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RESEARCH ARTICLE

Effect of Whey Protein-Enriched Water on Performance and in Vivo Carcass Measurements in Fattening Merino Lambs

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ABSTRACT

Whey, a by-product of the dairy industry, is primarily used for protein and energy sources in livestock diets due to its high nutritional value, which equivalent to grain corn and barley. In the current study, whey powder was added to lamb drink water to evaluate its effects on performance and in vivo carcass measurements. Twenty-four non-castrated healthy male Merino lambs with an average of 3 months weaning age and 23.44 ± 0.62 kg (mean ± SE) initial live weight (LW) used in this study. Lambs were randomly allocated into two trial groups according to their LW and adapted to concentrate and whey protein-enriched water. The total period of trial was 45 days, with 15 days adaptation and 30 days for data collection. Lambs were housed in a group and received ad libitum wheat straw, lamb-grower feed, and water (enriched with whey protein or not). There were no significant differences observed in treatment groups for total weight gain (TWG, $P > 0.05$). On the other hand, the whey-treated group's average TWG value is 8.60% higher than the control group. Besides, the differences between initial and final loin eye depth (LED) was 4.7 times higher in the whey group than the control group (0.28 cm vs. 0.06 cm). Also, no significant differences were observed between the trial group for fat thickness ($P > 0.05$). Obtained results from the present study indicated that using whey powder even in animal drinks improved TWG and LED in the fattening period.

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Introduction

There has been a great interest in using by-products as an alternative feed source to decrease feeding costs for ruminants worldwide. One of the most important and highly nutritious by-products is whey, classified in unusual by-products.

Whey, a by-product of the dairy industry, is utilized well when used in animal diets in different forms such as liquid, condensed, or dried whey or whey products (Ahlam, 2016). Because of its high protein and energy contents, whey is primarily used for protein and energy sources in livestock diets. Also, the broad regional diversity of whey makes itself a valuable source for reducing the cost of diets in neighboring sheep farmers contributing to the reduction of environmental contamination (Primo, 2010; Palmieri et al., 2017; Pinheiro Rogério et al., 2019). It has been

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suggested that whey could be replaced with concentrate ingredients such as corn or soybean meal, which reduced production costs and better feed conversion ratio adjusting the dietary energy level of diets (Kushibiki et al., 2001; Pinheiro Rogério et al., 2019).

Anderson et al. (1974) reported dairy cows could consume 30% of their daily dry matter intake as liquid whey, and this ratio can be rise to 40-50% of their dry matter intake in calves without any adverse effects on animals. Additionally, Thivend (1977) and Rapetti et al. (1995) noted that feeding animals with a liquid form of whey is the least expensive method compared to condensed or dried form when they are located close to dairy plants. Moreover, several authors suggest that utilization of whey or whey-derived products reduces feed costs and contributes to the cleanness of the environment (Rapetti et al., 1995; Kafantaris et al., 2019; Pinheiro Rogério et al., 2019). On the other hand, storing large quantities of whey as a liquid form does not seem possible because of its corrosive properties, low pH value, and insufficient storage area. Therefore, the dried form of whey was preferred by plants mainly two reasons; legal liability and storage conditions.

Whey is a highly nutritious by-product because of its not only high soluble protein and lactose contents but also its minerals, essential amino acids, and B-complex vitamins (Hoffman and Falvo, 2004; Hernández-Ledesma et al., 2011; Bilal and Altıner, 2017; Lupo et al., 2019). On the other hand, the high lactose (70-73%) and mineral contents (7-11%) of whey often limit the amount of whey which can be added in the diets; therefore, a larger proportion of lactose must be removed from the whey (Thivend, 1977). Removing lactose from the whey allows a whey product, often called delactosed whey, containing higher concentrations of protein and minerals (Schingoethe, 1973; Yıldırım and Güzeller, 2013).

Dried whey and whey products have been used to feed non-ruminants and ruminants for many years due to their positive effects on weight gain, feed efficiencies, protein and fat digestibility, mineral absorption and retention, and nitrogen retention (Ali-Ani et al., 1972; Berry et al., 1943; Hintz et al., 1971; Sewell and West, 1955; Balloun and Khajerarn, 1974; Kavaz Yuksel et al., 2019). On the other hand, there is a limited study in the literature about the effect of whey on loin eye development (Lupo et al., 2019). Therefore, the objective of the present study was to evaluate the fattening performance and in vivo carcass characteristics of Merino lambs receiving ad-libitum whey protein-enriched water in their diet.

