Journal of Elementology ISSN 1644-2296

Şahar A.K., Vurarak Y., Çubukcu P., Oluk C.A. 2022.
*Effects of storage length and variety on some quality and color parameters in soybean silage.*
J. Elem., 27(4): 981-994. DOI: 10.5601/jelem.2022.27.4.2291



RECEIVED: 20 April 2022
ACCEPTED: 19 November 2022

**ORIGINAL PAPER**

# EFFECTS OF STORAGE LENGTH AND VARIETY ON SOME QUALITY AND COLOR PARAMETERS IN SOYBEAN SILAGE*

**Ahmet Korhan Şahar, Yasemin Vurarak, Pinar Çubukcu, Celile Aylin Oluk**

**Eastern Mediterranean Agricultural Research Institute Adana, Türkiye**

**Abstract**

With its high protein content, forage soybean is an important legume roughage that should be included in animal rations. However, the traditional silage production of pure soybean as forage is limited by its high protein content. The aim of the study was to determine the effect of the duration of storage and soybean variety on some quality parameters and color change in pure soybeans silage. Two soybean forage varieties (Yemsoy and Yesilsoy) as the main factor were harvested in the appropriate harvesting period and with an appropriate technology, and after wilting the soybean plants were ensilaged without any additives in small bales of 40-50 kg. The bales were stored for 5 lengths of storage (20, 40, 60, 80, and 100 days), which was the second experimental factor. The silage samples as 3 replications were collected at the end of the storage period to evaluate dry matter (DM), pH, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), relative feed value (RFV), digestible dry matter (DDM), dry matter intake (DMI), fleig score (FS) and CIELab color scale (L, a, b). The data from 2 years were processed statistically in randomized blocks according to a split plot design. No statistical difference between the duration of storage and varieties in terms of RFV was observed. However, it was determined that the pH value was statistically lower ($p<0.01$) in the soybean bale silage stored for 80 and 100 days. In addition, it was determined that silages stored for 100 days were higher ($p<0.01$) in terms of the brightness value L. It is evident that high quality and bright colored roughage can be obtained in soybean silage stored for 80 and 100 days without any additives.

**Keywords:** CIELab, roughage, soybean, storage, quality

Ahmet Korhan Sahar, PhD, Plant Production Department, Eastern Mediterranean Agricultural Research Institute, 01321 Yüreğir/Adana –Türkiye, e-mail: akorhansahar@gmail.com
* Financed: Republic of Türkiye Ministry of Agriculture and Forestry General Directorate of Agricultural Research and Policies. Eastern Mediterranean Agricultural Research Institute Adana, Türkiye (Application Project 2018-2019).

# INTRODUCTION

In recent years, it has been determined that protein-rich pure legume roughage made by using new roughage technologies has no negative effect on animals, and therefore their use in forage production has displayed an increasing trend (Dumlugül, Tan 2013). Although roughage made from corn plants is widely used today, this roughage is known for its low protein rate and high carbon emissions (Sezer 2014). The most important cost in rations of high-yielding ruminant farm animals is incurred by increasing the protein content. Increasing the protein content is an important strategy that raises the amount of sustainable quality products and also protects animal health (Spanghero et al. 2015). Therefore, examining the possibilities of using legumes as roughage continues to be an important issue for sustainable livestock breeding. While the amount of soluble protein in leguminous hays is 37.7% on average, this share rises to 55.8% in legume silages. In summary, the addition of silage and legume sources to rations is a prerequisite for efficiency (Albrecht, Beauchemin 2003). When used alone, the high protein, organic acid and cation levels in the forage soybean, which is a good alternative for closing the quality roughage deficit, causes an increase in odor density, which is not preferred by animals, as well as the buffering capacity that prevents fermentation. This situation limits the possibility of using soybean as traditional silage, which is valid for all legumes (Ni et al. 2017).

However, by using the haylage technique, which is one of the forage preparation technologies, roughage can be prepared from pure legumes, pure forage grasses or mixtures with better quality and are more affordable with a structure that is preferred by animals, and which is also practical to make, compared to traditional silage and hay (Vurarak 2016). Forage soybean is one of the important crops among leguminous feeds with its high nutritional value and low production cost (less fertilizer, less water requirement), which is often emphasized by researchers in various studies (Vargas et al. 2008, Drewnoski et al. 2012). It has been determined that legumes have low fiber and high digestion rates when harvested in the appropriate period. Therefore, legumes generate more animal yield compared to forage grasses (Steinshamn 2010). The harvest time, harvest type, withering time and packaging are the most important stages in roughage quality. It was determined that the protein content and green grass yield of soybean increased when the soybean was harvested in the R6 period when the full seed stage formation period was the highest. (Sahar 2017). Dry matter content is the most important quality parameter between traditional silage and haylage. While the DM content is around 30-25% in traditional silage, this rate is increased to 40-60% in haylage by wilting (Kutlu, Celik 2010). Thus, the buffering capacity can be reduced. The DM content of alfalfa which was 26.3% at harvest was increased to 44.1% by withering for 24 h, and it was reported that fermentation could be achieved in the desired direction by reducing the buffering capacity with the withering process (Rangrab et al. 2000, Cavallarin et al. 2005).

