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# The Use of Whey Powder Additions for Grass Silage: Effects on Nutrient Content, Fermentation Properties and Aerobic Stability

Şevin GÜLTEKİN[1], Emrah KAYA[2*]

**ABSTRACT:** The aim of this study was to determine the nutrient content, fermentation properties, and aerobic stability of grass ensiled with the addition of different doses of whey powder. Freshly cut grasses (*Festuca arundinacea, Festuca rubra, Poa pratensis,* and *Lolium perenne*) were ensiled with the addition of whey powder at a rate of 0, 2, 4, and 6% in the laboratory in 1.5-liter plastic jars with 4 replications. At the end of the 60-day ensiling period, the nutrient content, fermentation properties, and aerobic stability values of silages were investigated. The pH measurements revealed that the silages were of high quality. Although dry matter (DM), crude protein (CP), and ether extract (EE) values increased depending on the increase in whey powder rate in the silages, crude ash (CA), ADF, and NDF values decreased. The lowest pH and the highest Fleig Score (FS) were obtained in silage with a 6% whey powder addition. Except in the control group, no mold formation was detected in silage groups after the seven-day aerobic stability test. As a result, different mixing ratios of grass and whey powder did not cause negative results in silages and increased the quality. According to Fleig scores and aerobic stability results, the best quality silages were obtained from silages with 4 and 6% whey powder additions. It was concluded that the ensiling of grass with whey powder was effective in improving the nutritional and fermentation quality of silages and provided a partial solution to environmental pollution.

**Keywords:** Grass, silage, whey powder, fermentation, aerobic stability

[1] Şevin GÜLTEKİN (**Orcid ID:** 0000-0002-6879-0817), Iğdır University, Postgraduate Education Institution, Department of Animal Science, Iğdır, Türkiye
[2*] Emrah KAYA (**Orcid ID:** 0000-0001-7337-0406), Iğdır University, Faculty of Agriculture, Department of Animal Science, Iğdır, Türkiye
***Corresponding Author:** Emrah KAYA, e-mail: emrah.kaya@igdir.edu.tr

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## INTRODUCTION

Roughages are very important in terms of eliminating the feeling of hunger, providing satiety, and the nutritional physiology of animals (Kılıç, 2006). In addition to the feed expenses, which constitute 60-70% of the production cost in animal nutrition, the inability to reach quality roughages is also an important problem. Since the quality roughage consumption of animals decreases, the requirements cannot be met, which reduces the yield and quality. As in all seasons, in order to increase meat and milk yield in winter, green fodder plants, which are abundant in other seasons, should be stored by making silage and fed to animals in winter (Karslı and Bingöl, 2009, Levendoğlu and Karslı, 2010). Grasses are more cost-effective and require fewer labor force when compared with other roughage sources. However, feeding with the grass after it has dried causes nutrient losses and necessitates more labor. In order to increase the usefulness of grass in the nutrition of ruminants, it is important to feed and keep it by making silage instead of giving it by drying (Akyıldız, 1986; Kamalak et al., 2009; Kaya et al., 2009). Considering both the feed value and the production cost, the importance of intensive use of silage feeds in the nutrition of ruminants is emphasized (Yüksel, 2011).

When the benefits of silage are considered, it is the most important roughage source for ruminants (Machin, 1999). To improve the nutritional qualities of silages and increase their utility for animals, various silage additives are applied during the silage production process of roughages (Kung et al., 2000; Cajarville et al., 2012; Atalay and Kamalak, 2017). The search for alternative feed materials has directed producers and researchers in the livestock sector to natural resources, and studies on the evaluation, processing, and use of waste and residues have been emphasized. It has been reported that the demand for cheap and easily available raw material sources has increased in order to reduce the cost of feed and to provide natural nutrition.

