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INVESTIGATION OF SILAGE PROPERTIES OF ORGANIC RESIDUES OF TOMATO (*Solanum lycopersicum*), PEPPER (*Capsicum annuum*) AND CUCUMBER (*Cucumis sativus*) GREENHOUSES

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Abstract

In this study, the greenhouses in Kumluca, Antalya. It is aimed to bring organic waste to animal husbandry. For this purpose, tomato (Solanum lycopersicum), pepper (Capsicum annuum) and cucumber (Cucumis sativus) seedling and vegetable wastes were mixed in March, July and September for silage. Nutrients, in vitro gas production and true digestibility analyzes were performed on silages. In dry matter analysis, cucumber plant silage had the lowest dry matter and there was a statistically significant difference between the groups periodically (p=0.01). The highest dry matter ratio was obtained in September for all plants and in tomato plant silage with 29.41%. The rate of crude ash was: in cucumber plant silages 28.47%, 33.03%, 33.99%; in tomato plant silages 19.18%, 20.41%, 17.41%; in pepper plant silages 18.10%, 15.33%, 17.49% found. NDF ratios were found to be: in cucumber plant silages 34.76%, 29,56%, 26,31%; in tomato plant silages were 36,81%, 41.70%, 39.18%; in pepper plant silages 36.31%, 36.75%, 35.93% found. The ADF ratios were respectively: in cucumber plant silages 28.99%, 33.28%, 27.54%; in tomato plant silages 35.89%, 38.08%, 33.89%; in pepper plant silages 34.83%, 39.58%, 32.20% found. The highest value in terms of metabolic energy was obtained in March with 1,830 mcal/kg in silages obtained from pepper greenhouse wastes in September. No statistically significant difference was found in cucumber, tomato and pepper plant silages in terms of in vitro gas production (p>0.05). The highest gas production was 19.27 ml/200 mg in September and tomato plant silage. In vitro true digestibility (IVGS) was statistically significant difference in cucumber plant silages periodically (p = 0.02). The highest IVGS was realized in March with 87.59%.

***Key words**: Cucumber, greenhouse, pepper, tomato.*

INTRODUCTION

There are more than 2 million hectares of greenhouse areas worldwide. Greenhouse cultivation started for the first time in our country in 1940s with the establishment of greenhouses for research purposes in some agricultural institutions in our southern provinces. The growth rate of greenhouse cultivation was very slow between 1940-1960. During this period, a small number of commercial greenhouses were established around Antalya and Izmir. The first big step to save the greenhouses in Turkey was seen after 1970. The most important reason for this development is the use of transparent polyethylene material as cover material in greenhouses (Emekli et al., 2008). According to 2016 data, Kumluca, Finike and Demre districts located in the west of Antalya have 8 thousand hectares of greenhouse area.

March, July and September are dismantling times. Approximately 400 thousand tons of organic waste is generated for this region after the dismantling. In addition to this organic waste, the amount of inorganic waste originating from rope used in greenhouses is 240 tons. Assuming that plastic dissolves in nature in a thousand years, the damage to nature with these wastes is scary. It also prevents the recycling of plant wastes by silage production and pollution of the environment with plastic wastes.

Long-term use of roughage as green is provided by silage production or drying. Drying is an expensive and costly procedure. The advantage of dry material is that it is easily transported. However, long-term protection is provided by silage production under suitable conditions. The most important reason for using greenhouse wastes is low cost. The water content of the product is high. Greenhouse wastes can be combined with many feedstuffs to produce fermentation due to the high water content. However, obtaining the right mixing ratio requires quality product and correct application. The siloable by-products list includes apple pulp, beet pulp, citrus pulp, grape pulp and vegetables. Greenhouse wastes can be mixed with dry by-products. It can be mixed with rice, wheat and cotton wastes. It is very important to benefit from the wastes generated especially in developed countries. Especially small enterprises do not have enough capital to cover the cost of feed (Machin, 2000; Chedly and Lee, 2000; Caluya, 2000). Turkey in terms of feed costs is the most important part of their business inputs.