Reducing contact with $O_2$ in the environment is an extremely important step in terms of reducing the high moisture content of legumes harvested during the period when the withering and protein ratio is highest, and then reducing aerobic respiration (Rooke, Hatfield 2003). At this stage, the withered product is made into bales in the desired dimensions by using specially made coating materials made from PE (polyethylene film) material and covered with 4, 6, 8 or more layers depending on the size of the bale. It has been determined empirically that depending on the average climate conditions, 18-22 h of wilting should be applied for soybean haylage to reach the desired dry matter amount of 40-60% after the harvest is done with a conditioning type mower in Mediterranean climate conditions (Sahar et al. 2020).

The supply of affordable and high-quality roughage, which is one of the inputs of the livestock sector, is known as one of the most important problems in terms of animal and human health. Increasing the possibilities of using legumes as roughage is a priority study goal of many experts. In addition, it is known that soybean, which is an annual plant, has achieved important results in different study areas in terms of increasing the nitrogen fixing capacity of the soil on which it is planted as forage every year.

Knowing the effects of the storage period, which is the last stage in the transformation of forage soybean into roughage with the haylage technology, in terms of quality is important in animal nutrition. The time from storage to unpacking is an important factor that affects the supply of quality feed and determines the amount of stock required according to the number of animals, and this can differ according to each product.

This study was carried out for 2 years under the Mediterranean climate conditions. Silage bales made from two different forage soybean varieties were tested to determine the effects of 5 lengths of storage on some quality parameters and L, a, b color values.

## MATERIAL AND METHOD

The study was conducted during two trial periods covering the seasons in 2018-2019 and 2019-2020. The experiment was carried out at the Eastern Mediterranean Agricultural Research Institute (EMARI) Dogankent research area (Turkey, Southeast 36°85′ north latitude, 35°34′ east longitude and 12 m above sea level). The experimental area presented slightly alkaline, calcareous clayey loamy soil with pH of 7.8, and the organic matter content of 1.07%. Some seasonal climatic data according to the trial years are given in Table 1.

Table 1

Periodic climate data for the 2018-2019 and 2019-2020 trial periods

| Months | Temperature (°C) | | | Humidity (%) | Precipitation (mm) | Months | Temperature (°C) | | | Humidity (%) | Precipitation (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | max | averge | min. | | | | Max | Ave. | Min. | | |
| May 18 | 31 | 23 | 16 | 72 | 76.3 | May 19 | 33 | 23 | 15 | 63 | 6.9 |
| June 18 | 32 | 25 | 19 | 79 | 14.0 | June 19 | 37 | 26 | 20 | 77 | 17.5 |
| July18 | 32 | 27 | 22 | 82 | 2.3 | July 19 | 43 | 27 | 22 | 77 | 3.6 |
| Aug 18 | 33 | 28 | 23 | 80 | 0.3 | Aug 19 | 43 | 28 | 23 | 77 | 3.9 |
| Sep 18 | 34 | 26 | 20 | 75 | 17.0 | Sep 19 | 38 | 26 | 19 | 70 | 1.0 |
| Oct 18 | 30 | 21 | 15 | 70 | 44.5 | Oct 19 | 32 | 22 | 16 | 71 | 46.0 |
| Nov 18 | 22 | 16 | 11 | 76 | 54.5 | Nov 19 | 25 | 16 | 9 | 63 | 26.7 |
| Dec 18 | 16 | 11 | 8 | 85 | 274.0 | Dec 19 | 17 | 11 | 7 | 90 | 506.4 |
| Jan 19 | 16 | 10 | 9 | 82 | 287.9 | Jan 20 | 16 | 9 | 5 | 78 | 203.7 |

Two soybean forage varieties were used as plant material in the trials. The technical characteristics of Yemsoy and Yesilsoy forage soybean varieties are given in Table 2.

The dates of the agricultural activities and practices of the two periods in the trial are given in Table 3.

Both varieties were planted over an area of 0.3 hectares each. During the two years of the study, the soybean seeds were planted in June. A planting machine was used, to plant the seeds at 70 cm row spacing, 4.5 cm

Table 2

Some technical characteristics of soybean forage varieties used in the trial (EMARİ, 2019)

| Parameters* | | Yemsoy | Yesilsoy |
|---|---|---|---|
| Fresh fodder yield (t $ha^{-1}$) | | 45-60 | 40-56 |
| Dry biomass yield (t $ha^{-1}$) | | 14-20 | 12-16 |
| Plant height (cm) | | 150-180 | 140-150 |
| Growing period | | medium late | medium late |
| Hay | CP (%) | 14-16 | 15-17 |
| | ADF (%) | 36-38 | 33-35 |
| | NDF (%) | 44-53 | 42-48 |
| | RFV | 103-122 | 120-139 |
| Silage | CP (%) | 16-18 | 18-20 |
| | ADF (%) | 36-38 | 33-38 |
| | NDF (%) | 44-53 | 46-55 |
| | RFV | 103-122 | 110-128 |

* CP – crude protein, ADF – acid detergent fiber, NDF – neutral detergent fiber, RFV – relative feed value

