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RESEARCH ARTICLE

Feeding Raw Garlic to Dairy Goats: Effects on Blood Metabolites and Lactation Performance [1]

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Summary

The study were conducted to evaluating the effects of raw garlic (GAR; 0, 30, 50 and 70 g/kg of DM) on metabolic status and milk production of dairy goats. Eight dairy goats (59±1 kg initial live weight) were randomly assigned according to a repeated 4×4 Latin square design over an 8-week period. Each experimental period lasted 14 d with the first 12 days used for diet adaptation and 2 days for data collection. Results of this study showed that there were no differences in feed intake or body weight changes during the experimental period due to garlic supplementation. Also feeding garlic increased serum glucose concentration (P<0.05), however no effects of garlic supplementation on blood non-esterified fatty acids (NEFA), β-hydroxybutyrate (BHB), total triglycerides, total protein, and albumin concentration were observed. In addition production of milk, milk protein, and lactose and fat corrected milk showed no treatment effects. However, milk fat content was decreased significantly (P<0.05) by garlic supplementation. The results of this study indicate that potency of garlic to increase serum glucose concentration can play a role in improvement the energy status of dairy goats.

Keywords: *Blood, Dairy, Garlic, Goat, Milk*

Sütçü Keçilerin Çiğ Sarımsak ile Beslenmesi: Kan Metabolitleri ve Laktasyon Performansına Etkileri

Özet

Bu çalışma çiğ sarımsağın (GAR; 0, 30, 50 ve 70 g/kg DM) sütçü keçilerde metabolizmaya ve süt üretimine etkisini araştırmak amacıyla yapılmıştır. Sekiz sütçü keçi (başlangıç ağırlıkları 59±1 kg) 8 haftalık tekrarlanan 4×4 Latin kare dizayna uygun olarak rastgele dağıtılmışlardır. Her bir deneysel periyot ilk 12 günü diyet adaptasyonu ve 2 günü veri toplama olmak üzere toplam 14 gün sürdü. Çalışma sonuçları sarımsak ile beslemenin yem tüketimi ve vücut ağılık artışı açısından fark oluşturmadığını gösterdi. Sarımsak ile besleme serum glikoz konsantrasyonunu artırırken kan esterlenmemiş yağ asitleri (NEFA), β-hidroksibütrat (BHB), total trigliserid, total protein ve albümin konsantrasyonlarında bir değişime neden olmadı. Sarımsak ile besleme uygulamasının ayrıca süt ve süt proteini üretimi ile laktoz ve yağ düzeltilmiş süte bir etkisinin olmadığı gözlemlendi. Ancak sarımsak uygulaması süt yağı miktarını önemli oranda düşürdü (P<0.05). Bu çalışmanın sonuçları serum glikoz konsantrasyonunu artırmak suretiyle sütçü keçilerde enerji düzeyini geliştirmek amacıyla sarımsağın kullanılabileceğini göstermektedir.

Anahtar sözcükler: *Kan, Sütçü, Sarımsak, Keçi, Süt*

INTRODUCTION

During the transition between late pregnancy and early lacta tion, dairy goats, like dairy cows, are under metabolic stress [1]. Failure to counteract this stress compromises postpartum health and milk production. In recent years, aromatic plants and their extracts have received increased attention as potential alternatives to growth promoters. In this regard, effects of garlic and its bioactive components have been partly demonstrated on rumen manipulation

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(*e.g.* defaunation, decreased methane production, decreased ruminal degradation of dietary proteins, reducing the proportion of acetate and increasing that of propionate) and consequently on animal production and performances [2-5]. The hypothesis addressed in this paper was that dietary addition of raw garlic would lead to efficacy of food utilization and improving in energy related blood metabolites, which would be reflected by increases in milk production and changes in milk composition.