The aim of this study is to provide economic returns to the business owners by evaluating the hundreds of thousands of tons of waste generated under the greenhouse cultivation and providing them to be used in animal feeding. In addition, to reduce the workload of municipalities on cleaning by preventing organic wastes from being generated by greenhouse owners after burning and burning and increasing carbon emissions by preventing global warming.

MATERIALS AND METHODS

In this study, periodical harvesting of tomato, cucumber and pepper in Kumluca (36° 25'29.8 "N 30° 17'07.4"E) districts of Antalya in March, July and September was carried out. Samples were taken from 6 different greenhouses, two replications in three periods. Silage materials were shredded (Figure 1). The disintegrated materials was made in two parallel to special glass jars (Weck, Wher-Oftlingen, Germany) with a capacity of 1 liter which only allow gas to escape. Samples were opened after being kept in darkness and average 25°C for 30 days.

Figure 1. View before sampling in cucumber and pepper greenhouse

The opened samples were first subjected to pH measurement and then the samples were dried for 48 hours at 50°C in a fan-drying cabinet for the purpose of chemical analysis. The dry matter levels of the silages formed from tomato, pepper and cucumber wastes after the first drying were determined by drying until the weight was fixed at 105ºC for 6-8 hours (Figure 2).

Weighing was performed with a balance of 0.001 g. Dried samples, dry matter, crude ash, crude oil crude protein analyzes were carried out according to the method described in A.O.A.C (1984). The acid detergent fiber (ADF) and neutral detergent fiber (NDF) analyzes performed to determine cell wall elements were performed on Ankom-200 device according to the method reported by Van Soest (1970). Protein fractions were made according to the method employed by Krishnamoorthy et al. (1982).

Figure 2. Appearance after drying of cucumber, tomato and pepper silages

The *in vitro* medium used to determine the gas formation values of feedstuffs was prepared according to the method reported by Menke and Steingass (1988). In order to determine the true digestibility of the in vitro method, samples were prepared with rumen fluid and buffer solutions prepared according to the method taken from the hot chain 4-6 hours after feeding from cannulated cows and prepared in D200-Daisy II Incubators (ANKOM Technology, 2004) as shown in Figure 3 and incubated for 48 hours (Van Soest, 1994). In this system, gas production was observed after 48 hours incubation of 200 mg feed dry matter. Gas measurements were performed at 4, 8, 12, 24, 36 and 48 hours (Menke and Steingass, 1988).

Evaluation of data were analyzed using SPSS 20 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0 Armonk, NY: IBM Corp) statistical package program. Variables mean ± standard deviation, percentage and frequency values were used. In addition, homogeneity of variances from prerequisites of parametric tests was checked by Levene test. The normality hypothesis was examined by app "Shapiro-Wilk" test. Kruskal Wallis and Bonferroni-Dunn tests were used for comparison of three and more groups when two-way ANOVA and Tukey HSD test were used. Statistical significance level was accepted as p<0.05, p<0.01.

Figure 3. Daisy incubator and *in vitro* gas production

RESULTS AND DISCUSSIONS

Tomato, pepper and cucumber silages were opened after 30 days fermentation period. The ph value of cucumber plant silage in March, July and September, respectively; was 7.07%, 7.17% and 6.67% (Table 1). These values indicate that the cucumber plant has buffer capacity. Tomato plant silage pH was 4.63%, 4.55% and 4.77%; and pepper plant silage pH were determined 4.89%, 3.39% and 4.91%. When compared with cucumber, the silage material of tomato and pepper plants was found to be closer to pH 3.8-4.2 which is the average value in terms of average acid-base degree.

