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Changes in serum electrolyte levels of whey-drinking lambs

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ABSTRACT

Aim: The study was aimed to reveal the effects of high biological value whey on serum electrolyte levels of lambs.

Method and materials: Weaned 3 months old and 24 healthy male Merino lambs kept in a farm were randomly divided into 2 equal groups. The lambs were fed with lamb grower feed as concentrate feed and wheat straw as roughage. The control group was given *ad libitum* tap water as drinking water. Drinking water was prepared by adding 6.56 g of whey powder to 100 L of tap water and given to the experimental group *ad libitum*. The trial period was 45 days. On days 0 and 30 of the following 30 days, blood was collected from the vena jugularis of all lambs. Serum potassium and sodium analyzes were performed using a fully automatic dry chemistry analyzer.

Results: The serum potassium concentrations of the 30th day in the control and experimental groups were found significantly lower than those of the 0th day ($p<0.05$). Serum sodium concentrations were not significantly different between days 0 and 30 in the control and experimental groups. Serum potassium and sodium concentrations were not significantly different between the control and experimental groups, neither at day 0 nor at day 30.

Conclusion: It was concluded that essentially, high serum potassium levels are also not a desirable outcome due to its harmful effects on the heart.

Keywords: Lamb, potassium, sodium, whey.

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Introduction

Whey is the liquid fraction of milk that remains after the production of paneer, cheese, casein and chana. Serum proteins contain approximately 45-55% of the nutrients in milk consisting of vitamins, proteins, lactose and minerals. Whey-based blends are formulated to provide a composition similar to nonfat dry milk (Macwan et al., 2016).

The beneficial effects of whey on nutrition may be due to the protein synthesis-stimulating anabolic effects of its protein and branched-chain amino acid content (Huang et al., 2017). Soy protein and casein produce potentially less muscle protein synthesis than whey proteins (Tang et al., 2009). Whey protein has high biological value and branched-chain amino acids that promote muscle recovery by further stimulating protein intake and synthesis (Hassan, 2017).

An antioxidant with anti-inflammatory properties was also constituted that increase glutathione content and prevent DNA damage (Hassan et al., 2012). It has been reported that especially polymerized whey protein is stable in the presence of pepsin and is rapidly degraded by pancreatin (Wang et al., 2017).

One of the ways whey can be utilized is by incorporating it into animal feed formulations (Zadow, 1987). Whey mixtures are mainly used in animal feed products (Macwan et al., 2016). About 16% of 2.67 million tons of whey production in New Zealand and about 28% of 1.65 million tons of whey production in Australia is used for pig feed (Zadow, 1987). 5% of total whey production in Australia is used as calf milk replacer. The dairy industry in the Netherlands uses approximately 120.000 tons of lactose-deprived whey powder and 15.000 tons of liquid whey for the production of calf milk replacer (Hoogstraten, 1987).

Whey is a rich source of nutritional components and the effects of its biological components have been proven in the treatment of various chronic diseases such as cancer, HIV and cardiovascular diseases. It is also successfully applied in the treatment of scaling in the urinary tract, skin problems, diarrhea, some poisonings and biliary diseases (Macwan et al., 2016). The mineral content of whey contains low molecular weight milk proteins together with high concentrations of beneficial electrolytes, and the K/Na ratio of milk is approximately 3 (Mitsubori et al., 1990). Whey is a good source of electrolytes (Macwan et al., 2016), containing potassium and sodium needed during diarrhea relief, but has low potassium and sodium content (Sohrabi et al., 2019). The present study aimed to reveal the effects of high biological value whey on serum electrolyte levels of lambs.

Materials and Methods

The study protocol was approved by the Veterinary Control Central Research Institute Ethics Committee (Approval number: 2017/06). Weaned 3 months old and 24 healthy male Merino lambs kept in a farm were randomly divided into 2 equal groups. All lambs were fed with concentrate and roughage twice a day (8:00 in the morning and 17:00 in the evening). The lambs were fed with lamb grower feed as concentrate feed and wheat straw as roughage. The control group was given *ad libitum* tap water as drinking water. Drinking water was prepared by adding 6.56 g of whey powder purchased from Astosan (Gönen, Balikesir) to 100 L of tap water and given to the experimental group *ad libitum*. The content of lamb grower feed used in the research was presented (Table 1), and the chemical analysis results of lamb grower feed, wheat straw and whey powder were presented (Table 2).