Materials and Methods

The animal trial of whey protein-enriched water was conducted in a private farm located in Gonen, Balikesir, Turkey, from mid-March to early-May 2019. Twenty-four non-castrated healthy male Merino lambs with an average of 3 months weaning age and 23.44 ± 0.62 kg (mean ± SE) initial live weight (LW) used in this study. Lambs were randomly allocated into two trial groups according to their LW and adapted to concentrate and whey protein-enriched water on reducing the incidence of rumen acidosis. The total period of trial was 45 days, with 15 days adaptation to whey protein-enriched water and 30 days for data collection. Lambs were housed in a group where they received the concentrate and roughage twice a day, 08:00 and 17:00 h. All animals received ad libitum wheat straw, lamb-grower feed, and water (enriched with whey protein or not).

6.56 g of whey powder was mixed in a small container until completely dissolved, and then transferred into their water tank and complete 100 L final volume for stimulating liquid whey. Among the two treatment groups, one group (control) received normal water while the other group (whey) received whey protein-enriched water.

The LW of lambs was recorded at the initial, mid-and final period of the study on the same day with the in vivo carcass measurements after 15 days adaptation period. The lambs' LW was individually measured using an ovine weight scale after at least 12 h of fastening.

The loin eye depth (LED), the fat thickness (FT), and the skin thickness (ST) between the 12th and 13th ribs of each lamb were monitored using Mindray DP-30 ultrasound device and transrectal linear probe at 7.5 MHz after the morphometric measurements at the initial and final period of the study. One-way analysis of variance (ANOVA) was used to determine the effects of whey protein enriched water on LW, LED, and FT of Merino lambs by using SAS (JMP, Version 13.2). Significance between individual means was identified using t-Test. Mean differences were considered significant at $P < 0.05$.

Results and Discussion

The ingredients and chemical composition of concentrate, roughage, and whey used in this study are presented in Tables 1 and 2.

Previous studies clearly showed that; dry matter of whey nearly 7% and half of the original nutrient components of milk such as protein, lactose, mineral, vitamins, amino acids, lactic acids, and fat found in this solid part (Anderson et al., 1974; Guler et al., 2006). Thus, it makes whey a valuable source for supplying additional nutrients for livestock. In the current study, due to its ease in storage conditions, whey powder was used by imitating liquid whey to evaluate the effects of liquid whey on weight gain and in vivo carcass measurements of fattening Merino lambs.

Table 1. Ingredients of concentrate used in the study

Feedstuffs, g/kg			
Wheat bran	251.0	Rice bran	35.5
Corn grain	170.0	Limestone	31.0
Corn germ meal	127.3	Ammonium chloride	6.0
Barley	100.0	Molasses	5.0
Sunflower meal	96.4	Provin	5.0
Bonkalite	80.0	Salt	3.0
Linseed meal	50.0	*Vit+Min premix	1.5
DDGS	38.3		

DDGS: Distiller's dried grains with solubles; Vit+Min premix: 150 mg $ZnSO_4.7H_2O$, 80 mg $MnSO_4.H_2O$, 200 mg MgO, 5 mg $CuSO_4.7H_2O$, 1 mg KIO_3, 5000 IU vitamin A, 1000 IU vitamin D, and 20 IU vitamin E.

Table 2. Chemical composition of concentrate, roughage, and whey used in the study

Chemical composition	Concentrate	Wheat straw	Whey powder
DM, g kg-1	875.8	927.0	974.1
CP, g kg-1	225.2	48.0	174.3
CA, g kg-1	95.1	76.1	85.3
EE, g kg-1	75.9	16.0	19.0
CF, g kg-1	83.3	323.6	-
NDF, g kg-1	227.3	730.5	-
ADF, g kg-1	105.1	494.4	-
ADL, g kg-1	40.4	88.0	-
NFC, g kg-1	376.3	129.4	721.4
ME, Mcal/kg	3052.1	2439.7	3057.2

DM: Dry matter (fed basis); CP: Crude Protein; CA: Crude Ash; CF: Crude Fiber; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; ADL: Acid Detergent Lignin; NFC: Non-Fiber Carbohydrate; ME: Metabolizable Energy (Kcal/kg)

Total weight gain (TWG) of treatment groups are presented in Figure 1. There were no significant differences observed in treatment groups (P > 0.05). On the other hand, the average TWG value of the whey group is 8.60% higher than the control group (13.96 kg vs. 12.76 kg).