Table 3

Application dates of agricultural activities

| Applications | 2018-2019 period | 2019-2020 period |
|---|---|---|
| Seeding | 16 June 2018 | 20 June 2019 |
| Harvesting | 2 October 2018 | 27 September 2019 |
| Bale making and wrapping | 3 October 2018 | 28 September 2019 |
| Opening haylage bales and sampling dates | | |
| 1. Sampling date | 23 October 2018 | 18 October 2019 |
| 2. Sampling date | 12 November 2018 | 6 November 2019 |
| 3. Sampling date | 3 December 2018 | 26 December 2019 |
| 4. Sampling date | 24 December 2018 | 17 December 2019 |
| 5. Sampling date | 14 January 2019 | 9 January 2020 |

intrarow spacing and 60-80 kg ha$^{-1}$ of seeds, the exact amount depending on the size of the seeds and according to the 1000 seed weight differences between the varieties. 30 kg ha$^{-1}$ N, 70 kg ha$^{-1}$ $P_2O_5$ and 100 kg ha$^{-1}$ $K_2O$ fertilizers were applied to the soil when sowing. Soybean seeds were inoculated with the *Bradyrhizobium japonicum* bacteria just before planting. During both years of the experiment, the trial area was irrigated three times, at the beginning of the pre-blooming period of the soybeans, during the full flowering stage and the pod development phase. All the harvesting was done using a conditioner-type mower at the R6 (full seed stage) development stage of the soybeans. The harvested products were left to wither under field conditions for 18-22 h, and then small bales weighing 40-50 kg bale$^{-1}$ on average were formed for each treatment (Sahar et al. 2019). These bales were covered with 4 layers of 25 cm wide and 25 μm thick polyethylene film without adding any additives, and left to storage. The duration of storage was applied as 5 in trials with 20-day intervals. Date were evaluated in randomized blocks with three replications according to the experimental design of the split plots. The main plot was two varieties (Yesilsoy, and Yemsoy), and the sub-plot were five lengths of storage (20, 40, 60, 80 and 100 days).

DM, pH, FS, CP, NDF, ADF, DDM, DMI, RFV and color scale (L, a, b) values formed the data in the study. FS (Uygur 2015), pH (Chen 1997), DM% (AOAC 1990) and the crude protein (CP) content (calculated as Nx6.25) was determined on soybean and haylage samples by the standard Kjeldahl procedure (AOAC 1996) and expressed on the dry matter basis. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined according to the procedure of Van Soest et al. (1991).

The DDM%, the DMI% and RFV were calculated using methods and formulas reported by Mayouf and Arbounche (2014). The CIELAB color scale (L, a, b) was used in the color analysis of the samples collected at the end of the fermentation period and evaluations were made according to each color scale in the trials (Mc Guire 1992).

The two-year data obtained in the study were subjected to the analysis of variance carried out with the Jump 7.0 statistical package program. Multiple comparisons were made according to the ‘LSMeans student’s *t*’ test at a significance level of 5% for the parameters with significant *F* values.

## RESULTS AND DISCUSSION

The statistical results of the years are given in Tables 4, 5, 6 and 7, and the combined variance analysis results of the two years are given in Table 8.

Table 4 indicates that no statistical effect had incurred on the DM and CP of the first year cultivars and the CP of the subjects and the DM and pH of the second year cultivars and the pH and CP of the subjects. All the other components were statistically effective on the DM, pH and CP at a significance level of 1% and 5%. The average of the first-year cultivars indicated that the haylages with the storage length of 80 days had the lowest pH level.

Table 4

Variance analysis results and groups of DM, CP (%DM) content and pH value for the 1st and 2nd years

| Variation sources | (%) DM | | pH | | (%) CP | |
|---|---|---|---|---|---|---|
| | 1st year | 2nd year | 1st year | 2nd year | 1st year | 2nd year |
| Varieties | | | | | | |
| Yesilsoy | 47.11 | 48.67 | 6.09$^{a}$ | 6.26 | 13.47 | 13.34$^{a}$ |
| Yemsoy | 41.62 | 53.07 | 5.94$^{b}$ | 6.48 | 12.71 | 11.99$^{b}$ |
| $LSD_{.05}$ | - | - | 0.13 | - | - | 0.73 |
| Storage lenght | | | | | | |
| 20. day | 45.77$^{ab}$ | 54.09$^{a}$ | 6.08$^{b}$ | 6.34 | 13.32 | 12.69 |
| 40. day | 47.62$^{a}$ | 49.54$^{b}$ | 6.33$^{a}$ | 6.29 | 12.77 | 12.69 |
| 60. day | 41.05$^{b}$ | 50.75$^{b}$ | 6.07$^{b}$ | 6.42 | 12.65 | 12.81 |
| 80. day | 44.86$^{ab}$ | 49.11$^{b}$ | 5.71$^{c}$ | 6.49 | 12.95 | 12.91 |
| 100. day | 42.52$^{b}$ | 50.85$^{b}$ | 5.91$^{bc}$ | 6.31 | 13.77 | 12.23 |
| $LSD_{.05}$ | 4.78 | 3.05 | 0.20 | - | - | - |
| CV (%) | 8.8 | 4.9 | 2.7 | 2.2 | 10.5 | 13.9 |
| *P* value | | | | | | |
| Variety | 0.08$^{ns}$ | 0.063$^{ns}$ | 0.04$^{*}$ | 0.136$^{ns}$ | 0.191$^{ns}$ | 0.0169$^{*}$ |
| Subject | 0.07$^{*}$ | 0.028$^{*}$ | 0.0001$^{**}$ | 0.129$^{ns}$ | 0.634$^{ns}$ | 0.968$^{ns}$ |
| Variety x Storage length | 0.04$^{*}$ | 0.296$^{ns}$ | 0.168$^{ns}$ | 0.025$^{*}$ | 0.007$^{**}$ | 0.787$^{ns}$ |

1st year – 2018-2019 period, 2nd year – 2019-2020 period, DM – dry matter, pH – acidity level, CP – crude protein in %DM; * $P$<0.05, ** $P$<0.01 significant, ns – not significant. The difference between the same letters in the same row and column is negligible.

