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IMPACT OF SODIUM ACETATE AND SODIUM SUCCINATE SUPPLEMENTAL TO RATIONS OF LACTATING GOATS ON MILK PRODUCTION, MILK COMPOSITION AND SOME RUMINAL AND BLOOD PARAMETERS

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SUMMARY

Effect of including sodium acetate or sodium succinate and their combination in the lactating goats rations on dry matter intake, milk yield and composition, feed efficiency and some ruminal and blood serum parameters were studied. Twelve lactating baladi goats in early lactation were divided into four groups using 4x4 Latin square design with 30 day-periods. The control diet (C) used consisted of berseem hay as source of roughage and concentrates (40:60%, dry matter basis). The three experimental diets used were: control diet plus 300 mg/Kg live body weight (LBW) of sodium acetate (T_1), control diet plus 7 mg/kg LBW of sodium succinate (T_2) and control diet plus 300 mg/kg LBW of sodium acetate + 7 mg/kg LBW of sodium succinate (T_3). Dry matter intake (DMI) differed significantly ($P<0.05$) among treatments, where intake was reduced ($P<0.05$) by adding the supplements. Milk yield and 4% FCM were significantly ($P<0.01$) higher in treated groups compared with control. Yields of milk contents were also higher ($P<0.05$) in treated groups. TS and SNF contents were higher ($P<0.05$) in treated groups, however, Fat, TP, Lactose and ash contents were not differed significantly among treatments. Feed efficiency (g/g) calculated as milk yield /DMI and FCM/DMI were better in T_3 than the other treatments and control.

Ruminal pH, TVFA's, TN, true-protein nitrogen, NPN and NH_3-N values were slightly higher in treated groups. There were significant ($P<0.05$) effects due to sampling time among different values of rumen parameter investigated. Serum TP, globulin and urea were slightly increased ($P>0.05$) with treated groups. Serum glucose increased significantly ($P<0.01$) with inclusion the combination of sodium acetate and succinate (T_3) in the diets.

Keywords: sodium acetate, sodium succinate, lactating goats, milk, feed efficiency, rumen, blood serum

INTRODUCTION

Improvements in milk yield and milk fat percentage due to buffers supplementation has been noted in low fiber diets. Some buffers reduce the molar percent of propionate, which in turn might lead to an increase in milk fat percent, and others buffers increase the molar percent of propionate, which lead to an increase in milk production. Another role is altering the rumen fermentation which appear to adjust rumen dilution rate of the rumen fluid, while some buffers may increase the digestibility of starch in the lower gut (Davis, 1978) or increase the digestibility of feeds including fibrous materials that have been observed when buffers are consumed by ruminants and result in a higher and more stable rumen pH (Mertens, 1978).

The purpose of the present study is to evaluate the effect of supplementing

ration with sodium acetate or sodium succinate and their combination from them on dry matter intake, milk yield, milk composition, feed efficiency and some ruminal and blood serum parameters of lactating goats during the first four months of lactation period.

MATERIALS AND METHODS

Animals and diets:

Twelve lactating Baladi goats, in early lactation (being 4 years old and weighting on average of 26.5 ± 0.5 kg) were divided into four groups using 4x4 Latin square design with 30 day periods. The control (C) diet used consisted of berseem hay (BH), as source of roughage, and concentrate feed mixture (CFM) as a concentrate source (40:60 % on dry matter basis). The three experimental diets used were : control diet plus 300 mg/Kg live body weight (LBW) of sodium acetate (T_1), control diet plus 7 mg/kg LBW of sodium succinate (T_2) and control diet plus 300 mg/kg LBW of sodium acetate plus 7 mg/kg LBW of sodium succinate (T_3). The CFM, consisting of 47% crushed corn, 23% wheat bran, 27% crushed faba bean by-products, 1% salt and 2 % dolomite. The chemical composition of ingredients are showed in Table (1). The offered feeds were assessed to cover the requirements for each animal (A.R.C. 1965). The CFM for each animal was offered individually once daily at 8.00 am, while berseem hay was offered at 10.00 am. Dry matter intake was measured during the last refusals of the previous day. Water was offered two times daily.

Analysis of feed samples:

Samples of ingredients and rations were analyzed for DM, ash, crude fiber (CF) and ether extract (EE) according to methods of A.O.A.C. (1995). Nitrogen-free extract (NFE) was calculated by difference.