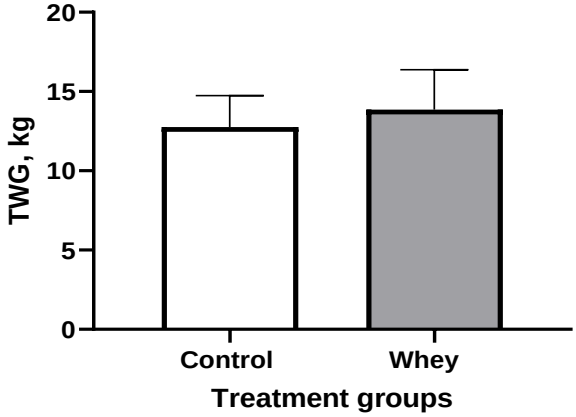

Figure 1. Total weight gain in control whey-treated group

As shown in Figure 1, no significant differences were observed between the control and whey treatment groups (P > 0.05). On the other hand, obtained results from this study clearly show that whey-protein enriched water improved TWG in fattening lamb. The high lactose content of whey protein-enriched water and rumen fermentation patterns maybe explain the improvement of TWG. It has been well documented by Schingoethe (1976) that; ruminants can consume up to 30% of their dry matter intake as liquid whey without impaired performance, while non-ruminants, such as swine, cannot consume more than 20% of their dry matter intake without being diarrhea. One limitation of this study is that; it was performed in farm conditions without any obtaining feed and water consumption data of lambs. Therefore, it is not possible to make a clear-eyed assessment for how much lamb consumed protein-enriched water on a dry matter basis in their diets. Also, considering this situation, there was no adverse effect of whey protein-enriched water observed during the animal trial in this study.

A sample image from the ultrasound measurement was given in Figure 2, while the measured values for LED and FT are given in Figures 3 and 4. The initial and the final LED of control and whey groups were measured as 2.12 – 2.18 and 1.99 – 2.27 cm, respectively (Figure 3). The differences between initial and final LED was 4.7 times higher in the whey group than the control group (0.28 cm vs. 0.06 cm). As the LED, there were no significant differences observed between treatment groups for FT (P > 0.05). The initial and the final FT of control and whey groups were measured as 3.91 – 3.28 and 3.45 – 3.26 mm, respectively (Figure 4).

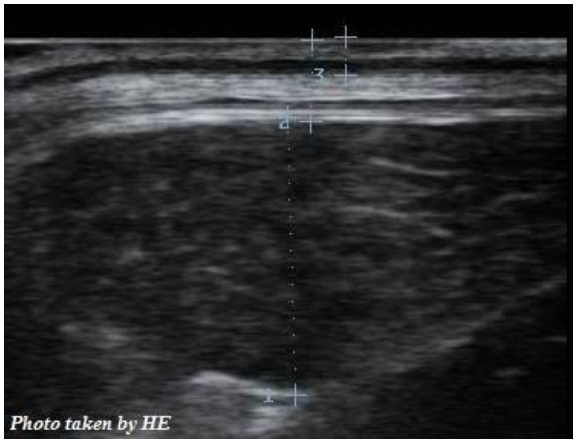

Figure 2. A sample image from ultrasound measurement (1: LED, 2: FT + ST; 3: ST)