The evaluations made according to the years showed that the DM value was affected by the varieties and length of storage, while the CP value was affected by the factors at the same statistical level during both years.

When ADF, NDF and RFV data were analyzed according to the years (Table 5), it was determined that first- and second-year cultivars had no statistical effect on ADF and RFV. The RFV value, on the other hand, was not statistically affected by the factors during both trial years.

Table 5

ADF, NDF and RFV 1st and 2nd year variance analysis results and groups

| Variation sources | (%) ADF | | (%) NDF | | RFV | |
|---|---|---|---|---|---|---|
| | 1st year | 2nd year | 1st year | 2nd year | 1st year | 2nd year |
| Varieties | | | | | | |
| Yesilsoy | 36.97 | 37.55 | 47.80 | 45.79$^{b}$ | 116.5 | 121.9 |
| Yemsoy | 36.25 | 38.14 | 47.49 | 48.06$^{a}$ | 119.4 | 115.6 |
| $LSD_{.05}$ | - | - | - | 1.8 | - | - |
| Storage length | | | | | | |
| 20. day | 36.96$^{ab}$ | 39.14 | 49.86 | 46.40 | 112.4 | 118.5 |
| 40. day | 34.88$^{c}$ | 38.70 | 45.13 | 47.25 | 124.2 | 116.7 |
| 60. day | 38.33$^{a}$ | 37.02 | 47.35 | 46.60 | 116.7 | 120.4 |
| 80. day | 37.35$^{a}$ | 37.72 | 47.07 | 48.24 | 118.9 | 115.9 |
| 100. day | 35.53$^{bc}$ | 36.66 | 48.83 | 46.16 | 117.6 | 122.2 |
| $LSD_{.05}$ | 1.68 | - | - | - | - | - |
| CV (%) | 3.7 | 8.5 | 7.1 | 6.9 | 7.5 | 11.2 |
| *P* value | | | | | | |
| Variety | 0.304$^{ns}$ | 0.304$^{ns}$ | 0.840$^{ns}$ | 0.033$^{*}$ | 0.463$^{ns}$ | 0.103$^{ns}$ |
| Subject | 0.0035$^{**}$ | 0.635$^{ns}$ | 0.208$^{ns}$ | 0.814$^{ns}$ | 0.289$^{ns}$ | 0.918$^{ns}$ |
| Variety x Storage length | 0.108$^{ns}$ | 0.05$^{ns}$ | 0.083$^{ns}$ | 0.031$^{*}$ | 0.103$^{ns}$ | 0.052$^{ns}$ |

1st year – 2018-2019 period, 2nd year – 2019-2020 period, ADF – acid detergent fiber, NDF – neutral detergent fiber, RFV – relative feed value; * $P<0.05$, ** $P<0.01$ significant, ns – not significant. The difference between the same letters in the same row and column is negligible.

When the DDM, DMI, and FS values were analyzed according to the years, it was determined that the cultivar factor did not have a statistically significant effect on any of the three values during both trial years (Table 6). While the factors did not have a statistically significant effect on DMI during the two years, it was determined that they had a statistically significant effect on FS at the 1% and 5% significance level during both trial years.

In Table 7, it was determined that the varieties had a 5% significance level effect on the a color value of the haylages during the two years, but no statistical effect on the L and b color values. On the other hand, it was determined that the fermentation period was effective on the L color value at an

Table 6

Variance analysis results and groups of % DDM, % DMI and FS values for the 1st and 2nd years