Table 1. pH values of cucumber, tomato and pepper silage (n = 6)

	March		July		September		
	x̄	S	x̄	S	x̄	S	P
Cucumber	7.07	0.28	7.17	0.11	6.67	0.26	0.17
Tomato	4.63	0.44	4.55	0.53	4.77	0.13	0.07
Pepper	4.89	0.73	3.39	0.08	4.91	0.38	0.08

In March, dry matter ratios after dismantling were calculated as 10.28%, 10.29% and 13.94% for cucumber, tomato and pepper plant silages, respectively. This is normal in the early stage of vegetation. In addition, dry matter ratios for these plants were calculated as 18.16%, 29.41% and 28.32% in September, respectively. A statistically significant difference was found between the periods of March, July and September in terms of the first dry matter ratio for silage of cucumber plant (p = 0.01). The highest dry matter content was 18.16% in September, as expected (Table 2). A statistically significant difference was found between the periods of March, July and September in terms of the first dry matter ratio in terms of silage of tomato plant (p = 0.01). There was a statistically significant difference between the first dry matter ratio in terms of silage of pepper plant between March, July and September (p = 0.02). Cucumber, tomato and pepper plants reached the highest dry matter rate in September. In this case, it was found that the structurally dry matter ratio of cucumber silage was lower than tomato and pepper, but tomato and pepper plants had a dry matter ratio close to the silage corn plant in September.

For the silage of tomato, pepper and cucumber plant, the highest protein content was reached in pepper plant in terms of crude protein parameter. A statistically significant difference was found between silage of cucumber plant between March, July and September (p = 0.01) and crude protein ratio of silage decreased due to progression of harvesting time. If the pH is considered to be high depending on the buffer capacity of the cucumber plant, it is considered that this plant will contain higher crude protein if the pH decreases to average values. A statistically significant difference was found between the March, July and September periods in terms of crude protein parameters of tomato plant (p = 0.01).

Tomato plant silage reached the highest protein rate with 17.24% periodically in March (Table 3). A statistically significant difference was found between the months of March, July and September in terms of silage material of pepper plant (p = 0.01). In March, pepper plant contained 19.38% and in September 21.53% crude protein. It is thought that the ratio of crude protein in pepper plant does not decrease despite the progression of the harvest period because of the high rate of fruit in addition to pepper plant.

When the cucumber silage plant was examined in terms of crude ash parameter, a statistically significant difference was found between March, July and September (p = 0.01) and periodically crude ash rates were 28.47%, 33.99% and 33.03%, respectively. In terms of tomato silage plant, the rate of crude ash in March, July and September was 19.18%, 20.41% and 17.41%, and statistically significant difference was found between the periods (p = 0.01). Crude ash content of pepper silage plant was 18.10%, 15.33% and 17.49% and statistically significant difference was found between the periods (p = 0.02).

Table 2. Nutrient analysis results of cucumber silage (n = 6)