The trial period was 45 days. The first 15 days were evaluated as the adaptation process of lambs to whey. On days 0 and 30 of the following 30 days, blood was collected from the vena jugularis of all lambs in 8 ml vacuum and gel tubes (Vacutest® Kima, Italy). Blood brought to the laboratory in cold conditions was centrifuged at 2000 g for 10 minutes (Hettich® Rotofix 32A, Kirchlengern, Germany). The serums were transferred to 2 ml eppendorf serum storage tubes and stored in a deep freezer at -80 °C until analysis. At the time of analysis, the sera were thawed at 4 °C. Serum potassium and sodium analyzes were performed using a fully automatic dry chemistry analyzer (Fujifilm® DRI-Chem NX500i, Fuji Medical Sys. Co., Ltd., Tokyo, Japan).

Statistical analyzes were made with the help of IBM® SPSS® Statistics for Windows program (V. 21, Armonk, NY, USA). Data are given as means and standard error of means. Differences between days and groups were tested by analysis of variance (one-way ANOVA) and Tukey post-hoc test. Statistically significant differences are given as $P<0.05$.

Table 1. Components of lamb grower feed used in the study (Eseceli et al., 2021).

Components	g/kg	Components	g/kg
Wheat bran	251.0	Rice bran	35.5
Corn grain	170.0	Limestone	31.0
Cornflour	127.3	Ammonium chloride	6.0
Barley	100.0	Molasses	5.0
Sunflower seed meal	96.4	Provin	5.0
Boncalite	80.0	Salt	3.0
Flaxseed meal	50.0	Mineral and vitamin premix*	1.5
Distillers dried grains with solubles	38.3		

*Mineral and vitamin 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, 20 IU vitamin E.

Table 2. Chemical composition of lamb grower feed, wheat straw and whey powder used in the study (Eseceli et al., 2021).

Chemical composition	Lamb grower feed	Wheat straw	Whey powder
Dry matter (fed basis), g/kg	875.8	927.0	974.1
Crude protein, g/kg	225.2	48.0	174.3
Crude ash, g/kg	95.1	76.1	85.3
Ether extractives, g/kg	75.9	16.0	19.0
Crude fiber, g/kg	83.3	323.6	-
Neutral detergent fiber, g/kg	227.3	730.5	-
Acid detergent fiber, g/kg	105.1	494.4	-
Acid detergent lignin, g/kg	40.4	88.0	-
Non-fiber carbohydrate, g/kg	376.3	129.4	721.4
Metabolizable energy, kcal/kg	3052.1	2439.7	3057.2
Potasyum g/kg	8.35	22.83	22.22
Sodyum g/kg	1.78	0.46	1.78

Results and Discussion

Serum potassium concentrations were 6.23 mmol/L on day 0 and 1.14 mmol/L on day 30 in the control group, 5.70 mmol/L on day 0 and 1.14 mmol/L on day 30 in the experimental group. The standard error of the means was 0.03. The serum potassium concentrations of the 30th day in the control and experimental groups were found significantly lower than those of the 0th day ($p<0.05$). Concentrations were not significantly different between the control and experimental groups, neither at day 0 nor at day 30 (Fig 1).

Serum sodium concentrations were 77.1 mmol/L on day 0 and 78.4 mmol/L on day 30 in the control group, 77.6 mmol/L on day 0 and 77.5 mmol/L on day 30 in the experimental group. The standard error of the means was 0.10. Serum sodium concentrations were not significantly different between days 0 and 30 in the control and experimental groups. Similarly, the concentrations were not significantly different at either day 0 or day 30 between the control and experimental groups (Fig 2).

All members of the animal and plant kingdom in nature need inorganic elements for their survival and efficient performance. These elements are present in the cells and tissues of animals in certain concentrations necessary for the normal growth, health and productivity of animals (Ranjith and Pandey, 2015). Electrolytes in the blood are important substances needed to maintain the body's acid-base balance and osmotic pressure. Electrolytes have different distributions inside and outside the cell, and electrolyte disturbance causes clinical symptoms, especially cardiac related (Hinkle, 2011).

The main function of potassium ion is to modulate acid-base balance and osmotic pressure and maintain normal function of myocardium, neuromuscular stress and cell metabolism (Wang et al., 2023). Potassium is also involved in the transmission of muscle contractions and nerve impulses (Macwan et al., 2016).

Fig 1. Changes in serum potassium levels in lambs with or without whey added to drinking water (there are significant differences at $p<0.05$ level between levels indicated with different letters).