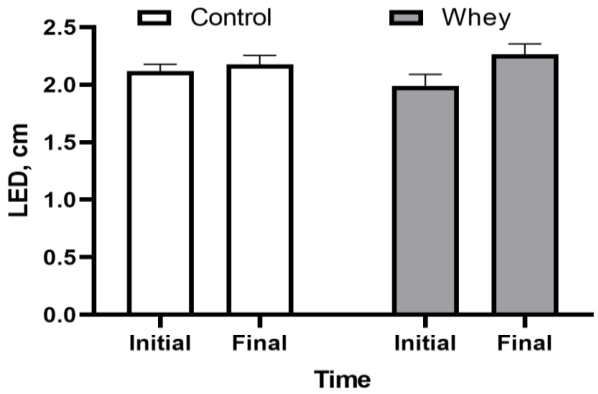

Figure 3. The mean loin eye depth of control and whey-treated group

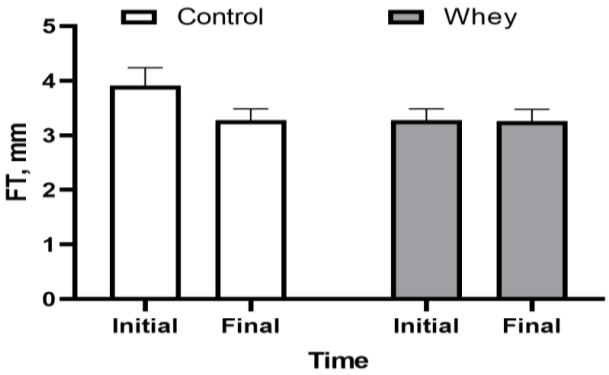

Figure 4. The mean fat thickness of control and whey-treated group

It has been reported that the protein efficiency ratio (PER) of whey is higher than casein (3.0-3.2 vs. 2.5).

Moreover, whey proteins have more branched-chain (leucine, isoleucine and, valine) and sulfur-containing amino acids (cysteine and methionine), which contributes to higher PER compared to casein (Bastien and Harper 2003; Saleh et al., 2007). Therefore, whey protein is described as a well-known one of the highest quality naturally-occurring proteins by several authors (Schingoethe, 1976; Walzem et al., 2002; Saleh et al., 2007). It has also been noted that the maximum concentration of essential amino acids in the plasma of pig was 1.5-2.5 times higher when whey-based beverages were ingested than casein-based beverages (Lorieau et al., 2019). Recent studies clearly show that with the presence of abundance of an amino acids in the plasma, muscular protein synthesis tent to increase due to increased mechanistic target of rapamycin (mTOR) activity (Ham et al., 2014). In the current study, as shown in Figure 3, the LED of the whey protein-enriched group did not statistically differ from the control group ($P > 0.05$). The other obtained results show that muscle development in the whey treated group was higher than the control group due to the differences in LED measured at the initial and the final periods (0.28 cm vs. 0.06 cm). It may be explained by an increased level of insulin secretion in plasma may result in more muscle development because of the high level of branched-chain essential amino acids, e.g., leucine, isoleucine, valine, and lysine, as well as individual differences of lambs. Similar results were also reported by Schweiger et al. (1986) and Nilsson et al. (2007).

Subcutaneous FT measurement was also performed in the current study, and no significant differences were observed between treatment groups (Figure 4). Regarding the FT measurements taken from the end of the fattening period were slightly higher than measured by Lupo et al. (2019) in crossbreeds of Santa Inês and undefined breed (3.28 mm for control and 3.26 mm for whey-treated vs. 2.80 for control, 3.09 for a diet with whey powder, 3.02 for a diet with liquid whey). As previously reported by Beauchemin et al. (1995), fat deposition in ruminants is directly influenced by the diet's energy level. Such as, increased glucose levels in plasma may result in more fat deposition throughout the body. The final FT values of treatment groups were nearly the same in the current study. It may be related to the usage of whey powder in a lesser amount to imitate liquid whey. It has also been reported that up to 30% of total dry matter intake of whey could be tolerated by ruminants without any adverse effects or impaired performance (Anderson et al., 1974; Schingoethe, 1976). These literature reports and obtained results from the study indicate that there are no adverse effects of whey on subcutaneous FT when used in liquid or imitating liquid form (about 6-7% percent of dry matter).

Conclusion

The fattening performance and in vivo carcass measurements obtained from the current study clearly shows that adding whey into the lamb drink could be used to improve TWG and LED without increasing the FT in the fattening period. Moreover, due to ease of use and storage conditions of dried whey, expanding the usage of whey will contribute to both livestock enterprises and a cleaner environment.

Compliance with Ethical Standards

a. Authors' Contributions

TB, AA, and HE contributed to the project idea, design and execution of the study. HE, SE, and MK carried out the feeding trial, live weight, and in vivo carcass measurements. SE and HE performed the statistical analysis and drafted the manuscript. TB and AA revised it critically. All authors read and approved the final manuscript.

b. Conflict of Interest

The authors declare that there is no conflict of interest.

c. Statement on the Welfare of Animals

The study protocol was approved by the Ethical Committee of the Veterinary Control Central Research Institute (Approval number: 2017/06).

d. Statement of Human Rights

This study does not involve human participants.

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