	MARCH		JULY		SEPTEMBER		
	x̄	S	x̄	S	x̄	S	p
Dry matter, %	10.28b	0.68	17.91a	1.34	18.16a	3.25	**0.01**
Crude protein, %	16.49a	1.07	12.25b	0.86	14.24b	1.08	**0.01**
Crude fat, %	2.68	0.42	2.63	0.42	3.47	0.46	0.05
Crude ash, %	28.47b	1.25	33.99a	2.39	33.03a	1.71	**0.01**
NDF, %	34.76a	3.31	29.56b	2.45	26.31b	0.67	**0.01**
ADF, %	28.99b	1.96	33.28a	1.17	27.54b	0.39	**0.01**
NFC, %	17.60b	2.91	21.58a	1.64	22.95a	0.95	**0.02**
Lignin, %	8.54b	1.07	13.25a	1.86	5.18c	0.30	**0.01**
NDICP, %	2.83	0.49	3.20	0.43	2.75	0.15	0.05
ADICP, %	2.51b	0.59	2.97a	0.18	1.57c	0.05	**0.01**
A Frak. %CP	39.98a	6.97	18.31b	2.85	32.40a	3.56	**0.01**
B Frak. %CP	44.67b	3.26	57.44a	2.76	56.54a	2.76	**0.01**
C Frak. %CP	15.36b	4.21	24.25a	1.29	11.07c	1.06	**0.01**
RUP 2%	28.97b	4.18	39.45a	1.88	31.40b	2.22	**0.01**
RUP 4%	31.15b	4.34	41.95a	1.90	33.81b	2.32	**0.01**
RUP Dig., %	61.40b	1.52	61.06b	0.78	64.31a	0.12	**0.01**
DE-1X, Mcal/kg	1.90a	0.14	1.54b	0.13	2.06a	0.09	**0.01**
ME-3X, Mcal/kg	1,37a	0.13	1.03b	0.12	1.52a	0.08	**0.01**
NEL-3X, Mcal/kg	0,77a	0.09	0.54b	0.09	0.88a	0.06	**0.01**
NEL-4X, Mcal/kg	0,74a	0.09	0.51b	0.08	0.84a	0.06	**0.01**
NEM-3X, Mcal/kg	0,53a	0.14	0.16b	0.14	0.70a	0.09	**0.01**

Table 3. Nutrient analysis results of tomato silage (n = 6)

	MARCH		JULY		SEPTEMBER		
	x̄	S	x̄	S	x̄	S	p
Dry matter, %	10.29b	1.25	13.24b	0.94	29.41a	4.43	**0.01**
Crude protein, %	17.24a	3.37	16.25a	0.67	14.40b	0.56	**0.01**
Crude fat, %	2.84b	0.21	3.71a	1.50	2.66b	0.31	**0.01**
Crude ash, %	19.18b	1.40	20.41a	0.87	17.41b	0.70	**0.01**
NDF, %	36.81	7.07	41.70	2.22	39.18	0.95	0.07
ADF, %	35.89a	4.92	38.08a	2.34	33.89b	1.09	**0.02**
NFC, %	23.94a	4.06	17.92b	3.16	26.34a	0.94	**0.01**
Lignin, %	6.92c	1.16	34.13a	1.95	30.20b	1.68	**0.01**
NDICP, %	1.72c	0.25	4.73a	0.32	2.36b	0.24	**0.01**
ADICP, %	2.10b	0.34	3.01a	0.29	1.17c	0.18	**0.01**
A Frak., %CP	55.42a	7.56	35.17c	5.66	47.82b	2.58	**0.01**
B Frak., %CP	32.14b	6.34	46.33a	5.71	44.05a	2.97	**0.01**
C Frak., %CP	12.44b	2.38	18.50a	1.82	8.12c	1.22	**0.01**
RUP, %2	19.68c	3.83	36.28a	2.77	24.99b	1.18	**0.01**
RUP, %4	21.32c	4.04	37.87a	3.01	26.79b	1.27	**0.01**
RUP Dig., %	64.07b	1.31	62.10c	0.77	66.56a	0.48	**0.01**
DE-1X, Mcal/kg	2.35a	0.18	1.62b	0.05	1.79b	0.04	**0.01**
ME-3X, Mcal/kg	1.79a	0.17	1.11b	0.05	1.27b	0.03	**0.01**
NEL-3X, Mcal/kg	1.07a	0.11	0.59b	0.04	0.70b	0.03	**0.01**
NEL-4X, Mcal/kg	1.03a	0.11	0.57b	0.03	0.67b	0.02	**0.01**
NEM-3X, Mcal/kg	0.97a	0.17	0.25b	0.05	0.43b	0.04	**0.01**

Filya (2004) reported that 3.8-4.4% crude ash rate for corn silages in different vegetation periods was quite low compared to crude ash rates in this study. The reason for this high value is considered as the inorganic substance content.