| Variation sources | (%) DDM | | (%) DMI (% of body mass) | | FS | |
|---|---|---|---|---|---|---|
| | 1st year | 2nd year | 1st year | 2nd year | 1st year | 2nd year |
| Varieties | | | | | | |
| Yesilsoy | 60.09 | 59.64 | 2.50 | 2.63 | 55.38 | 51.59 |
| Yemsoy | 60.65 | 59.18 | 2.54 | 2.51 | 50.27 | 51.86 |
| $LSD_{.05}$ | - | - | - | - | - | - |
| Storage length | | | | | | |
| 20. day | 60.10$^{bc}$ | 58.40 | 2.41 | 2.60 | 53.28$^{b}$ | 59.39$^{a}$ |
| 40. day | 61.72$^{a}$ | 58.74 | 2.59 | 2.55 | 46.78$^{bc}$ | 52.28$^{ab}$ |
| 60. day | 59.03$^{c}$ | 60.05 | 2.54 | 2.58 | 44.10$^{c}$ | 49.56$^{bc}$ |
| 80. day | 59.80$^{c}$ | 59.51 | 2.56 | 2.50 | 66.33$^{a}$ | 43.28$^{c}$ |
| 100. day | 61.21$^{ab}$ | 60.33 | 2.47 | 2.61 | 53.63$^{b}$ | 54.11$^{ab}$ |
| $LSD_{.05}$ | 1.31 | - | - | - | 7.87 | 7.21 |
| CV (%) | 1.7 | 4.2 | 6.7 | 7.4 | 12.23 | 11.4 |
| *P* value | | | | | | |
| Variety | 0.304$^{ns}$ | 0.304$^{ns}$ | 0.646$^{ns}$ | 0.057$^{ns}$ | 0.36$^{ns}$ | 0.949$^{ns}$ |
| Subject | 0.0035$^{**}$ | 0.635$^{ns}$ | 0.409$^{ns}$ | 0.871$^{ns}$ | 0.0002$^{**}$ | 0.0038$^{**}$ |
| Variety x Storage length | 0.108$^{ns}$ | 0.056$^{ns}$ | 0.153$^{ns}$ | 0.034$^{*}$ | 0.051$^{*}$ | 0.336$^{ns}$ |

1st year – 2018-2019 period, 2nd year – 2019-2020 period, DDM – digestible dry matter, DMI – dry matter intake, FS – Fleig score; * $P<0.05$, ** $P<0.01$ significant, ns – not significant. The difference between the same letters in the same row and column is negligible.

importance level of 1% during both years, and this factor had no statistical effect on the a color value during those years.

The combined variance analysis results of the years are given in Table 8. According to the final results of this analysis, it was determined that the cultivars made a statistical difference on HP at a 5% importance level and on the a color value at a 1% importance level. It was determined that there was a statistically significant difference between the storage lengths on DM at a 5% significance level and on pH, FS, L and a color values at a 1% significance level. In addition, in terms of Variety x storage length interaction, DM, CP, DMI, RFV and a color values were observed to differ statistically at a significance level of 1%, and pH and NDF values – at a significance level of 1%.

According to the results of the combined analysis of variance, it can be said that the DDM rate does not differ statistically between the storage lengths, although the DDM rate from each storage length is high

Table 7

Variance analysis results and groups of L, a, b values for the 1st and 2nd years

| Variation sources | L | | a | | b | |
|---|---|---|---|---|---|---|
| | 1st year | 2nd year | 1st year | 2nd year | 1st year | 2nd year |
| Varieties | | | | | | |
| Yesilsoy | 34.24 | 31.91 | 4.69$^{a}$ | 3.54$^{a}$ | 15.74 | 14.00 |
| Yemsoy | 31.63 | 32.90 | 2.44$^{b}$ | 1.96$^{b}$ | 15.15 | 14.25 |
| $LSD_{.05}$ | - | - | 1.1 | 0.87 | - | - |
| Storage length | | | | | | |
| 20. day | 26.83$^{c}$ | 26.83$^{b}$ | 2.89 | 2.89 | 18.30 | 18.30$^{a}$ |
| 40. day | 32.64$^{b}$ | 33.31$^{a}$ | 3.57 | 3.10 | 12.02 | 14.66$^{b}$ |
| 60. day | 33.48$^{b}$ | 33.61$^{a}$ | 3.65 | 2.49 | 16.54 | 12.94$^{bc}$ |
| 80. day | 34.49$^{ab}$ | 33.18$^{a}$ | 3.69 | 2.67 | 13.09 | 11.37$^{c}$ |
| 100. day | 37.24$^{a}$ | 35.10$^{a}$ | 4.05 | 2.60 | 17.27 | 13.35$^{bc}$ |
| $LSD_{.05}$ | 3.43 | 3.52 | - | - | - | 2.34 |
| CV (%) | 8.5 | 8.9 | 35.8 | 31.27 | 27.9 | 13.6 |
| *P* value | | | | | | |
| Variety | 0.07$^{ns}$ | 0.152$^{ns}$ | 0.012$^{*}$ | 0.032$^{*}$ | 0.652$^{ns}$ | 0.739$^{ns}$ |
| Subject | 0.0002$^{**}$ | 0.0014$^{**}$ | 0.638$^{ns}$ | 0.75$^{ns}$ | 0.093$^{ns}$ | 0.0002$^{**}$ |
| Variety x Storage length | 0.123$^{ns}$ | 0.252$^{ns}$ | 0.164$^{ns}$ | 0.102$^{ns}$ | 0.699$^{ns}$ | 0.062$^{ns}$ |

1st year – 2018-2019 period, 2nd year – 2019-2020 period, L – brightness, a – redness, b – yellowness; * $P<0.05$, ** $P<0.0$ significant 1; ns – not significant. The difference between the same letters in the same row and column is negligible.

(60.77% - 59.25%). Taylor et al. (2017) used pure soybean, soybean-millet mixture and pure alfalfa silage in their study to test the digestibility of their heifer feed rations, and determined that the digestibility of pure soybean silage was better than that of the other roughages.

The pH value varies between 6.10 and 6.24 in our study. This is supposed to be due to the increase in DM with the withering process in haylages as soybean roughages. Similar results were found by Huhnkle et al. (1997), and it is reported that the pH value of haylage roughage can be even higher than 6.5, depending on the climate conditions in a given country.