Sampling and analysis of milk:

At the last 3 days of each period, the animals were handly milked (twice/day), milk yield was recorded and pH of milk was determined (Ling, 1963). Milk samples were also, analyzed for fat, total solids (TS), total protein (TP) and ash (Ling, 1963) lactose (Barnett and Abd El-Tawab, 1957). solids-not-fat (SNF) was calculated by difference.

Sampling and analysis of rumen liquor:

At the last of each period, rumen liquor samples were collected from each animal at zero, 3 and 6 hrs. post morning feeding by a stomach tube. The samples were strained through two layers of cheese cloth and then stored in glass bottles (10ml) with 3 drops of toluene and a thin layer of paraffin oil just to cover the surface to stop microbial activity and to prevent volatilization and stored at −18°C till they were analyzed. Ruminal pH was determined using a digital pH-meter, total nitrogen (TN), non-protein-nitrogen (NPN) and NH_3-N were determined according to A.O.A.C. (1995). True protein nitrogen (TPN) was calculated by difference (TN-NPN). Total volatile fatty acids (TVFA's) were determined by steam distillation as described by Warner (1964).

Sampling and analysis of blood serum:

Blood samples were collected from the jugular vein of each animal at the last day of each period (4 hr. post morning feeding). The collected blood samples were centrifuged at 4000r.p.m./20min. to separate the serum. The obtained serum was stored at −18°C till it was analyzed. Serum total protein was determined as described by Armstrong and Carr (1964), while, albumin (Doumas et al. 1971), urea (Patton and Crouch,1977), glucose (Siest *et al.*,1981) and serum glutamic-oxaloacetate-transaminase (GOT) and

glutamic-pyruvate-transaminase (GPT) (Reitman and Frankel, 1957). Globulin and albumin/globulin ratio were calculated.

Statistical analysis:

Data obtained from this study were statistically analyzed according to procedures outlined by Snedecor and Cochran (1982). These procedures were:

1-Latin square design for yield and composition of milk and blood parameters using the general linear model procedure:

$$Y_{ijk} = \mu + R_i + C_j + T_k + e_{ijk}.$$

Where Y_{ijkl} is the parameter under analysis of the ijkl goat, μ is the overall mean, R_i is the effect due to the lactation period on the parameter under analysis, C_j is the effect due to the animals on the parameter under analysis, T_k is the effect due to treatment on the parameter under analysis, e_{ijk} is the experimental error for ijk on the observation,

2- Splite plot design for rumen liquid parameter:

$$Y_{ijk} = \mu + R_i + T_j + (RT)_{ij} + B_{kt} + (TB)_{jk} + E_{ijk}.$$

Where, R_i: replicate, T_j : treatment, $(RT)_{ij}$: interaction, B_{kt} :sampling time, $(TB)_{jk}$: interaction (TB) and E_{ijk}: experimental error.

The Duncan's multiple range test was used to test the significance between means.

RESULTS AND DISCUSSION

Dry matter intake:

Effect of supplementing rations with sodium acetate and sodium succinate and their combination on dry matter intake (DMI) are presented in Table (2). Dry matter intake differed among treatments, being 926.41, 902.62, 893 and 875.11 g/d in control, T_1, T_2 and T_3, respectively. The animals of sodium acetate and sodium succinate combination treated groups consumed significantly lower ($P<0.05$) amount of dry matter following by T_2 and then T_1. Values of grams consumed /kg metabolic body size ($kgW^{0.75}$) supported the previous results. It also seemed that the reduction in intake was concentrated on the amount consumed from roughage source (BH). These results are in agreement with Forbes *et al.*, (1992) and Azahan and Forbes (1992) who attributed that a better absorption of nutrients in body tissues or to the osmotic load and acid effect which may influence intake.

Milk yield and composition:

Milk yield and 4% fat corrected milk (FCM) were significantly ($P<0.01$) higher in T_3 representing an increase of about 33.71%, 13.9% and 8.8% for milk yield and 41.1%, 14.1% and 10.5% for FCM compared to goats receiving control, T_1 and T_2, respectively (Table 2). The relative improvement in milk production of T_3 (sodium acetate and sodium succinate combination) might be due to the increase in rumen microflora activity and the associated effect between acetate and succinate in rumen microflora, which lead to improve feed efficiency, resulting in an increase in milk production for these animals. Similar results were reported by Preston and Leng (1987), Vojtisek *et al.*, (1989), Chen *et al.*, (1989), Abo El-Nor, (2000) and El-Sayed (2002).