NDF ratio of cucumber plant was 34,76%, 29.56%, 26.31% and ADF rates were 28.99%, 33.28% and 27.54% and there was a statistically significant difference between NDF rates (p = 0.01). There was a statistically significant difference between ADF rates (p = 0.01). The difference between NDF and ADF values increased in favour of ADF from March to July. NDF ratios of tomato plants were 36.81%, 41.70%, 39.18% and ADF rates were 35.89%, 38.08% and 33.89% and there was a statistically significant difference between NDF rates (p = 0.07). There was a statistically significant difference between the ADF ratios between the periods (p = 0.01). NDF rates for pepper plant were 36.31%, 36.75%, 35.93% and ADF rates were 34.83%, 39.58% and 32.20%, and there was no statistically significant difference between NDF rates (p = 0.93). There was a statistically significant difference between ADF rates (p = 0.01). Pepper and cucumber plant NDF rate is lower than ADF in July and it is thought that these two plants have lower digestibility.

In terms of the lignin parameter, the cucumber plant is 8.54%, 13.25% and 5.18% respect-tively. There was a statistically signifycant difference between the months (p = 0.01). Tomato plant has 6.92%, 34.13% and 30.20% lignin, respectively. Pepper plant contains 8.98%, 34.21% and 28.82% lignin periodically (Table 4). Tomato plant has the highest lignin value although it has high NDF rate for July period. This value is an unexpected result and the cause is unknown. Pepper plant is expected to have high lignin due to high ADF value especially in July.

Table 4. Nutrient analysis results of pepper silage (n = 6)

	MARCH		JULY		SEPTEMBER		
	x̄	S	x̄	S	x̄	S	p
Dry matter, %	13.94	1.38	16.18	0.57	28.32	1.38	**0.02**
Crude protein, %	19.38b	0.82	18.80b	1.18	21.53a	0.57	**0.01**
Crude fat, %	3.52a	0.45	4.34a	0.48	1.31b	0.42	**0.01**
Crude ash, %	18.10	3.34	15.33	0.33	17.49	0.78	**0.02**
NDF, %	36.31	3.08	36.75	5.35	35.93	2.45	0.93
ADF, %	34.83b	2.91	39.58a	2.79	32.20b	1.82	**0.01**
NFC, %	22.70	2.60	24.79	6.59	23.75	2.15	0.54
Lignin, %	8.98c	1.06	34.21a	2.51	28.82b	1.86	**0.01**
NDICP, %	1.32b	0.29	2.85a	0.33	2.76a	0.32	**0.01**
ADICP, %	1.68a	0.14	1.74a	0.42	1.20b	0.20	**0.01**
A Frak., %CP	57.66a	3.15	51.14b	1.43	50.27b	3.20	**0.01**
B Frak., %CP	33.66c	3.05	39.59b	2.51	44.13a	2.64	**0.01**
C Frak., %CP	8.69a	0.97	8.27a	2.28	5.61b	1.02	**0.01**
RUP, %2	16.04b	0.52	13.47b	0.73	22.37a	1.98	**0.01**
RUP, %4	17.68b	0.70	13.33c	0.73	24.30a	2.09	**0.01**
RUP Dig., %	65.17	0.29	65.56	1.19	66.27	0.53	**0.11**
DE-1X, Mcal/kg	2.39a	0.16	2.12b	0.19	1.96b	0.09	**0.01**
ME-3X, Mcal/kg	1.83a	0.15	1.58b	0.18	1.42b	0.09	**0.01**
NEL-3X, Mcal/kg	1.10a	0.10	0.92b	0.13	0.80b	0.06	**0.01**
NEL-4X, Mcal/kg	1.06a	0.10	0.89b	0.12	0.77c	0.06	**0.01**
NEM-3X, Mcal/kg	1.02a	0.15	0.76b	0.19	0.59b	0.09	**0.01**