MATERIAL and METHODS

Experimental Design, Animal Management and Diets

The study was performed at the experimental dairy goat farm of the University of Urmia, Iran. Eight pregnant Mahabadi (a native breed) goats with age of 4 years and body weight of 59±1 kg were selected as far as possible, for kidding date, parity and were randomly assigned according to a repeated 4×4 Latin square design with 12 days of adaptation and 2 days of sampling periods. At day 120±1 of pregnancy, the goats were fed daily a diet designed to cover 2.16 Mcal of metabolizable energy and 11.5% of crude protein (CP) per kg of DM [6]. The animals were divided into four groups and acclimatized to individual pens (5 m^2) for at least 4 weeks before the start of the experiment. Does were given their respective diets throughout gestation and were switched to a standard lactation diet (15.5% CP and 2.35 Mcal of metabolizable energy per kg of DM), offered to the animals immediately after kidding. The composition of the lactation diets is shown in *Table 1*.

All animals were fed with alfalfa hay and corn silage without or with garlic (0, 30, 50 and 70 g per Kg of DM, respectively) on top of concentrate. Concentrate was offered in equal amounts twice daily (08:00 and 18:00 h) while alfalfa hay and corn silage was offered *ad libitum* as a roughage source. Meat grinder used for fine grinding the fresh garlic bulb. The homogenized raw garlic mixed thoroughly with concentrate just before feeding. The animals from the 30, 50 and 70 gram garlic treatments consumed, on average, 0.1, 0.15 and 0.2 g allicin respectively (assuming an average allicin content of 4.5 mg/g [7]. Diets were adjusted weekly to account for changes in BW and physiological status. Raw garlic bulb were from the Hamadan County and purchased at the peak of their maturity at the local market. This study was approved by the Institutional Animal Care and Use Committee of the University of Urmia, Iran.

Feed Intake and BW

Feed consumption was recorded daily by weighing feeds offered to and refused by the goats and data from day 10 to 14 were included in the statistical analysis. Body weight was determined at the beginning and the end of each experimental period after the a.m. milking on 2 consecutive sampling days.

Milk Production and Milk Composition

Goats were milked twice daily (07:00 and 17:00 h) and milk yield was recorded at each milking. During the last two days of each 14-d period, milk samples were taken from each animal at each milking, pooled on a yield basis, stored at +4°C with a preservative (bronopol-B2) and measured for fat, protein, lactose, and total solids within 48 h.

Sample Collection and Analytical Procedure

Analytical DM contents of basal diet and garlic were determined by oven-drying at 105°C for 48 h [8]. Ash contents of basal diet and garlic were determined by incineration at 550°C overnight, and the organic matter (OM) content was calculated as the difference between 100 and the percentage of ash [8]. Ether extract (EE), Kjeldahl N, calcium and phosphorous were determined according to AOAC [8]. Kjeldahl N was multiplied by 6.25 to estimate crud protein (CP). The concentrations of neutral detergent fiber (NDF) in basal diet and garlic were determined as described by Van Soest et al.[9] without the use of sodium sulfite. The acid detergent fiber (ADF) content of diet and garlic were determined according to AOAC [8].

Blood samples were collected from the jugular vein on day 13 and 14 of each experimental period at 3 h after morning feedings. Blood samples were left at room temperature until clotting was finished. Tubes were then centrifuged for 20 min at 2500 × g. Serum for determination of glucose, non-esterified fatty acids (NEFA), β-hydroxybutyrate (BHB), cholesterol, albumin, sodium, potassium, calcium and phosphorus were stored at −20°C until analyses. β-Hydroxybutyrate and NEFA were determined by a D-3-hydroxybutyrate kit and a NEFA Kit (Randox Laboratories Ltd, Ardmore, UK), respectively. The concentration of serum glucose, cholesterol, triglyceride, total protein, albumin, calcium and inorganic phosphorus were determined using an auto analyzer spectrophotometer (RA 1000, Unico, model S, serial number 2100, USA) using commercial kits (Parsazmoon, Tehran, Iran). Sodium and potassium concentrations were measured with flame photometery (Model PFP7, Serial number 12377, Genewey factory England).