RFV constitutes the most important data in terms of feed quality. It has been determined that RFV is not statistically affected by the experimental factors, and it can be said that all storage lengths have the same characteristics statistically. According to the RFV scale developed by Mayouf and Arbounche (2014), it has been determined that all silage samples achieved the second quality class value (115.49-120.20). It is necessary to choose the silage with the lowest statistical pH value to determine the best variant. In this case, the silages with the statistically lowest pH values were sub-

Table 8

Combined analysis of variance table and groups

| Variation sources | (%)DM | pH | (%)CP | (%)ADF | (%)NDF | (%)DDM | %DMI | RFV | FS | L | a | b |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | | | | | | | | | | | | |
| 2018-2019 | $44.36^{b}$ | $6.02^{b}$ | 13.09 | 36.61 | 47.65 | 60.37 | 2.52 | 118.0 | 52.82 | 32.93 | $3.57^{a}$ | 15.44 |
| 2019-2020 | $50.87^{a}$ | $6.37^{a}$ | 12.66 | 37.85 | 46.93 | 59.41 | 2.57 | 118.7 | 51.72 | 32.41 | $2.75^{b}$ | 14.12 |
| LSD | 2.73 | 0.09 | - | - | - | - | - | - | - | - | 0.39 | - |
| Variety | | | | | | | | | | | | |
| Yesilsoy | 47.89 | 6.18 | $13.41^{a}$ | 37.26 | 46.80 | 59.87 | 2.56 | 119.2 | 53.48 | 33.08 | $4.12^{a}$ | 14.87 |
| Yemsoy | 47.34 | 6.21 | $12.35^{b}$ | 37.20 | 47.77 | 59.91 | 2.52 | 117.5 | 51.06 | 32.27 | $2.20^{b}$ | 14.70 |
| LSD | - | - | 0.82 | - | - | - | - | - | - | - | 2.39 | - |
| Storage length | | | | | | | | | | | | |
| 20. day | $44.93^{a}$ | $6.21^{ab}$ | 13.00 | 38.05 | 48.13 | 59.25 | 2.50 | 115.4 | $56.33^{a}$ | $26.83^{c}$ | 2.89 | $18.30^{a}$ |
| 40. day | $48.58^{ab}$ | $6.31^{a}$ | 12.73 | 36.79 | 46.19 | 60.23 | 2.57 | 120.5 | $49.53^{bc}$ | $32.98^{b}$ | 3.33 | $13.34^{bc}$ |
| 60. day | $45.90^{b}$ | $6.24^{a}$ | 12.73 | 37.68 | 46.97 | 59.54 | 2.56 | 118.5 | $46.83^{c}$ | $33.54^{b}$ | 3.07 | $14.74^{bc}$ |
| 80. day | $46.98^{b}$ | $6.10^{b}$ | 12.93 | 37.53 | 47.65 | 59.65 | 2.53 | 117.4 | $54.81^{a}$ | $33.83^{ab}$ | 3.18 | $12.23^{c}$ |
| 100. day | $46.68^{b}$ | $6.11^{b}$ | 13.00 | 36.09 | 47.49 | 60.77 | 2.54 | 119.9 | $53.87^{ab}$ | $36.17^{a}$ | 3.33 | $15.31^{b}$ |
| $LSD_{.05}$ | 2.72 | 0.12 | - | - | - | - | - | - | 5.13 | 2.36 | - | 2.76 |
| CV (%) | 6.9 | 2.5 | 12.2 | 6.6 | 7.1 | 3.2 | 7.2 | 9.5 | 11.8 | 8.7 | 34.4 | 22.6 |

