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# Effects of Freely Accessed Whey on Performance and Metabolism of Growing *Murciano-Granadina* Goats

Research Article

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## ABSTRACT

The objective of the present study was to determine effects of freely accessed whey on feed intake and efficiency, growth performance, and various blood indicators of intermediary metabolism in growing *Murciano-Granadina* dairy goats. Thirty 5-month-old growing goats (16±1 kg body weight; 15 males and 15 females) were randomly assigned to three treatments (10 goats per each treatment) in a completely randomized design study. The experimental treatments were provisions of 1) only freely accessed water or WA (without whey), 2) only freely accessed whey or WY (without water), and 3) freely accessed whey and water or WW (separately). The experiment lasted for 84 days including 14 days of adaptation and 70 days of sampling and data collection. A same total mixed ration was offered to all goats three times daily at 07:00, 14:00, and 21:00 h. Feed and liquid (whey and water) intakes were recorded daily and body weight (BW), body condition score (BCS), and rectal temperature (RT) were recorded biweekly. Blood was sampled at 0900 h on days 37, 60, and 84 for blood metabolites measurements. Data were analyzed by using the Mixed Model Procedures of SAS program. Results showed that BCS, RT, and daily feed and liquid intakes were not affected by treatments (P>0.05). However, average daily gain (ADG) and feed conversion ratio (FCR) were different among treatments (P<0.05), such that female goats fed WY had lower ADG and higher FCR than other female groups. Blood beta-hydroxy butyric acid concentrations were higher (P<0.05) in goats fed WY than in other goats. Blood insulin and non-esterified fatty acids concentration were lower (P<0.05) in goats on WW than in other goats. Blood total protein, albumin, and urea concentration were similar (P>0.05) among treatments. Findings confirmed that offering water and whey together (WW) had no undesirable impacts on goat growth performance. Thus, based on the results of the present study, freely accessed whey may be offered to growing goats alongside water. Also, male goats can effectively utilize WY (offering only whey without water) without any impacts on growth performance. Offering WY to growing goats increased blood glucose and different lipids and decreased some of the liver enzymes, which possess health and metabolic implications and warrant future investigations.

KEY WORDS feed intake, growing goat, metabolism, water, whey.

## INTRODUCTION

Whey is a nutritious byproduct of cheese-making industries (Bylund, 2003). To prevent its wastage in the environment and causing pollution, whey may be utilized in animal nutrition. Whey contains 40-50% of milk's total solids, 70% of milk's lactose, 20% of milk's protein, 70-90% of milk's minerals and almost all milk's water-soluble vitamins.

Whey proteins include 50% β-lactoglobulin, 25% α-lactalbumin, and 25% other proteins. Whey is also a source of calcium, phosphorous, and essential amino acids (Devi *et al.* 2017). Whey is either acidic (pH<5.1) or sweet (pH>5.6) (Miller *et al.* 2006).The acidic whey has more calcium and ash, less protein, and lacks caseinomacropeptide (Konrad *et al.* 2012). As a result, acidic whey is less palatable and has limited nutritional value (Baldissera *et al.* 2011).

Whey as a source of organic matters is considered an environmental pollutant (Thivend, 1977). Thus, whey may be used in animal nutrition to minimize and possibly avoid its excretion to the environment. As such, whey has been fed to large ruminants namely dairy cattle (Schingoethe, 1976; Remond *et al.* 1978). In a study (Pinchasov *et al.* 1982), milk fat content was improved by feeding whey to dairy cows. In another study (Salem and Fraj, 2007), feeding whey to dairy cows increased dry matter intake, feed efficiency, and fat-corrected milk yield, but did not affect dry and organic matters digestibility. In a dairy goat study (Rapetti *et al.* 1995), feeding whey improved feed efficiency and milk fat content. The scarcity of data on growing goats was the impetus for the current study. Feeding whey would prevent wasting it and contaminating the environment. In addition, water intake may be reduced where water shortages seriously exist. Therefore, the objective of the current study was to determine effects of freely accessed whey on total liquid and feed intake, feed conversion ratio, average daily gain, rectal temperature, body condition score (BCS), and selected blood metabolites in growing *Murciano-Granadina* dairy goats.