Statistical Analysis

Data were analyzed using the PROC GLM of SAS [10], according to the following statistical model: $Y_{ijk} = \mu + Ti + Cj + Pk + eijk$, where, Yijk = observed variables; μ = general mean; T_i = effect of treatment i, (where i = 1, 2, 3, 4); C_j = effect of animal j, (where j = 1, 2...8); P_k = effect of period k, (where k = 1, 2, 3, 4); e_{ijk} = experimental error of the observations Y_{ijk}. Differences between treatments were declared significant at $P<0.05$ using the Tukey correction for multiple comparisons.

RESULTS

Chemical Composition of Basal Diet and Garlic

Table 1 and *Table 2* respectively presents the results obtained from analysis of the chemical composition of basal diet and garlic fed to experimental animals. Chemical analysis of garlic showed that crude fat content of garlic was 6.9 g kg^{-1} on a DM basis and 370 g kg^{-1} of DM, which could consist of active aromatic compound as previously reported by Saenthhaweesuk [11].

Table 1. *Daily ingredient allowance and chemical composition of the basal diet offered to dairy goats*
Tablo 1. *Sütçü keçilere verilen bazal diyetin günlük içeriği ve kimyasal kompozisyonu*

Item	Diet
Ingredient (%)	
Lucerne hay	34.70
Corn silage	28.90
Barley	23.20
Soybean meal	11.50
Vitamin and mineral mixture	1.70
Chemical analysis	
DM (%)	89.90
CP (%)	15.53
ME Mcal/kg of DM	2.35
EE (%)	3.88
NDF (%)	37.50
ADF (%)	23.10
Ca (%)	0.99
P (%)	0.48

***DM** = Dry matter, **CP** = Crude protein, **NDF** = Neutral detergent fiber, **ADF** = Acid detergent fiber, **EE** = Ether extract. **ME** = Metabolizable energy*

Table 2. *Chemical composition of the raw garlic*
Tablo 2. *Çiğ sarımsağın kimyasal kompozisyonu*

Composition	Raw Garlic %
DM	37.03
OM	95.74
Crude protein	9.62
Ether extract	0.69
NDF	6.70
ADF	5.21
Calcium	0.03
Phosphorus	0.02

***DM** = Dry matter, **OM** = Organic matter, **CP** = Crude protein, **NDF** = Neutral detergent fiber, **ADF** = Acid detergent fiber, **EE** = Ether extract*

Feed Intake and Body Weight Changes

In the current study, no significant differences observed in the dry matter intake (DMI) and body weight changes between treatments in the lactational period *(Table 3)*.

Milk Production and Milk Composition

Milk production ranged from 1.12 to 1.24 kg/d and was not different among the treatments *(Table 3)*. Overall, there were no treatment differences (P>0.05) in milk and fat corrected milk yield, milk protein, lactose and total solids. Even though feeding garlic showed the lower-milk fat percentage compared to animal not received the garlic in the diet *(Table 3)*.

Blood Metabolites

Blood metabolite concentrations are shown in *Table 4*. Administering garlic (in the two levels of 50 and 70 g/Kg DM) in dairy goats increased significantly (P<0.05) serum glucose concentration. No significant effects were found for BHB, NEFA, triglycerides, cholesterol, total protein, albumin, calcium, inorganic phosphorus, sodium and potassium concentration in lactating dairy goats *(Table 4)*.

DISCUSSION

The effects of feeding garlic or other garlic components have been reported to vary according to the dose and type of products. In contrast with Kholif et al.[5] who reported that supplementing goats with garlic oil increased DMI, garlic supplementation at the selected levels did not affect the feed consumption in this study, these findings were in agreement with previous reports with total mixed ration of lambs [12], sheep [4,13] and cows [14].