Most of the whey, which is released as waste material as a result of cheese production, is discarded without being evaluated (El-Shewy, 2016; El-Tanboly et al., 2017). Whey powder, which is used in some foods, meat products, and beverages, is known to contain high levels of lactose as an industrial raw material (Küçüköner, 2011). Due to its high lactose content, it is thought that it can be used as an additive with the potential to increase silage quality in the silage of feeds with low water-soluble carbohydrate content (Castano and Villa, 2017; Keener, 2019).

Within the scope of this study, it was thought that adding whey powder to grass could increase the dry matter content of silages, decrease pH, and improve silage quality. The aim of this study was to determine the nutrient content, fermentation properties, and aerobic stability of grass ensiled with the addition of different doses of whey powder.

## MATERIALS AND METHODS

The silage material for the research was grown in Iğdır University Şehit Bülent Yurtseven Campus in 2021; a mixture of *Festuca arundinacea* (50%), *Festuca rubra* (20%), *Poa pratensis* (5%), and *Lolium perenne* (25%) formed grasses. Whey powder, which is used as an additive, comes from a private recycling company in Tekirdağ that enables the evaluation of whey; it was obtained after concentrating pasteurized whey, reducing the minerals with the demineralization process, and obtaining it by the spray dry method. The whey powder consists of 11% protein, 6% ash, 1% fat, and 70% lactose.

The grasses cut with automatic mowers were spread on clean ground and homogeneously mixed with the whey powders at the ratios of 0, 2, 4, and 6%, which were previously weighed and prepared.

Afterwards, this mixture was hand-pressed into 1.5-liter capacity plastic jars in such a way that there was no air left. Each treatment was prepared in triplicate.

The silage period of grass was determined as 60 days. At the end of the ensiling period, the samples were opened and physical and chemical analysis methods were used to obtain the findings of pure and whey powder-added grass silages. Dry matter (DM), crude ash (CA), ether extract (EE), and crude protein (CP) contents of the silages were determined according to the method reported by AOAC (1990). ADF and NDF contents were determined by Van Soest et al. (1991) according to the method reported. The pH of the silage samples was determined by an electronic pH meter with a sensitivity of 0.01 and a digital display. The temperature change that occurred after the contact of the grass silage with the air was recorded every hour by means of the temperature probes (TMC6-HD), and the data was loaded into the loggers. These data were then transferred to a computer to determine the aerobic stability of the silage materials (Kung et al., 2000).

In order to determine the quality of grass silages, Fleig scores (FS) (Kılıç, 1984) and Required pH (RpH) (Meeske, 2005) values were determined according to the equations given below.

$$Fleig\ Score\ =\ 220\ +\ (2\ \mathrm{x}\ (\%\ DM\ -\ 15))\ -\ (40\ \mathrm{x}\ pH) \quad (1)$$

The following Fleig Scores are used to identify silage quality classes;
0-20: bad; 21-40:medium; 41-60:satisfactory; 61-80:good; 81-100:very good; 100+:excellent

$$Required\ pH\ value\ =\ (0.00359\ \mathrm{x}\ DM)\ +\ 3.44 \quad (2)$$

The study's data were statistically evaluated (Tukey 5%) using one-way analysis of variance (One-way ANOVA) with SPSS (2017).

## RESULTS AND DISCUSSION

Nutrient content, fermentation properties, and aerobic stability results of silages are given below. In comparison to the control group (Table 1), adding whey powder to grass silages increased the level of DM by 2.9% in the samples with 6%, 1.53% in 4%, and 0.85% in 2%. The CA, ADF, and NDF levels of silage samples were significantly reduced with the whey powder addition ($P<0.05$). The addition of whey powder had no statistically significant influence on the CP and EE contents, which varied from 20.49 to 22.95% and 3.48 to 3.80%, respectively.

