it will be possible to use this as an alternative feed for ruminant animals. Thus, it is possible to reduce environmental pollution caused by waste products. The purpose of this study was to investigate the possibility of silage of orange, tangerine and lemon pulps, as well as the determination of feed value in ruminant animals.

Materials and Methods

In the study; orange, tangerine and lemon pulps were obtained from a private fruit juice factory operating in Kayseri. Maize was obtained from Erciyes University Agricultural Research and Application Center (ERUTAM) and beet pulp was obtained from Kayseri Sugar Factory. Silo materials were exposed to fermentation for 60 days by pressing in glass jars with a volume of 5 L. In silages, at the end of two months (60 days), 25 g of the silage sample was mixed and homogenized in 100 ml of distilled water for 5 minutes and then pH measurements were made (Polan et al., 1998). Analyzes of dry matter (DM), crude protein (CP) and organic matter (OM) of silages according to the methods described in AOAC (1990), neutral detergent fiber (NDF) and acid detergent fiber (ADF) analyzes were determined according to Van Soest and Robertson 1979) and Goering and Van Soest (1975) respectively. Water soluble carbohydrate (WSC) contents were determined by phenol sulfuricacid method reported by Dubois et al. (1956). Acetic, propionic and butyric acid analyzes in silage samples were carried out by gas chromatography (Schimadzu GC 2010 Plus, with a capillary column; Stabilwax-DA, 30 m, 0.25 mm ID, 0.25) and lactic acid analysis according to Barker and Summerson (1941). The *invitro* gas production technique reported by Menke and Steingass (1998) was used to determine organic matter digestibility (OMD) and metabolisableenergy (ME) and net energy lactation (NEL) levels of silages *in vitro*. Approximately 200 ± 10 mg of dried silage samples were placed in a special glass tubes (Model Fortuna, HäberleLabortechnik, Lonsee-Ettlenschieb, Germany) with a volume of 100 ml for the detection of *in vitro* gas production quantities of silages and ME and organic matter digestibility (OMD) by Menke et al., (1979)were determined. The ME, NEL and OMD of silages are calculated according to the formulas below (Menke and Steingass, 1998):

$$OMD = 14.88 + 0.889 \times GP + 0.45 \times CP + 0.651 \times Ash$$
$$ME = 2.20 + 0.1357 \times GP + 0.057 \times CP + 0.002859EE$$
$$NEL = 0.101GP + 0.051CP + 0.112EE$$

OMD : Organicmatter digestibility (%)
ME : Metabolizable energy (MJ/kg DM)
NEL : Net energy for lactation (MJ/kg DM)
GP : 24-hour net gas production
CP : % Crude protein
EE : % Ether extract

In the statistical analysis of the data obtained from the study, one-way ANOVA was used by SPSS (1997) package program and Duncan multiple comparison test was used in determining the differences between the groups.

Results and Discussion

The silage of citrus pulp materials dry mater (DM), crude protein (CP), organic matter (OM), ether extract (EE), crude cellulose (CC), acid detergent fiber (ADF), neutral detergent fiber (NDF) values are given in Table 1.

The DM levels of the raw silage materials used in the study were determined as the highest in maize and lemon pulp silages. CP level in the raw materials was detected at the highest beet and lemon pulps. The EE, ADF and NDF values were obtained highest in maize silage. The nutrient contents of citrus fruit silages obtained at the end of the study are given in Table 2.

Table 1 Chemical content of raw silage materials

Raw materials	Parameters, DM %						
	DM, %	CP	OM	EE	CC	ADF	NDF
Orange pulp	20.13	4.63	96.45	0.81	6.83	14.44	15.51
Tangerine pulp	21.45	4.81	96.16	0.98	7.53	13.15	14.84
Lemon pulp	23.79	7.56	95.28	2.84	11.52	19.45	21.61
Maize	26.32	6.26	80.98	1.84	26.15	37.63	59.05
Sugar beet pulp	20.08	8.65	93.25	0.38	19.32	26.75	36.73

DM: dry matter; CP: crude protein; OM: organic matter; EE: ether extract; CC: crude cellulose; ADF: acid detergent fiber; NDF: neutral detergent fiber