As an impact of the increased milk yield, daily fat, TS, SNF, TP, lactose and ash yields were significantly higher ($P<0.05$) in T_3 followed by T_2 and then T_1 compared with control.

Data of milk composition of the experimental goats are also summarized in Table (2). Milk TS and SNF contents were higher ($P<0.05$) in T_3 (sodium acetate and sodium succinate combination) than control, $T_1$and T_2. However, milk fat and lactose contents did not differ significantly among

Table (1): Chemical composition of dietary ingredients (%DM basis).

Items	Ingredients	
	CFM	BH
Dry matter (DM)	89.9	91.31
Organic matter (OM)	92.4	88.9
Ash	7.6	11.1
Crude protein (CP)	15.3	11.4
Ether extract (EE)	3.3	3.12
Crude fiber (CF)	9.1	28.36
Nitrogen free extract (NFE)	64.7	46.02

CFM: Concentrate feed mixture, composed of 47% crushed corm, 23% wheat bran, 27% crushed faba bean by-products, 1% salt and 2 % Dolomite. BH: Berseem hay.

Table (2): Effect of treatments on milk yield and composition and feed efficiency.

Items	Treatments				± SE
	Control	T_1	T_2	T_3	
No. of animals	3	3	3	3	-
Live body weight kg	26.65	26.93	26.88	26.95	0.07
Dry matter intake (g/h/d)	926.41^{a}	902.62^{b}	893.0^{b}	875.11^{c}	5.13
From CFM	626.3	621.3	620	615.1	3.11
From BH	300.11^{a}	281.32^{b}	273.0^{b}	260.0^{c}	2.71
g/kg $W^{0.75}$	78.98	76.35	75.64	73.98	0.31
Yield (g/d):					
Milk	521.7^{C}	612.5^{B}	641.2^{B}	697.54^{A}	41.20
4% FCM	477.1^{C}	590.0^{B}	609.0^{B}	673.0^{A}	38.31
Fat	17.89^{c}	23.03^{b}	23.53^{b}	26.29^{a}	2.71
Total solids	60.88^{c}	66.94^{b}	75.98^{b}	84.47^{a}	6.77
Solids not fat	42.83^{b}	43.91^{b}	52.45^{a}	58.17^{a}	3.53
Protein	16.74^{b}	19.04^{a}	20.19^{a}	22.18^{a}	1.81
Lactose	16.32^{c}	20.76^{b}	21.92^{b}	25.53^{a}	3.57
Ash	3.70^{c}	4.80^{b}	5.60^{a}	5.51^{a}	0.77
Milk composition %:					
Fat	3.43	3.76	3.67	3.77	0.16
Total solids	11.67^{b}	10.93^{b}	11.85^{b}	12.11^{a}	0.44
Solids not fat	8.24^{a}	7.17^{b}	8.18^{a}	8.34^{a}	0.33
Protein	3.21	3.11	3.15	3.18	0.15
Lactose	3.13	3.39	3.42	3.66	0.13
Ash	0.71	0.78	0.79	0.79	0.03
Feed efficiency					
Milk yield/DMI	0.56^{c}	0.68^{b}	0.72^{b}	0.80^{a}	0.08
FCM yield/DMI	0.51^{c}	0.65^{b}	0.68^{b}	0.77^{a}	0.05

Each value is mean of 36 samples for 12 animals.
A,B,C means with different superscripts are significant (P<0.01) difference.
a,b,c means with different superscripts are significant (P<0.05) difference.

treatments. It is of importance to note that milk fat content was slightly higher (P>0.05) in treated groups. Generally, feed efficiency calculated as milk yield / DMI and 4% FCM / DMI were improved by T_3 followed by T_2 and then T_1 (Table 2).

Rumen liquor parameters:

Effects of treatments on characteristics of ruminal fermentation are shown in Table (3). Ruminal pH values were slightly higher (P>0.05) in treated groups than control group. All values were above pH 6.0 which indicated a better digestion of cellulolytic materials (Mertens, 1978). Values of VFA's, TN, TPN, NPN and NH3-N were insignificantly increased in treated groups compared with control group. Similar results were reported by Schneider *et al.*, 1988, Yijun *et al.*, 1995 and El-Sayed (2002) who concluded that adding sodium acetate to the diet caused insignificantly increase in rumen pH, TVFA's and NH3-N in the rumen of cows. Although no significancy (P>0.05) were detected among different treatments in NH3-N concentrations, values of NH3-N seemed to be sufficient to cover the microbial demands for microbial protein synthesis as obtained from the reports of previous investigators (Mehrez *et al.*, 1977, Wallace, 1979 and Erdmann *et al.*, 1986).