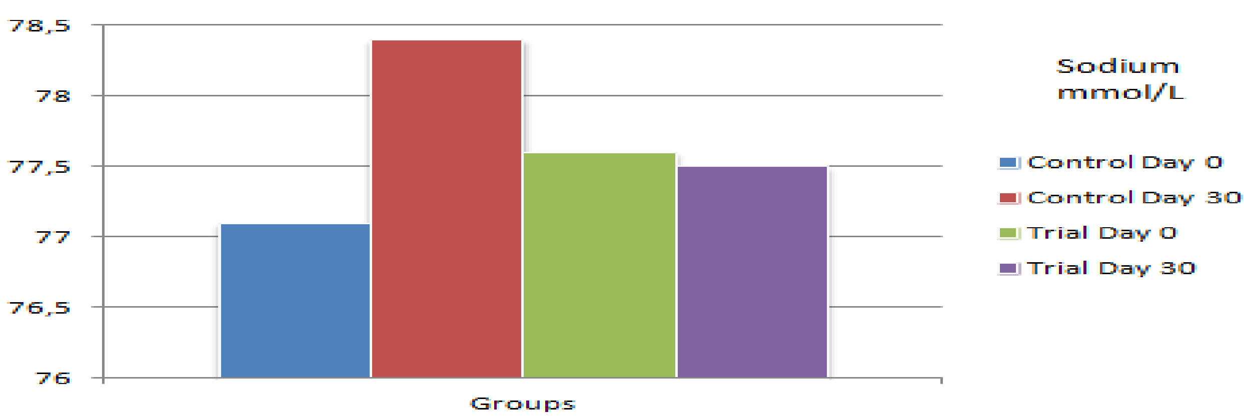

Fig 2. Changes in serum sodium levels in lambs with and without whey added to drinking water.

Some epidemiological reports on the beneficial effects of potassium report that higher intake of this electrolyte is always associated with higher milk intake (Mitsubori et al., 1990). Decreased food consumption or increased urination can cause blood potassium to drop (Wang et al., 2023). It was also reported that any change in serum potassium may cause cardiac fatal outcomes (Sohrabi et al., 2019).

There was no literature on the effect of whey use on serum potassium concentrations in other animals except rats. Wang et al. (2023) divided the rats into 4 groups in their study. While they did not make any contribution to the first group, they added 0.5% a polymerized whey protein concentrate nanoparticle powder with CoQ_{10} added to the feeds of the 2nd group, 1% to the 3rd group's feeds and 4% to the 4th group's feeds. The researchers determined that the serum potassium concentrations of the rats, which were added 4% mixture to their feed, were significantly lower than the other groups. Sahathevan et al. (2018) added whey protein isolate for 6 months to the diets of the patients in the experimental group who underwent peritoneal dialysis. They found high potassium concentrations in only 1 of 65 patients in the trial group. The investigators reported that the reason for this was that this patient was fed a nutrient-rich diet with whey protein isolate.

Limwannata et al. (2021) added whey protein isolate to the diets of malnourished hemodialysis patients. After 30 days, they could not detect a significant difference between serum potassium concentrations of the supplemented group (4.4 mEq/L) and those of the control group (4.2 mEq/L). Polberger et al. (1999) fed premature infants with either bovine whey protein supplement or ultrafiltered human milk protein for 24 days. The investigators found that serum potassium concentrations at both the beginning and the end of the study were not significantly different between the 2 groups.

Hall et al. (1984), divided premature infants into 2 groups and fed 1 group with soy isolate formula and fed the other group with whey premature formula. While the researchers did not find the serum potassium concentrations significantly different between the 2 groups at the 3rd, 5th and 7th weeks of the study, they found the soy group concentrations (4.8 mEq/L) to be significantly lower than the whey group (5.5 mEq/L) at the 8th week ($p<0.05$). Similarly, Kawase et al. (2000), made healthy adult men drink fermented milk supplemented with whey protein concentrate for 8 weeks. While the serum potassium concentration of the fermented milk drinker group was not significantly different from the pre-experimental levels at 4 weeks (4.21 vs. 4.08 mEq/L), it was found to be significantly higher (4.31 vs. 4.08 mEq/L) at 8 weeks ($p<0.01$).