Table 2 Chemical composition of citrus, maize and sugar beet pulp silages

Silages	Parameters, DM %							
	pH	DM,%	CP	OM	EE	CC	ADF	NDF
Orange pulp	3.61^{c}	15.87^{c}	9.20^{b}	94,78^{d}	1.87^{b}	11.91^{c}	22.59^{c}	21.55^{c}
Tangerine pulp	3.73^{b}	16.23^{c}	10.79^{a}	94.02^{c}	2.50^{a}	11.43^{c}	26.88^{b}	21.55^{c}
Lemon pulp	3.63^{c}	21.22^{b}	7.91^{c}	94.33^{c}	1.82^{b}	10.69^{c}	22.36^{c}	23.35^{c}
Maize	3.84^{a}	36.97^{a}	6.57^{d}	90.16^{a}	2.41^{a}	23.37^{a}	38.57^{a}	58.37^{a}
Sugar beet pulp	3.50^{d}	21.94^{b}	9.59^{b}	93.33^{b}	0.88^{c}	17.39^{b}	27.65^{b}	34.60^{b}
SEM	0.032	2.207	0.227	2.550	0.131	1.025	1.128	2.635
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

$^{a-d}$: The differences between the means indicated by different letters in the same column are statistically significant; SEM: standard error of means; P: probability; DM: dry matter; CP: crude protein; OM: organic matter; EE: ether extract; CC: crude cellulose; ADF: acid detergent fiber; NDF: neutral detergent fiber.

Table 3 Gas production parameters and nutritional composition of citrus, maize and sugar beet pulp silages

Silages	Parameters					
	GP, mL	CH_4, mL	CH_4, %	ME, Mj/kg	NEL, Mj/kg	OMD, DM %
Orange pulp	77.00^{a}	11.73	15.24	12.72^{a}	8.53^{a}	87.76^{a}
Tangerine pulp	74.67^{ab}	11.77	15.77	12.42^{ab}	8.28^{b}	86.50^{a}
Lemon pulp	74.00^{ab}	12.39	16.78	12.31^{ab}	8.18^{bc}	84.61^{ab}
Maize	63.20^{c}	10.43	16.51	10.83^{c}	6.92^{c}	74.67^{c}
Sugar beet pulp	64.90^{bc}	10.63	16.37	11.08^{bc}	7.13^{bc}	77.33^{bc}
SEM	1.802	0.264	0.200	0.246	0.209	1.658
P	0.014	0.099	0.161	0.013	0.012	0.010

$^{a-d}$: The differences between the means indicated by different letters in the same column are statistically significant; SEM: standard error of means; P: probability; GP: Gas production; CH_4: methane production; ME: metabolizable energy; NEL: net energy lactation; OMD: Organic matter digestibility

One of the important criteria for determining the qualities of silages is the pH value (Kiermeier and Renner, 1963). In this study, pH values of silages (3.50-3.84) were found similar to optimum silage pH values of 3.8-4.2 (Coskun et al., 1998). The pH value of the beet pulp was significantly lower than the other groups (P <0.001). When the study findings (Table 2) were examined, it was found that the DM levels of the silages were changed between 15.87% in the orange group and 36.97% in the maize silage group. These values were lower than the average DM values (25-35%) reported for silages (Demirel and Yıldız, 2000). Ergül et al. (2001) reported that the pH values of the silages prepared by adding broiler bottoms at 0, 15, 30 and 45% to fruit juice pulps and wet sugar beet pulp were between 4.1-4.2, Deniz et al. (2001) found similarities in this study between groups of 3.72-4.30 in groups containing 20% DM. Avcı et al. (2005) found that pH was 3.64-4.33 in silage containing 17% DM and pH 3.96-4.34 in silage containing 20% DM. In a study, the pH value of beet pulp was found to be 3.76 but in this study the pH value of sugar beet pulp silage was found to be lower (Ülger et al., 2015).