cont. Table 8

| Variation sources | (%)DM | pH | (%)CP | (%)ADF | (%)NDF | (%)DDM | (%)DMI | RFV | FS | L | a | b |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *P* value | | | | | | | |
| Year | 0.0006$^{**}$ | <.0001$^{**}$ | 0.264$^{ns}$ | 0.092$^{ns}$ | 0.492$^{ns}$ | 0.092$^{ns}$ | 0.337$^{ns}$ | 0.81$^{ns}$ | 0.661$^{ns}$ | 0.353$^{ns}$ | 0.0015$^{**}$ | 0.050$^{ns}$ |
| Variety | 0.662$^{ns}$ | 0.466$^{ns}$ | 0.017$^{*}$ | 0.925$^{ns}$ | 0.360$^{ns}$ | 0.925$^{ns}$ | 0.471$^{ns}$ | 0.60$^{ns}$ | 0.346$^{ns}$ | 0.169$^{ns}$ | <.0001$^{**}$ | 0.772$^{ns}$ |
| Year x Variety | 0.0033$^{**}$ | 0.003$^{**}$ | 0.428$^{ns}$ | 0.343$^{ns}$ | 0.231$^{ns}$ | 0.343$^{ns}$ | 0157$^{ns}$ | 0.185$^{ns}$ | 0.298$^{ns}$ | 0.010$^{*}$ | 0.089$^{ns}$ | 0.48$^{ns}$ |
| Storage lenght | 0.036$^{*}$ | 0.008$^{**}$ | 0.984$^{ns}$ | 0.332$^{ns}$ | 0.677$^{ns}$ | 0.332$^{ns}$ | 0.898$^{ns}$ | 0.82$^{ns}$ | 0.0035$^{**}$ | <.0001$^{**}$ | 0.846$^{ns}$ | 0.014$^{**}$ |
| Year x Storage lenght | 0.033$^{*}$ | <.0001$^{**}$ | 0.689$^{ns}$ | 0.152$^{ns}$ | 0.219$^{ns}$ | 0.152$^{ns}$ | 0.395$^{ns}$ | 0.544$^{ns}$ | <.0001$^{**}$ | 0.742$^{ns}$ | 0.508$^{ns}$ | 0.122$^{ns}$ |
| Variety x Storage lenght | 0.030$^{*}$ | 0.004$^{**}$ | 0.033$^{*}$ | 0.178$^{ns}$ | 0.005$^{**}$ | 0.178$^{ns}$ | 0.0126$^{*}$ | 0.036$^{*}$ | 0.222$^{ns}$ | 0.104$^{ns}$ | 0.039$^{*}$ | 0.333$^{ns}$ |
| Year xVariety x Storage lenght | 0.110$^{ns}$ | 0.624$^{ns}$ | 0.226$^{ns}$ | 0.010$^{*}$ | 0.217$^{ns}$ | 0.010$^{*}$ | 0.19$^{ns}$ | 0.056$^{ns}$ | 0.039$^{*}$ | 0.221$^{ns}$ | 0.344$^{ns}$ | 0.623$^{ns}$ |

DM – dry matter, pH – acidity level, CP – crude protein, ADF – acid detergent fiber, NDF – neutral detergent fiber, RFV – relative feed value, DDM – digestible dry matter, DMI – dry matter intake, FS – fleig score, L – brightness, a – redness, b – yellowness: * $P<0.05$, ** $P<0.01$ significant, ns – not significant. The difference between the same letters in the same row and column is negligible.

jected to the 6,10 and 80 days and 6,11 and 100 days lengths of storage. Furthermore, the fact that the calculated FS value during this period was statistically the highest brings these two variants to the fore. According to these results, in terms of quality, practitioners can be recommended to use roughage left to ferment for 80 or 100 days in soybean haylage. Since there is no statistical difference between cultivars, both cultivars are considered to be suitable for haylage technology.

The $R^2$ test was performed in the study to determine the relationship between color values and some quality parameters, and no significant relationship could be found between the parameters (Table 9).

Table 9

The level of relationship between some quality parameters and L, a, b values

| *x*-axis | *y* axis | Equation | $R^2$ |
|---|---|---|---|
| RFV | L | $y = -0.0016x + 32.870$ | 2E-05 |
| | a | $y = -0.0185x + 5.3588$ | 0.023 |
| | b | $y = -0.0376x + 19.249$ | 0.015 |
| (%)NDF | L | $y = 0.0084x + 32.278$ | 6E-05 |
| | a | $y = 0.0375x + 1.3891$ | 0.009 |
| | b | $y = 0.1132x + 9.4366$ | 0.013 |
| (%)ADF | L | $y = 0.0646x + 35.082$ | 0.001 |
| | a | $y = 0.0424x + 1.5861$ | 0.006 |
| | b | $y = 0.1413x + 9.5265$ | 0.011 |
| (%)CP | L | $y = -0.375x + 37.506$ | 0.022 |
| | a | $y = 0.2675x + 0.2819$ | 0.090 |
| | b | $y = -0.125x + 16.4$ | 0.003 |
| pH | L | $y = -0.7702x + 37.45$ | 0.002 |
| | a | $y = -0.7931x + 8.0808$ | 0.025 |
| | b | $y = -2.7686x + 31.952$ | 0.047 |
| (%)DM | L | $y = -0.0074x + 33.026$ | 0.0001 |
| | a | $y = -0.0008x + 3.206$ | 1E-5 |
| | b | $y = 0.0024x + 14.674$ | 1E-5 |

An examination of the color parameters after 80 and 100 days of fermentation revealed that the the L brightness value of 36.17 of the haylage which had been left for storage for 100 days was statistically the best. It is thought that the high brightness value could be an effective factor in animal preferences. It was determined that the brightness L and yellowness b values did not change statistically according to the cultivars, but the L and b color values were affected by the fermentation time at a significance level of 1%.

In a study conducted by Ince and Vurarak (2019) on a similar subject, it was found that the color change in roughage could be determined by following the L and b values and that NYD also decreased with the haylages prepared as legume + wheatgrass mixtures in response to the 50% decrease in L, b color values at the end of 55 days of fermentation.

## CONCLUSION

Soybean haylage as bale silage made by using two different forage soybean varieties, Yesilsoy and Yemsoy, was stored for 20, 40, 60, 80, and 100 days. As a result of the examinations and analyses of samples at the end of the storage, it was determined that the silages stored for 80 and 100 days stood out statistically in terms of pH, RFV and L brightness values compared to the other treatments. At the end of the study, it was observed that the RFV value increased by increasing the brightness value.

### REFERENCES

Albrecht K.A., Beauchemın K.A. 2003. *Alfalfa and other perennial legumes silage.* In: *Silage Science and Technology*. Agron. Monogr. 42, ASA, CSSA, and SSSA, Madison, WI, pp. 633-664.