Concerning the effect of time of sampling (Table, 4), it was found that the ruminal pH was significantly (P<0.05) higher for pre-feeding samples while the lowest pH value was obtained after 3 hrs. post feeding, then it began to reincrease. This trend was similar to the findings of El-Sayed (2002). In contrary, ruminal TVFA's and ammonia nitrogen were significantly (P<0.05) increased with time after feeding from zero to 3hrs. post feeding. These results are in an agreement with the conclusion of Roddy and Roddy (1985) who stated that, the pH values were inversely related to VFA's concentrations in the rumen. The TN, NPN and TPN reached to highest (P<0.05) values at 6 hrs. post feeding , while, the highest values of NH3-N were obtained at 3hrs. post feeding. The significancy (P<0.05) among sampling times in the ratio of NH3-N/NPN reflected the pattern of metabolism and production of ammonia in the rumen along the sampling time (Table, 4).

Blood serum metabolites:

Data in Table (5) showed no significant differences (P>0.05) among different treatments on some blood serum parameters, except glucose values (P<0.01). Diets containing sodium succinate tend to increase TP, globulin and urea nitrogen, however, albumine and A/G ratio were slightly decreased (P>0.05). Serum glucose had the same trend of milk yield (Table, 2) which was in accordance with the results of Clark *et al.*, (1977) who claimed a positive correlation between blood glucose and milk yield. Blood serum glutamic-oxaloacetate-transaminase (GOT) and glutamic-pyruvate-transaminase (GPT) values were not significantly affected by treatments, however, blood serum GOT was slightly decreased while blood serum GPT was slightly increased with T3 compared with other treatments. These results indicated that supplementing sodium acetate and sodium succinate or their combination to lactating goats' rations were not affecting on liver activity or animals health.

CONCLUSIONS

It could be concluded that supplementing goats' rations with the proposed of sodium acetate and sodium succinate or their combination reduced dry matter intake, improved feed efficiency, improved milk production and composition with no deleterious effect on

Table (3): Rumen liquor parameters of lactating goats fed on experimental rations.

Items	Treatments				± SE
	Control	T_1	T_2	T_3	
pH	6.33	6.51	6.56	6.71	0.09
TVFA's (meq./dl)	6.23	6.75	6.88	6.88	0.31
Ammonia nitrogen (mg/dl)	20.44	21.71	22.22	22.63	1.12
Total nitrogen (mg/dl)	207	216	223	225	8.71
True-protein-nitrogen (mg/dl)	116	118	122	122	6.55
Non-protein- nitrogen (mg/dl)	95	98	101	103	3.10
NPN/TN	45.89	45.37	45.29	45.78	1.33
NH_3-N/NPN	21.52	22.15	22.0	21.97	0.51

Each value is mean of 36 samples for 12 animals.

Table (4): Effect of sampling time on rumen liquor parameters of lactating goats fed on experimental rations.

Items	Sampling time (hrs) after feeding			± SE
	Zero	3	6	
pH	6.44^{a}	5.92^{b}	6.34^{a}	0.21
TVFA's (meq./dl)	6.56^{b}	7.41^{a}	6.20^{c}	0.70
Ammonia nitrogen (mg/dl)	18.36^{c}	29.0^{a}	23.0^{b}	1.12
Total nitrogen (mg/dl)	195.0^{c}	212.3^{b}	226.34^{a}	10.46
True-protein-nitrogen (mg/dl)	99.39^{b}	102.3^{a}	105.13^{a}	6.91
Non-protein- nitrogen (mg/dl)	95.61^{c}	110.0^{b}	121.21^{a}	5.10
NPN/TN	49.03^{b}	51.81^{b}	53.55^{a}	0.60
NH_3-N/NPN	19.20^{b}	26.36^{a}	18.98^{b}	1.72

Each value is mean of 36 samples for 12 animals.
a,b,c means with different superscripts are significant (P<0.05) difference.