The silages' OM, CP, EE, CC, ADF and NDF contents were found to be significant between groups (P <0.001) (Table 1). There are few studies on the evaluation of citrus pulps as silage feed. The studies have done generally a mixture of citrus fruits. In some studies, about orange pulp, the ratios of OM, CP, EE and ADF were 96.5%, 6.4%, 4% and 15% respectively (Martinez-Pascual and Fernandez-Carmona (1980), Lanza (1984), Cerveraetal., (1985), Megiasetal., (1993), Silva et al. (1994), Fegeros et al. (1995) and Miron et al. (2001)). In a study on lemon varieties, the differences between the varieties were found to be significant; the mean values of OM, CP, EE, NDF and ADF were 94.73%, 7.4%, 5.60%, 20.05% and 17.16%, respectively (Özkan et al., 2017). In the present study, the citrus pulps group organic matter level was higher than maize silage, also contains lower cellulose and similar protein ratio. But in citrus group silages were included lower dry matter ratio than maize silage.

In the study, the GP values of silage materials were changed between 63.20 ml (maize) - 77 ml (orange) and the differences in GP values between silages were statistically significant (P<0.05). The 24-hour methane production levels of groups ranged from 10.43 ml to 12.39 ml and from 15.24 to 16.78 %.The lowest and highest values for ME contents were determined as 10.83 MJ / kg DM (lemon) and 12.72 MJ / kg DM (orange), respectively (P<0.05). The highest NEL was 8.53 Mj/kg DM obtained from the orange group, this value was found to be at least 6.92 Mj / kg DM in the maize group (P<0.05). The OMD values varied between 74.67% (maize) and 87.76% (orange). In a study of different types of lemon pulp silages, total gas production was reported between 68.7 and 77.6 mL. In the same study, CH4 production ranged from 10.1 to 13.6 mL, ME value ranged from 12.0 to 13.2 Mj / kg, and OMD ranged from 82.7 to 91.5% (Özkan et al., 2017).

In the study, WSC values of silages were found statistically significant (P = 0.05). The lowest value was found in the orange group at 3.45 g/kg, the highest value was detected in the 7.27 g/kg beet pulp group. Differences between the groups were statistically significant for LA concentration (P = 0.004). When the highest LA value was determined in a group of 126.06 g/kg sugar beet pulp, the lowest value was found in the tangerine group 31.13 g/kg. In the previous studies, the mean values of LA, AA, PA and BA in orange silage reported as 21.9 g/kg, 29.8 g/kg, 2.9 g/kg and 0.5 g/kg, respectively (Martinez-Pascual and Fernandez-Carmona (1980), Lanza (1984), Cerveraetal (1985), Megiasetal (1993), Silva et al. (1997), Scerra et al. (1994), Fegeros et al. (1995) and Miron et al. (2001)). In the current study, lactic acid production is higher than in previous studies, which may be due to the fact that the proportion of material remaining in the pulp during the production of fruit pulps does not vary with the sugar content. In addition, a good fermentation was observed in fruit pulp group silages while in the maturation period in this study.

Table 4 Fermentation parameters of citrus, maize and sugar beet pulp silages

Silages	Parameters, g/kg DM				
	WSC	LA	AA	PA	BA
Orange pulp	3.45[c]	72.61[bc]	28.8	1,24	0.20
Tangerine pulp	4.00[bc]	31.13[d]	14.15	0,88	0.01
Lemon pulp	5.65[ab]	37.51[cd]	17.02	1,02	0.02
Maize	4.46[abc]	101.21[ab]	31.60	2,08	0.24
Sugar beet pulp	7.27[a]	126.06[a]	35.06	2,15	0.26
SEM	0.52	12.32	8.21	0.05	0.01
P	0.050	0.004	0.042	0.051	0.054

[a-d]: The differences between the means indicated by different letters in the same column are statistically significant; SEM: standard error of means; P: probability; WSC; water soluble carbohydrates; LA: lactic acid; AA: acetic acid; PA: propionic acid

Conclusion

As a result, citrus pulps which are a waste material can be evaluated as silage. In this study, it was determined that citrus pulps can be ensiled alone and used as ruminant feed. Thus, the environmental pollution can be reduced with ensiling. So that economic livestock farming can be done by reducing both environmental gain and feed costs.

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