**Table 1.** Nutrient content of silage mixtures.

| Treatments | DM | CA | CP | EE | ADF | NDF |
|---|---|---|---|---|---|---|
| **Grass + % 0 WP** | 25.77$^{c}$ | 12.35$^{a}$ | 20.49 | 3.48 | 11.41$^{a}$ | 15.24$^{a}$ |
| **Grass + % 2 WP** | 26.62$^{b}$ | 11.77$^{b}$ | 20.81 | 3.80 | 8.30$^{b}$ | 13.55$^{a}$ |
| **Grass + % 4 WP** | 27.30$^{b}$ | 11.61$^{b}$ | 21.86 | 3.59 | 9.86$^{ab}$ | 11.10$^{ab}$ |
| **Grass + % 6 WP** | 28.67$^{a}$ | 11.84$^{b}$ | 22.95 | 3.76 | 7.87$^{b}$ | 8.33$^{b}$ |
| **SEM** | 0.254 | 0.136 | 1.713 | 0.955 | 0.904 | 1.323 |
| **Sig.** | *** | *** | NS | NS | *** | *** |

$^{abc}$ Column means with common superscripts do not differ (P>0.05.) WP: Whey powder. DM: Dry matter (%). CA: Crude ash (% of DM). CP: Crude protein (% of DM). EE: Ether extract (% of DM). ADF: Acid detergent fiber (% of DM). NDF: Neutral detergent fiber (% of DM). SEM: standard error mean. Sig: Significant level. ***: P<0.05. NS: Non-significant.

Contrary to Nkosi et al. (2013), the whey powder additives seemed to have a significant effect on the crude fiber values of the silages. The crude fiber content of grass silages decreased significantly with the addition of whey powder. This decrease in crude fiber values is in accordance with the findings of Kamalak et al. (2009) and Özüretmen et al. (2022).

Some research are also stated that adding whey to the silage significantly increased the dry matter level, which is consistent with the data obtained from the current study (Nkosi et al., 2013;

Atalay and Kamalak, 2018; Atalay and Öztürk, 2018; Atalay and Öztürk, 2019; Güven and Kamalak, 2021). The fact that the additions are in powder form is assumed to be the reason for the increase in the dry matter content of grass silages. The crude ash content of grass silages varied between 11.16 and 12.35% and decreased significantly with the increase in whey powder usage rate. The reason for this decrease in the crude ash content of silages is that the crude ash content of the additive is lower than that of grass. This decrease in crude ash values is in accordance with the findings of Atalay and Öztürk (2018), and Güven and Kamalak (2021).

The pH, FS, and RpH values of silage samples were significantly affected by the whey powder addition ($P<0.05$). The data presented in Table 2 shows that whey powder addition decreased the pH value and improved the fermentation quality of studied silages. As the dose increased, the pH of the groups decreased, with the lowest value found in the 6% whey powder added group.

**Table 2.** Fermentation properties of silage mixtures.

| Treatments | pH | FS | RpH |
|---|---|---|---|
| **Grass + % 0 WP** | $4.73^{a}$ | $67.21^{c}$ | $4.36^{c}$ |
| **Grass + % 2 WP** | $3.95^{b}$ | $99.98^{b}$ | $4.39^{b}$ |
| **Grass + % 4 WP** | $3.73^{b}$ | $110.14^{ab}$ | $4.42^{b}$ |
| **Grass + % 6 WP** | $3.69^{b}$ | $114.74^{a}$ | $4.47^{a}$ |
| **SEM** | 0.105 | 4.018 | 0.009 |
| **Sig.** | *** | *** | *** |

$^{abc}$ *Column means with common superscripts do not differ* ($P>0.05$.) WP: Whey powder. FS: Fleig score. RpH: Required pH value. SEM: standard error mean. Sig: Significant level. ***: $P<0.05$.

According to Özüretmen et al. (2022), the addition of whey powder to alfalfa decreased the pH value of silage samples. The results of the current study are in accordance with the findings of Özüretmen et al. (2022). In another study, 10% whey addition to corn silage showed a 7% decrease in silage pH compared to the control group, while in the current study, a decrease of nearly 22% was observed between the control group and the highest dose, 6%, with whey powder addition (El-Tanboly et al., 2017). It is predicted that this difference is due to the difference in lactose concentration in powder and liquid form.