In the current study, serum potassium concentrations were not significantly different between the experimental and control groups at the end of 30 days (1.14 mmol/L in both groups), based on the findings of Limwannata et al. (2021), Polberger et al. (1999), Hall et al. (1984), and Kawase et al. (2000). Hall et al. (1984) found no significant difference in serum potassium concentrations between the control and experimental groups at the 3rd, 5th and 7th weeks of their study, while Kawase et al. (2000) could not detect a significant difference between the pre-experiment and the 4th week levels.

Sohrabi et al. (2019) gave whey drink to malnourished hemodialysis patients for 2 months. They found that serum potassium concentrations of the whey drink group (5.20 mEq/L) were significantly higher than those of the control group (4.06 mEq/L) after 2 months ($p<0.05$). Mitsubori et al. (1990) fed male rats with spontaneous hypertension for 11 weeks and female rats for 9 weeks with whey mineral concentrate. At the end of these periods, the researchers determined that the serum potassium concentrations of the group given whey mineral concentrate were significantly higher than those of the control group, which was not given. While the levels were 7.7 mEq/L in the male experimental group and 6.6 mEq/L in the control group ($p<0.01$), they were 5.3 mEq/L in the female experimental group and 4.2 mEq/L in the control group ($p<0.05$).

In the present study, serum potassium concentrations at the end of 30 days were 1.14 mmol/L in the whey group and the control group. These results are not compatible with the findings obtained by Hall et al. (1984), Sohrabi et al. (2019), Mitsubori et al. (1990), and Kawase et al. (2000) 2 months later in their research. The reason why no significant difference was found between the 2 groups in the current study is probably because the trial period was shorter than that of other investigators (30 days). Other investigators continued the whey application for at least 2 months. In the current study, serum potassium concentrations (5.70 mmol/L to 6.23 mmol/L, respectively) determined before the experiment in the experimental and control groups were significantly decreased in both groups (1.14 mmol/L) at the end of the 30th day. The reason for the decrease in serum potassium levels in both groups with the following days may be the gradual enlargement of the lambs or changes in air temperature.

There was no literature on the effect of whey use on serum sodium concentrations in other animals except rats. Sohrabi et al. (2019) vücutta veya serumdaki düşük sodyum içeriğinin aşırı sıvı yüklenmesini ve hipertansiyonu azaltabileceğini belirtmişlerdir. Polberger et al. (1999) gave premature infants a bovine whey protein supplement or ultrafiltered human milk protein for 24 days and found no significantly different serum sodium concentrations between the 2 groups at the beginning and end of the study. Similarly, Limwannata et al. (2021) added whey protein isolate to the diets of malnourished hemodialysis patients and found no significant difference in serum sodium concentrations of the supplemented group (137.1 mEq/L) and the control group (142.0 mEq/L) after 30 days.

Kawase et al. (2000) fed fermented milk supplemented with whey protein concentrate to healthy adult males for 8 weeks and did not find the serum sodium concentration of the fermented milk beverage group to be significantly different from pre-experimental levels at weeks 4 and 8. Hall et al. (1984) divided premature infants into 2 groups and fed one group with soy isolate formula and the other group with whey premature formula. The researchers did not find the serum sodium concentrations significantly different between the 2 groups at the 3rd, 5th, 7th and 8th weeks of the study. Mitsubori et al. (1990) fed male rats with spontaneous hypertension for 11 weeks and female rats for 9 weeks with whey mineral concentrate and found that serum sodium levels were not affected by the diet regimen in both sexes. Conversely, Sohrabi et al. (2019) gave a whey beverage to malnourished hemodialysis patients for 2 months and determined that the serum sodium concentrations of the whey beverage group (135.38 mEq/L) were significantly lower than the control group (137.78 mEq/L) after 2 months ($p<0.01$).

In this study, serum sodium concentrations were not significantly different at the end of 30 days between the experimental (77.5 mmol/L) and control (78.4 mmol/L) groups. Although these results showed parallelism with findings of Polberger et al. (1999), Limwannata et al. (2021), Kawase et al. (2000), Hall et al. (1984), and Mitsubori et al. (1990), they are not compatible with the findings of Sohrabi et al. (2019). The reason for the difference may be duration of trial period of Sohrabi et al. (2019).

Conclusion

It was concluded that the use of whey for 30 days in lambs at the doses in the current study did not have a significant effect on serum levels of potassium and sodium electrolytes. The study can be repeated by increasing the application time or dose. Essentially, high serum potassium levels are also not a desirable outcome due to its harmful effects on the heart (Sohrabi et al., 2019). Accordingly, it can be recommended that the whey usage period should not exceed 2 months..

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