AOAC 1990. Association of Official Analytical Chemists. *Official Method of Analysis.* 15th Ed. Washington, DC. USA. pp. 66-88.

Cavalların L., Antonıazzı S., Borreanı G., Tabacco E. 2005. *Effects of wilting and mechanical conditioning on proteolysis in sainfoin (Onobrychis viciifolia* Scop.*) wilted herbage and silage.* J. Sci. Food Agric., 85: 831-838.

Chen V., Stoker M.R., Wallance C.R. 1997. *Effect of enzyme-ınoculant sistems on preservation and nutritive value of haycrop and corn silage.* J. Dairly, (77): 501-507.

Drewnoskı M.E., Poore M.H. 2012. *Effects of supplemantation frequency on ruminal fermantation and digestion by steers fed medium-quality hay and supplemented with soybean hull and corn gluten feed blend.* J Anim Sci, 90: 881-891.

EMARİ. 2019. *Registered varieties catalogue.* Eastern Medi Agric Res Inst, 2019. https://arastirma.tarimorman.gov.tr/cukurovataem/Sayfalar/EN/AnaSayfa.aspx

Ince A., Vurarak Y. 2019. *An approach to color change and quality relation in roughages.* J Agric Sci, 25(1): 21-28. DOI: 10.15832/ankutbd.538982

Kutlu H.R., Çelık L. 2010. *Yemler Bilgisi ve Yem Teknolojisi.* Çukurova Üniversitesi Ziraat Fakültesi Genel Yayın No 266, Kitap Yayın No A-86. Adana.

Mayouf R., Arbouche F. 2014. *Chemical composition and relative feed value of three Mediterranean fodder shrubs.* Afr J Agric Res, 9(8): 746-749.

Mcguire R.G. 1992. *Reporting of objective color measurements.* Hort Sci, 27(12): 1254-1255.

Nı K., Wang F., Zhu B., Yang J., Zhou G., Pan Y., Tao Y., Zhong J. 2017. *Effects of lactic acid bacteria and molasses additives on the microbial community and fermentation quality of soya silage.* Bioresour Technol, 238: 706-715.

Rangrab L.H., Muhlbach P.R.F., Berto J.L. 2000. *Silagem da alfafa colhida no início do florescimento e submetido ao emurchecimento e à ação de aditivos biológicos. Efeitos da adição de inoculantes microbianos sobre a composição bromatológicos.* Rev Brasil Zootec, Viçosa, 29(2): p. 349-356.

Rooke J.A., Hatfield R.D. 2003. *Biochemistry of ensiling*. In: *Silage Science and Technology*. Argon. Monogr. 42. ASA, CSSA, and SSSA, Madison, WI, p. 95-140.

Sahar A.K. 2017. *The effect of silage additives on the silage quality and different harvesting stages on the herbage yield at soybean cultivars grown as second crop in Cukurova conditions*. (2015-FBE-D218 Ph. D.Thesis, field Crops Sciences) 115 p, Van, Turkey.

Sahar A.K., Vurarak Y., Cubukcu P., Yucel H. 2020. *Determınıng the effects of wıltıng tıme on some qualıty parameters ın soybean haylage*. Turk J Field Crops, 25(1): 26-31. DOI: 10.17557/tjfc.526235

Sezer B. 2014. *Karbon Salınımı ve Toprak Yönetimi*. www.tarim.gov.tr/ABOGM/Belgeler.

Spanghero M., Zanfi C., Sıgnor M., Davanzo D., Volpe V., Venerus S. 2015. *Effects of plant vegetative stage and field drying time on chemical composition and in vitro ruminal degradation of forage soya silage*. Anim Feed Sci Technol, 200: 102-106.

Steinshamn H. 2010. *Effect of forage legumes on feed intake, milk production and milk quality – A review*. Anim Sci Pap Rep, 28(3): pp. 195-206.

Taylor E.G., Gunn P.J., Horstman L.A., Atkınson R.L., Herron K., Johnson K.D., Lemenager R.P. 2017. *Evaluation of forage soybean, with and without pearl millet, as an alternative for beer replacement heifers*. Translati Anim Sci, 1(2): 179-185.

Uygur M. 2015. *Silaj Kalitesinin Fiziksel ve Kimyasal Yöntemlerle Belirlenmesi*. Çiftçi Broşürü. Broşür no 127. Erişim 23.10.2015. www.araştırma.tarim.gov.tr./etae/Belgeler.

Van Soest P. J., Robertson, J. D., Lewıs B.A. 1991. *Methods for dietry fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition*. J Dairy Sci, 74: 3583-3597.

Vargas-Bello-Perez E., Mustafa A.F., Seguın P. 2008. *Effects of feding forage sybean silage on milk production, nutrient digestion, and ruminant fermentation of loatating dairy cows*. J. Dairy Sci., 91: 229-235.

Vurarak Y. 2016. *Determınation of effects of different harvesting and storage systems on machine management values and feed quality for some forage mixtures*. Cukurova Unıversity Institute of Natural and Applied Sciences Department of Agrıcultural Machinery and Technologies Engineering (Ph. D.Thesis ZF-2013-D29, Adana, Turkey).