Table (5): Blood serum parameters of lactating goats fed on experimental rations.

Items	Treatments				± SE
	Control	T_1	T_2	T_3	
Total protein g/dl	6.99	7.32	7.40	7.11	0.12
Albumin g/dl	3.68	3.71	3.40	3.67	0.07
Globulin g/dl	3.31	3.61	4.00	3.44	0.07
A/G ratio	1.11	1.03	0.85	1.07	0.32
Urea nitrogen mg/dl	41.32	45.10	45.22	45.81	4.11
Glucose mg/dl	48.47^{C}	67.81^{B}	68.22^{B}	74.73^{A}	1.11
GOT units/ml	29.23	30.92	31.91	24.44	1.57
GPT units/ml	12.78	13.07	13.63	14.64	0.41

Each value is mean of 12 samples for 12 animals.
A,B,C means with different superscripts are significant (P<0.01) difference.

general health of the treated animals as compared to animals fed the control ration.

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تأثير إضافة خلات الصوديوم وسكسينات الصوديوم لعلائق الماعز الحلاب على إنتاج اللبن ومكوناته وبعض مقاييس الكرش وسيرم الدم

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استخدم فى هذه الدراسة ١٢ أنثى ماعز بلدى حلاب قسمت إلي أربعة مجاميع باستخدام المربع اللاتينى ٤x٤ وقسمت التجربة إلى أربعة مراحل كل مرحله استمرت لمدة ٣٠ يوم، لتتلقى المعاملات التالية: مجموعه المقارنة: ٦٠% علف مركز + ٤٠% دريس برسيم. المعاملة الأولى: عليقه المقارنة + ٣٠٠ مجم/كجم وزن حى من خلات الصوديوم. المعاملة الثانية: عليقه المقارنة+٧ مجم/كجم وزن حى من سكسينات الصوديوم. المعاملة الثالثة: عليقه المقارنة+٣٠٠ مجم/كجم وزن حى من خلات الصوديوم + ٧ مجم/كجم وزن حى من سكسينات الصوديوم.

وكانت أهم النتائج المتحصل عليها انخافض معدل المأكول من المادة الجافة بمعنوية مع المجاميع المعاملة. كما ارتفع محصول اللبن معنويا (١%) مع المجموعة الرابعة (مخلوط خلات وسكسينات الصوديوم)، كما ارتفع محصول مكونات اللبن معنويا (٥%) للحيوانات المعاملة مقارنة بمجموعة المقارنة. كما ارتفع محتوى اللبن من الجوامد الكلية والجوامد اللادهنية معنويا (٥%) مع المجاميع المعاملة مقارنة بمجموعة المقارنة بينما لم يتأثر محتوى اللبن من الدهن والبروتين واللاكتوز والرماد بالمعاملات. كما ارتفعت الكفاءة الغذائية معنويا (٥%) المحسوبة على أساس كل جم لبن / كل جم مادة جافه مأكولة أو كل جم لبن معدل نسبة الدهن (٤%)/ كل جم مادة جافه مأكولة – مع المجاميع المعاملة مقارنة بمجموعة المقارنة.

كان هناك ارتفاع طفيف غير معنوى فى pH سائل الكرش ومحتواه من الأحماض الدهنيه الطياره والنيتروجين الكلى ونيتروجين البروتين الحقيقى والنيتروجين غير البروتينى والأمونيا مع المجاميع المعامله مقارنة بمجموعة المقارنه. بينما كانت هناك فروق معنويه على مستوى ٥% لوقت أخذ العينه لكل مكونات سائل الكرش.

ارتفع جلوكوز الدم معنويا (١%) مع المجموعه الرابعه المغذاه على مخلوط خلات وسكسينات الصوديوم تلتها المجموعه المغذاه على سكسينات الصوديوم ثم المجموعه المغذاه على خلات الصوديوم مقارنة بمجموعة المقارنه. كما ارتفع محتوى سيرم الدم من البروتين الكلى والجلوبيولين واليوريا بدون معنويه مع المجاميع المعامله.

مما سبق يمكن القول أن استخدام بعض الأملاح العضويه المنظمه لبيئة الكرش مثل خلات الصوديوم أو سكسينات الصوديوم أو توليفه بينهما يمكن أن يحسن من إنتاج اللبن ومكوناته كما يحسن من كفاءة حيوانات اللبن الغذائيه دون التأثير على صحة الحيوان.