In terms of ME-3X (Metabolic Energy) parameter, cucumber plant has a periodicity of 1.37; 1.03 and 1.52 mcal/kg and there was a statistically significant difference between the months (p = 0.01). Cucumber plant silage has the highest metabolic energy value in September (Table 2). This is normal as it contains the highest NFC in September. The tomato plant was 1.79; It has a metabolic energy of 1.11 and 1.27 mcal/kg and a statistically significant difference was found periodically (p = 0.01). Although it contains high NFC in September in terms of tomato plant, it is expected to have the highest metabolic energy in March considering the harvest period of the plant. In terms of pepper plant periodic respectively contained 1.83, 1.58 and 1.42 mcal/kg metabolic energy and a statistically significant difference was found periodically (p = 0.01). The pepper plant has the highest NFC in July, similar to the tomato plant, but has the highest metabolic energy rate in March, given the harvest period of the plant.

In vitro gas production of tomato, pepper and cucumber plants were measured for 48 hours (Table 5).

Table 5. *In vitro* gas production results of cucumber, tomato and pepper silage (ml/200 mg)

	March		July		September		
	x̄±	S	x̄	S	x̄	S	p
Cucumber	12.68	2.58	16.00	1.49	8.84	0.98	0.19
Tomato	18.44	1.92	17.01	2.55	19.27	0.66	0.28
Pepper	14.83	5.44	11.16	1.90	10.84	1.94	0.26

The cucumber plant silage produced 12.68, 16.00 and 8.84 ml/200 mg gas periodically. No statistically significant difference was found between the groups in the cucumber silage periodically (p = 0.19). The tomato plant produced 18.44, 17.01 and 19.27 ml/200 mg gas periodically. No statistically significant difference was found in tomato silage periodically (p = 0.28). The pepper plant produced 14.83, 11.16 and 10.84 ml/200 mg gas periodically. No statistically significant difference was found in pepper plant silage periodically (p = 0.26). Although the cucumber plant contains high crude ash in July, the ADF ratio is higher and the NFC (non fiber carbohydrate) ratio is average, the reason for periodically high *in vitro* gas production is unknown. Although the tomato plant had the highest lignin content in July and September, the reason for achieving the highest *in vitro* gas production in September, although the ADF rate was the lowest in September, is unknown. In addition, the pepper plant has the lowest lignin rate in March, and although the ash and ADF ratios are at average values, it has the highest gas rate in March, where the metabolic energy value is high as expected.

In terms of *in vitro* digestibility, cucumber silage was 87.59%, 82.55% and 86.88%, respectively, and there was a statistically significant difference (p = 0.02). In terms of tomato plant, it has 74.53%, 78.58% and 75.67% IVGS periodically (Table 6). However, there was no statistically significant difference in terms of periodicity (p = 0.09). Pepper plant has 75.81%, 66.30% and 75.09% IVGS periodically. There is no statistically significant difference in pepper plant periodically (p = 0.52). In terms of IVGS, cucumber plant has higher raw ash ratio than tomato and pepper plant. However, it has lower lignin. Therefore, it has higher *in vitro* digestibility as expected.

Table 6. *In vitro* true digestibility results of cucumber, tomato and pepper silage (%)

	March		**July**		**September**		
	x̄	**S**	**x̄**	**S**	**x̄**	**S**	**p**
Cucumber	87.59a	1.86	82.55b	0.48	86.88a	1.65	**0.02**
Tomato	74.53	0.95	78.58	0.79	75.67	2.98	0.09
Pepper	75.81	2.81	66.30	2.40	75.09	0.98	0.52

CONCLUSIONS

As a result; cucumber plant is thought to be difficult to silo in terms of high pH and low dry matter content. It is also expected that this plant may be a silage material with increased dry matter content and inoculant additions. Although tomato and pepper plants generally contain high crude ash and lignin content, it is concluded that it can be used in ruminant feeding due to its proximity to average pH with raw protein and dry matter ratios. The results of this study were found to be more efficient if supported by in vivo studies.

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