## MATERIALS AND METHODS

**Experimental design and animal management**

Thirty 5-month-old growing *Murciano-Granadina*goats (15 males and 15 females; 16 ± 1 kg body weight at the commencement of the experiment) were randomly assigned to three treatments in a completely randomized design study. The treatments included provision of freely accessed 1) clean water i.e., WA, 2) whey (without water) i.e., WY, 3) or whey and water (separately) i.e., WW. Each treatment had 10 replicates (5 males and 5 females). The experiment lasted for 84 days including 14 days of adaptation and 70 days of sampling and data collection. This study was conducted at Ghale-Ganj dairy goat farm (Kerman, Iran). The liquid whey's chemical composition was given in Table 1. Goats were offered a same total mixed ration three times daily at 00:70, 14:00, and 21:00 h. The diet was formulated using the SRNS software program (NRC, 2007). The diet nutritional characteristics were presented in Table 2. Animals were cared for according to the guidelines of Iranian Council on Animal Care (1995).

**Sampling and data collection**

Body weight was recorded weekly. Body condition score (1 to 5 scale) and rectal temperature were recorded biweekly. Liquid and feed intake were measured and recorded daily. Blood samples were taken on days 37, 60, and 84 at 09:00 h. Blood was put on ice immediately and transferred to the laboratory for later metabolite measurements. Blood samples were centrifuged at 2500 rpm for 10 min to harvest serum for later measurement of blood metabolites. Serum was kept at -20 degrees Celsius. Serum was analyzed for glucose, urea, non-esterified fatty acids (NEFA), beta-hydroxy butyric acid (BHBA), albumin, total protein, cholesterol, triglyceride, calcium, phosphorous, high-density lipoprotein (HDL), and liver enzymes (aspartate transaminase (AST), alanine aminotransferase (ALT)) using a spectrophotometer analyzer (Alcyon 300I, USA) with standard kits (Randox, Ranbut, UK; Pars Azmoon, Karaj, Iran). Serum insulin was measured by using an automated Analyzer (ELISA, BioTech ELX800, USA) with standard kits (Monobind, USA). Feed was analyzed for crude protein (CP), Neutral detergent fiber (NDF), and acid detergent fiber (ADF) according to AOAC (2005). Minerals were measured by using atomic absorption technique (AOAC, 2005).

**Statistical analysis**

Data were ensured to possess normal distribution after treating with Univariate Procedures of SAS (2004) Program. For this purpose, Shapiro-wilk and Bartlett's Tests were used. Data were then analyzed by using the Mixed Model Procedures of the SAS program. The final model included fixed effects of treatment, sex, treatment × sex, and random effects of goat within (treatment×sex) and residual errors. Models for repeated measurements included fixed effects of treatment, sex, time, and two-way and three-way interactions. The best fit covariance structure was used for the analysis of repeated measures. Initial values (e.g., BW) were modeled as covariate. Means were compared by using the multiple-range Tukey-Kramer test.

## RESULTS AND DISCUSSION

The paucity of literature exists on whey feeding in commercial goats. The present research reports new information onpractical whey nutrition and utilization by growing goats, investigating feed intake and growth performance, feed conversion ratio, body condition score, rectal temperature, and major blood metabolites responses. Data for daily dry matter and total fluid intakes and rectal temperature (RT) are shown in Table 3.

Dry matter intake (DMI), total liquid intake (TLI), and RT were not significantly affected (P>0.05) by the treatments across the experiment.

**Table 1** Chemical composition of liquid whey

| **Ingredients** | |
|---|---|
| Fat (%) | 1.2 |
| Protein (%) | 2.8 |
| Lactose (%) | 4.2 |
| Solids non-fat (%) | 7.6 |
| Ca (mg/L) | 45 |
| Mg (mg/L) | 10 |
| Cl (mg/L) | 40 |
| Na (mg/L) | 95 |
| K (mg/L) | 200 |
| NaCl (mg/L) | 66 |
| pH | 4.25 |
| Density | 28.52 |

**Table 2** Ingredients and nutrient composition of the experimental diet

| **Ingredients (%)** | |
|---|---|
| Alfalfa hay | 18.6 |
| Corn silage | 15.5 |
| Wheat straw | 4.5 |
| Ground corn | 19.0 |
| Ground barley | 9.5 |
| Soybean meal | 8.5 |
| Canola meal | 6.0 |
| Meat meal | 1.5 |
| Wheat bran | 11.0 |
| Calcium carbonate | 0.2 |
| Dicalcium phosphate | 1.4 |
| Salt | 0.3 |
| Premix[1] | 2.6 |
| Magnesium oxide | 0.68 |
| Bentonite | 0.72 |
| Total | 100 |
| **Nutrient composition** | |
| Crude protein (%) | 15.7 |
| Neutral detergent fiber (%) | 31.2 |
| Acid detergent fiber (%) | 22.0 |
| Non-fiber carbohydrates (%) | 40.8 |
| Ash (%) | 11.4 |
| Ca (%) | 0.9 |
| P (%) | 0.4 |
| Metabolizable energy (Mcal/kg DM) | 2.43 |

[1] The premix (per kg) contained: vitamin A: 5000 IU/kg; vitamin D: 1000 IU/kg; vitamin E: 6 IU/kg; Mn: 4000 mg; Cu: 700 mg; Zn: 5000 mg; Co: 50 mg; I: 100 mg; Se: 30 mg; P: 70 g and Ca: 100 g.