All the blood metabolites investigated were within the normal range for dairy goats [15,16]. Similar to those reported by Kholif et al.[5] who found an increased serum glucose in response to rumen propionate increment in garlic treated lactating Goats, in the current study serum glucose was improved significantly by garlic supplementation. Blood glucose levels could be considered as a reflection of gluconeogenesis. Bergman [17] estimated that 27% to 55% of the glucose metabolized by ruminants originates from propionate (as an energy precursor). Previous studies documented the lower acetate, the greater propionate and butyrate proportions and resulting lower acetate to propionate ratio in garlic supplemented diet suggested that garlic constituents might help to improve the efficiency of energy utilization in the rumen [3,4,18]. This may explain to some extent how garlic can improve serum glucose concentration. These results are contrast to the finding of Chaves el al.[12] who reported no difference in serum glucose concentration of growing lambs fed diets supplemented with garlic compared with control.

Table 3. *Body weight, feed intake, milk production and composition in dairy goats fed raw garlic*
Tablo 3. *Çiğ sarımsak ile beslenen sütçü keçilerin vücut ağırlığı, yem tüketimi, süt üretimi ve kompozisyonu*

Parameters	Treatments				SE	*P*- Value
	GAR0	GAR30	GAR50	GAR70		
Body weight (kg)	51.8	51.52	50.74	49.24	0.57	NS
Feed intake (kg DM/day)	1.63	1.65	1.76	1.78	0.04	NS
Milk production (kg/day)	1.14	1.24	1.22	1.12	0.05	NS
Fat Corrected Milk	1.26	1.31	1.22	1.28	0.09	NS
Milk composition (%)						
Fat	4.24^{a}	3.8^{b}	3.74^{b}	3.6^{b}	0.15	*
Protein	3.21	3.33	3.26	3.25	0.09	NS
Lactose	4.06	4.16	4.2	4.37	0.10	NS
Total solids	13.53	13.22	13.42	13.25	0.20	NS

GAR0 *= basal diet without garlic;* ***GAR30*** *= basal diet + raw garlic (30 g/kg DM);* ***GAR50*** *= basal diet + raw garlic (50 g/kg DM);* ***GAR70*** *= basal diet + raw garlic (70 g/kg DM);* ^{a,b} *Different letters indicate significant differences: P<0.05;* ***** *P<0.05;* ***NS*** *= Not significant*

Table 4. *Blood serum constituents of lactating goats fed on rations supplemented with raw garlic*
Tablo 4. *Çiğ sarımsak katılmış rasyon ile beslenen laktasyondaki keçilerin kan serum içerikleri*

Variables	Treatments				SE	*P*-value
	GAR0	GAR30	GAR50	GAR70		
Serum glucose (mmol/l)	3.10^{c}	3.11^{c}	3.60^{ab}	3.64^{a}	0.10	**
BHB (mmol/l)	0.59	0.49	0.55	0.61	0.12	NS
NEFA (mmol/l)	0.26	0.27	0.27	0.24	0.14	NS
Total triglycerides (mg/dl)	18.50	14.25	17.12	15.50	5.10	NS
Cholesterol (mg/dl)	59.37	56.25	57.37	56.87	1.58	NS
T. Protein (g/dl)	7.75	7.42	7.30	7.53	0.96	NS
Albumin (g/dl)	4.37	3.80	4.38	4.25	0.38	NS
Calcium (mg/dl)	9.11	8.40	8.24	7.80	1.44	NS
Phosphorous (mg/dl)	10.19	11.92	11.45	10.54	1.58	NS
Sodium (mEq/l)	94.87	97.87	95.12	97.62	9.05	NS
Potassium (mEq/l)	2.48	2.68	2.67	2.63	0.35	NS