On the other hand, whey powder increased the Fleig Score by improving the physical properties. The FS of silages significantly increased with the whey powder addition and varied between 67.21 and 114.74 ($P<0.05$). In comparison to the control group (Table 2), adding whey powder to grass silages increased the level of FS by “excellent” in the samples with 4 and 6%, and “very good” in the 2% addition. In the study of Özüretmen et al. (2022); 4% whey powder added to alfalfa silage could increase the silage quality from "medium" to "good", while the quality of grass silage increased to "excellent" with the same amount of additives. It is estimated that this difference between the results is due to the difference between the parameters used in the calculation of the Fleig Score.

The RpH value of silages significantly increased with the whey powder addition and varied between 4.36 and 4.47 ($P<0.05$). This increase in RpH values is in accordance with the findings of Güven and Kamalak (2021). Since the required pH results were calculated using the dry matter values of the current silages, the effects of additives on the dry matter of silages directly affect these results.

The effects of adding different doses of whey powder to grass silages on the aerobic stability of silages were determined by measuring the temperature changes of the silages for the first seven days. The time of degradation and temperature changes in silages are shown in Figure 1.

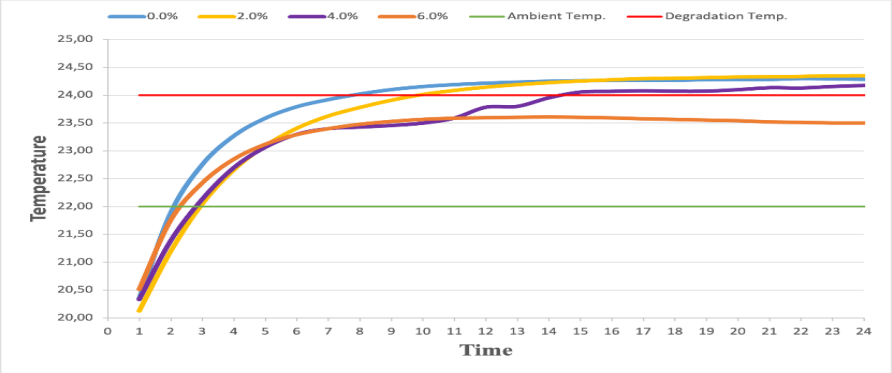


**Figure 1.** Effect of whey powder on aerobic stability of grass silages.

The temperatures measured from the silages with 0, 2, and 4% additives were higher than the ambient temperatures. However, the temperature change of the silage with 6% whey added was lower than the ambient temperature, ensuring that the silage did not show degradation. After the seven-day aerobic stability test, no mold formation was found in the silage groups except the control group. Özüretmen et al. (2022) reported that the addition of whey powder to alfalfa silages prevented mold formation in the added groups. As a result of both studies, it was concluded that the addition of whey powder additives prevented the formation of mold.

## CONCLUSION

The findings obtained in this study support the notion that completely organic whey powder, rich in water-soluble carbohydrates and lactose, which was used as an additive in the production of different silages, can be used to obtain better quality meadow silages and will provide added value to the economy. The nutrient content, fermentation properties, and aerobic stability of grass silage were improved with whey powder addition. The additive provided a crucial improvement in aerobic stability and prevented the mold growth. Considering the nutrient content, fermentation properties, and aerobic stability results, it has been reported that the most effective doses of whey powder additive that can be used for silage of grasses will be 4 and 6%. Also, it is concluded that utilizing whey powder, an industrial waste, as a silage additive would yield economic gains and a partial solution to environmental pollution.

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## Conflict of Interest

The article authors declare that there is no conflict of interest between them.

## Author's Contributions

The authors declare that they have contributed equally to the article.

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