**Table 3** The effect of experimental treatments on rectum temperature, and dry matter and fluid intakes in growing goats

| **Variable** | **WA** | **WY** | **WW** | **SEM** | **P-value** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Treatment (Trt) | Sex | Time | Time × Trt | Sex × Trt | Time × Sex | Sex × Time × Trt |
| Liquid intake (L) | 5.1 | 4.9 | 5.2 | 0.077 | 0.35 | 0.65 | 0.0001 | 0.01 | 0.77 | 0.0001 | 0.08 |
| Dry matter intake (g) | 1077 | 1008 | 1018 | 31.49 | 0.42 | 0.0001 | 0.0001 | 0.33 | 0.92 | 0.46 | 0.62 |
| Rectal temperature (˚C) | 39.1 | 39.1 | 39.8 | 0.04 | 0.09 | 0.53 | 0.36 | 0.79 | 0.84 | 0.76 | 0.88 |

WA: goats with free access to water; WY: goats with free access to whey and WW: goats with free access to whey and water.
SEM: standard error of the means.

However, treatments interacted with goat sex and time (P<0.05) in affecting TLI (Figures 1 and 2).

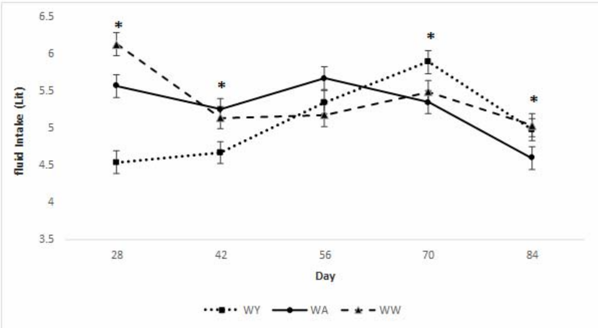


**Figure 1** Fluid intake in growing goats fed the experimental treatments at different times. WA: goats with free access to water; WY: goats with free access to whey and WW: goats with free access to whey and water

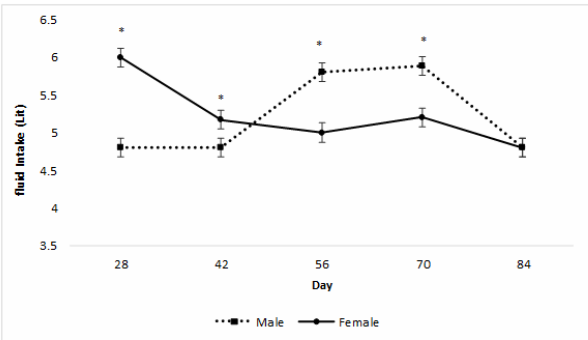


**Figure 2** The effect of goat sex on total fluid intake during the experiment

During the first 28 and 42 days of the experiment, goats fed WY had lower TLI (P<0.05) than goats on other treatments, but later on days 70 and 84, the WY goats had greater TLI (P<0.05) than the other goats (Figure 1). These results clearly show that growing goats learn to drink more liquid from WY if they would have access only to WY without access to water. In terms of goat sex interaction with time, male goats had lower TLI than did female goats at the beginning of the experiment, but achieved greater TLI later towards the end of the experiment (Figure 2). This interaction suggests time-dependent responses in liquid intake of different goat genders.

Growth and BCS data are presented in Table 4. Treatments were not different in terms of BCS (P>0.05). However, average average daily gain (ADG) and feed conversion ratio (FCR) were significantly affected by the treatments (P<0.05). Treatments interacted with sex on ADG and FCR (P<0.05), such that female goats on WY had lower ADG and higher FCR than did female goats on the other treatments. Male goats, however, had similar ADG and FCR across the treatments (Table 4).

These data suggest that goat gender affects how whey impacts growth and feed efficiency. Female goats had lower BCS than did male goats (P<0.05). The lower BCS of female than of male goats may have, thus, affected their significant responses to whey consumption.

Data for blood metabolites are presented in Table 5. Effects of treatment, sex, time and interactions on blood metabolites were studied.