GAR0 *= basal diet without garlic;* ***GAR30*** *= basal diet + raw garlic (30 g/kg DM);* ***GAR50*** *= basal diet + raw garlic (50 g/kg DM);* ***GAR70*** *= basal diet + raw garlic (70 g/kg DM);* ***BHB*** *= β-Hydroxy Butyrate,* ***NEFA*** *= Non esterified fatty acids;* ****** *P<0.01;* ***NS*** *= Not significant*

Negative energy balance (NEB) in dairy goats can be monitored by testing for BHBA or NEFA. In contrast to reports obtained in dairy goat [19], cows [20] and ewes [21], the blood concentration of BHB and NEFA did not change over entire experiments. Blood concentration of NEFA is considered an appropriate index of energy status in goats and concentrations of 0.20-0.21 mmol/l have been suggested for lactating does at zero energy balance [22]. When energy balance is negative, animals always mobilize the lipids stored in adipose tissues, mainly in the form of NEFA. In contrast to Zhu et al.[23] who observed lower concentration of NEFA in garlic oil supplemented dairy goats, in the present study, the concentration of NEFA did not change during the experimental period suggesting that the mobilization was not affected. Also BHB is one of the important energy status indicators during the peri-parturient period. Blood concentrations of BHB of 0.8 to 1.6 mmol/L are indicative of a NEB in ewes [24]. There are no data regarding the cutoff point for NEB in Mahabadi goats. As expected and similar to cows, BHB concentrations were higher postpartum than prepartum because of the high energy demands associated with the onset of lactation [25] and mobilization of adipose tissue resulting in variations of plasma glucose and BHB could occur when an increase of milk production is not supported by a proper energy intake. However in the current study change in plasma BHB concentrations did not differ significantly between groups. It has been proved that when animals are in negative energy balance (early lactation), the additional energy available due to the essential oil from medicinal supplementation was used to improve performance and reduce body reserve losses [26]. In this study, higher level

of serum glucose of treated goats without any changes in other plasma energy indicators (BHBA and NEFA) suggesting enough energy providing to support the milk production.

Most findings demonstrated lipid-lowering as well as hypochlosterolemic effects of garlic in human and animal [27-29]. However, the present study showed that garlic supplementation had no influences on the concentrations of total triglycerides and cholesterol in serum. These results were in agreement with the previous reports in sheep [12,21] and in dairy goats [23] supplemented with garlic oil. The discrepancies in the results of the studies can be attributed to differences in the experimental trials, composition and quantity of garlic supplemented to animal's diet.

Blood levels of minerals have a high diagnostic value in determining the nutritional status of animals due to their low variability in blood [30]. In the current study profiles of calcium, phosphorous, sodium and potassium concentrations in serum did not exhibit any changes. There is no information on effects of feeding garlic or its constituents on blood mineral concentration through the lactational period in dairy goats. In agreement with Amer et al.[31] who observed any changes in serum calcium and phosphorous levels during postpartum period in Saudi Ardy goats we also did not observe any significant effect of garlic supplementation on blood concentrations of calcium, inorganic phosphorus, sodium and potassium.

To our knowledge, little information is available on the effects of garlic supplementation on milk components. According to Kholif et al.[5] the present study showed that garlic supplementation did not affect milk components with the exception of decreasing milk fat content. This finding is in contrast with Yang et al.[14] who reported that garlic oil supplementation in dairy cattle tended to increase of fat milk content. Also Zhu et al.[23] observed that supplemented garlic oil in dairy goats' diets had no effect on milk concentrations of fat, protein and milk yields of fat and protein when compared with goats fed no garlic oil.

Based on the results of this investigation, garlic supplementation had no adverse effects upon efficacy of feed intake and milk production as well as on blood constituents known to be critical for the transition goats. Furthermore blood glucose indicated significantly, a positive energy balance for treatment goats. However, further research is warranted to investigate the underlying mechanism for better application of garlic and garlic component as a feed additives and to evaluate involvement of metabolic changes on the long-term health and productivity of dairy goats.

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