**Table 4** The effect of experimental treatments (Trt) on growth parameters in male and female growing goats

| Variable | Female | | | Male | | | SEM | P-value | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | WA | WY | WW | WA | WY | WW | | Trt | Sex | Sex × Trt |
| Average daily gain (gr/d) | 88[b] | 72[c] | 90[ab] | 99[a] | 96[ab] | 94[ab] | 3.08 | 0.01 | 0.002 | 0.009 |
| Feed conversion ratio | 11.3[b] | 13.2[a] | 10.9[b] | 11.2[b] | 11[b] | 11.4[b] | 0.37 | 0.02 | 0.15 | 0.002 |
| BCS | 2.8[ab] | 2.7[b] | 2.8[ab] | 3[a] | 3[a] | 3[a] | 0.065 | 0.73 | 0.0006 | 0.72 |

WA: goats with free access to water; WY: goats with free access to whey and WW: goats with free access to whey and water.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

**Table 5** The effect of experimental treatments (Trt), sex, time, and interactions on blood parameters of growing goats

| Variable | WA | WY | WW | SEM | P-value | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Trt | Sex | Time | Trt × Time | Trt × Sex | Sex × Time | Trt × Time × Sex |
| Total protein (g/dL) | 6.3 | 6.1 | 6.2 | 0.172 | 0.4 | 0.29 | 0.001 | 0.04 | 0.84 | 0.745 | 0.186 |
| Albumin (g/dL) | 3.3 | 3.1 | 3.2 | 0.076 | 0.648 | 0.504 | 0.002 | 0.05 | 0.441 | 0.2 | 0.769 |
| Urea (mg/dL) | 38 | 28 | 34 | 0.957 | 0.0001 | 0.288 | 0.0002 | 0.226 | 0.171 | 0.769 | 0.517 |
| NEFA (mmol/L) | 0.062[a] | 0.067[a] | 0.045[b] | 0.0005 | 0.022 | 0.606 | 0.016 | 0.282 | 0.623 | 0.772 | 0.373 |
| BHBA (mmol/L) | 0.362[b] | 0.532[a] | 0.361[b] | 0.021 | 0.0001 | 0.25 | 0.968 | 0.974 | 0.258 | 0.838 | 0.793 |
| Insulin (µIU/mL) | 7.2[a] | 6.8[a] | 5.5[b] | 0.206 | 0.0001 | 0.307 | 0.34 | 0.132 | 0.301 | 0.411 | 0.959 |

WA: goats with free access to water; WY: goats with free access to whey; WW: goats with free access to whey and water; NEFA: non-esterified fatty acids and BHBA: beta-hydroxy butyric acid.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Blood total protein, albumin and urea concentrations were not different among the treatments across the experiment (P>0.05). However, treatments interacted with time (P<0.05) on blood total protein and albumin (Table 5), such that goats on WY had lower blood albumin levels than did goats on other treatments at the earlier stage of the experiment, but achieved similar levels at later stages of the experiment (Figure 3).

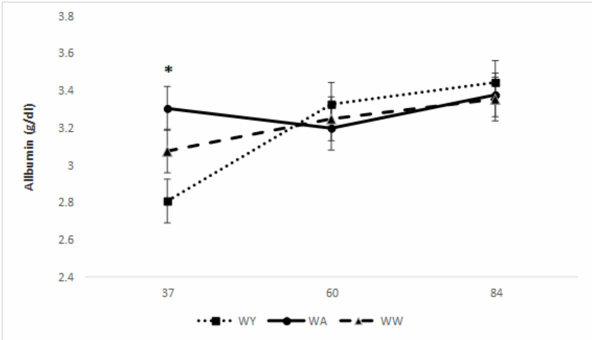


**Figure 3** Treatment effects on changes in blood albumin concentrations during the experiment. WA: goats with free access to water; WY: goats with free access to whey and WW: Goats with free access to whey and water

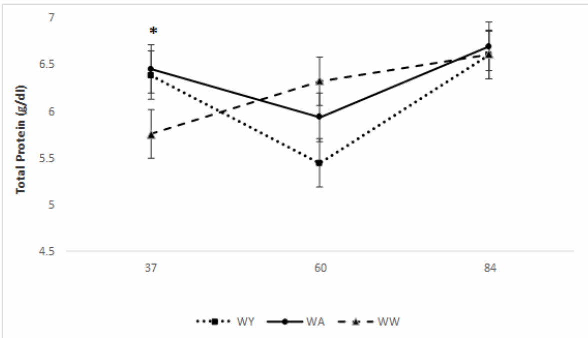


**Figure 4** Treatment effects on changes in blood total protein during the experiment. WA: goats with free access to water; WY: goats with free access to whey and WW: Goats with free access to whey and water

In addition, blood total protein concentrations fluctuated more in goats on WY than in other goats (Figure 4).

Blood NEFA and insulin concentrations were lower (P<0.05) in goats fed WW than in other goats. This finding suggests that offering water and whey together may reduce stress and trigger a positive metabolic response through which less body reserves are mobilized. Meanwhile, blood BHBA concentrations were higher (P<0.05) in goats on WY than in other goats. The circulating blood BHBA originates from two major sources including 1) incomplete metabolism of fatty acids in the liver and 2) increased rumen fermentation and rumen wall delivery of BHBA to the liver and circulating blood. Accordingly, the results of the present study suggest that offering whey alone WY may have affected the above two processes of BHBA production.

The concentrations of blood metabolites measured only at d 84 of the experiment are given in Table 6. Blood glucose concentrations were higher (P<0.05) in goats on WY and WW than in goats on WA. This finding confirmed that whey provision to growing goats improved energy status in all animals including both male and female goats. Although sex-dependent, offering WY increased blood concentrations of cholesterol and triglycerides. This increase was more pronounced in female than in male goats (Table 6). Also, WY decreased (P<0.05) some of the liver enzymes (i.e., ALT) concentrations.

These findings possess metabolic and health implications and suggest that offering WY to growing goats does alter intermediary metabolism and health indicators that require further examinations. Blood calcium and phosphorous concentrations were not affected (P>0.05) by the treatments (Table 6), suggesting that whey feeding did not affect the mechanisms underlying the changes in blood calcium and phosphorous.

Overall, whey provision improved energy status and manipulated intermediary metabolism and health markers of growing dairy goats.

**Table 6** The effect of experimental treatments (Trt) on blood parameters (day 84) of growing male and female goats

| Variable | Female | | | Male | | | SEM | P-value | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | WA | WW | WY | WA | WW | WY | | Trt | Sex | Trt × Sex |
| Glucose (mg/dL) | 44 | 47 | 47 | 45 | 49 | 52 | 1.86 | 0.049 | 0.221 | 0.586 |
| Cholesterol (mg/dL) | $48^{cd}$ | $51^{cd}$ | $111^{a}$ | $43^{d}$ | $56^{bc}$ | $65^{b}$ | 2.5 | 0.0001 | 0.0001 | 0.0001 |
| TG (mg/dL) | $20^{b}$ | $17.5^{a}$ | $36.6^{a}$ | $26.8^{ab}$ | $28^{ab}$ | $23.4^{b}$ | 2.5 | 0.01 | 0.594 | 0.0001 |
| AST (U/L) | $68^{a}$ | $53.8^{b}$ | $67^{ab}$ | $75^{a}$ | $75^{a}$ | $65^{ab}$ | 3.3 | 0.098 | 0.014 | 0.006 |
| ALT (U/L) | $15^{b}$ | $14^{bc}$ | $11^{c}$ | $21^{a}$ | $24^{a}$ | $17^{b}$ | 1.22 | 0.001 | 0.0001 | 0.023 |
| HDL (mg/dL) | $8.6^{c}$ | $10.8^{bc}$ | $18.4^{a}$ | $7.5^{c}$ | $10.5^{c}$ | $14.1^{b}$ | 0.771 | 0.0001 | 0.03 | 0.032 |
| Ca (mg/dL) | 8.9 | 8.1 | 9.2 | 9.4 | 10.1 | 9.3 | 0.61 | 0.959 | 0.229 | 0.266 |
| P (mg/dL) | 6.4 | 5.9 | 7 | 7 | 5.7 | 6.7 | 0.449 | 0.034 | 0.879 | 0.469 |

WA: goats with free access to water; WY: goats with free access to whey; WW: goats with free access to whey and water; AST: aspartate transaminase and ALT: alanine aminotransferase.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

## CONCLUSION

The findings confirmed that offering water and whey together (WW) is a practical and economical strategy that has no undesirable impacts on goat growth performance. Based on the results of the present study, freely accessed whey can be offered to growing goats alongside water. Also, male growing goats can effectively utilize WY (offering only whey without water) without any impact on growth performance. Although sex-dependent, offering WY to growing goats increased blood glucose and different lipids and decreased some of the liver enzymes. These data suggest improved energy status of growing dairy goats by whey provision and possess important metabolic and health implications that warrant future investigations.

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