Food Research 7 (4) : 122 - 126 (August 2023)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

The effects of dietary addition of acetic acid on milk yield and composition in Awassi ewes at an early stage of lactation

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Article history:
Received: 16 April 2022
Received in revised form: 24 May 2022
Accepted: 30 May 2022
Available Online: 11 August 2023

Keywords:
Acetic acid,
Awassi ewes,
Milk fat,
Milk yield

DOI:
https://doi.org/10.26656/fr.2017.7(4).202

Abstract

This study was conducted to evaluate the effect of dietary supplementation of acetic acid at different levels on milk yield and composition. A total of eighteen Awassi ewes in the early stage of lactation were used in this study, with average body weight (37.631.84) and ages (3–4 years). Animals were allocated to three treatments; the first treatment was control fed with a basal diet without additives (T1). Acetic acid (98%) was added to the concentrate feed daily before feeding by 5 mL/ewe daily in T2 and 10 mL/ewe in T3 after dilution 1:10 with tab water. Results indicate an insignificant increase in ewes' body weight in T2 and T3, which were 40.41 and 41.11 kg compared to T1 at 37.93 kg. Actual milk yield was not affected while fat corrected milk Increased in T3 was 390 g/day compared to T2 with 323 g/day. Milk fat percentage increased ($p \leq 0.05$) in T3 at 6.26% as compared to T1 and T2 at 5.65% and 5.43%, respectively, while fat yield was higher ($p \leq 0.05$) in T3 at 23.85 g/day than in T2 17.58 g/day. This was reflected in increased milk energy ($p \leq 0.05$) in the T3 at 953 kcal/kg compared to T2 at 858 kcal/kg. From the results, it can be concluded that acetic acid can be used as an additive to the ewes diet, and effect positively in ewes' weight and milk fat.

1. Introduction

Numerous factors can affect milk yield and composition, the most important is the type of feed and its quantity (Saadi and Hasan, 2019). In Iraq most breeders synchronize Awassi ewes' mating period at the beginning of summer hence, the parturition happens during the winter season when the natural pastures are not available. Therefore, animals depend on obtaining their nutrient requirements of concentrated feed and dried roughage, especially wheat straw in the Mediterranean area (Selmi *et al.,* 2019). The concentrate feeds provide or offers ewes requirements of energy and protein, but it reduces the availability of substrates for de novo fatty acid synthesis and milk fat production (King *et al.,* 1985) because it modified the rumen fermentation towards a lower acetic acid and an increase in propionic acid.

Acetate is the primary energy source in the body of ruminants, providing about 45% of the body's energy needed from total volatile fatty acids in well-fed animals. Also, beta-hydroxybutyric acid is used in the mammary gland as a source in the formation of fatty acids for milk fat, about 5% of beta-hydroxybutyric acid is its source of acetate after metabolized across the rumen wall. Thus, about 50% of the total milk fat produced in the mammary gland comes from the rumen metabolites of acetic acid (Bergman, 1990; Maxin *et al.,* 2011).

Previous studies report that lowering the acetate to propionate ratio when feeding concentrate feeds causes low fat in the milk (Hurtaud *et al.,* 1998; Lemosquet *et al.,* 2009). It makes milk fat one of the most sensitive ingredients to diet change, especially the type and quantity of roughage feed intake. The economic marketing value of milk and its content of energy depends on its content of fat. Therefore, it significantly affects newborn lambs' growth; many studies proposed infusion of volatile fatty acids in the rumen when ewes are fed with a concentrated diet to increase energy intake and prevent milk fat depression. Some studies indicated an improvement in milk and milk fat production with an increase in acetic acid, and subsequent studies by adding neutral sodium acetate to the feed indicated positive results. Recent studies on this subject showed that the addition of sodium acetate with the feed mixture led to an increase in milk production and its fat content, and the response to supplement of volatile fatty acids on milk

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eISSN: 2550-2166
Published by Rynnye Lyan Resources

yield and its fat content depends on the amount of energy intake (Urrutia *et al.,* 2019).

In Iraq, acetic acid in ruminant feed was not considered; in contrast, studies focused on the use of various additives that could affect the rumen fermentation products by increasing the activity of microorganisms. This study proposed the effect of adding acetic acid at different levels to the feed of Awassi ewes in the early stage of lactation on milk production and its components.

2. Materials and methods

2.1 Sample preparation

This study was conducted at the Technical Agricultural College, Northern Technical University, Mosul, Iraq for the period of 15-1-2022 to 1-3-2022 to investigate the effects of dietary supplementation with different levels of acetic acid on milk yield and its composition in Awassi ewes. Eighteen ewes after two weeks of lambing with their single lambs, were used in this experiment, with an average body weight of 37.63±1.84 and an age of 3–4 years.

2.2 Treatments

Animals were allocated into three treatments; the first was control fed with basal diet without additives, concentrated glacial acetic acid (99.85% food grade sanggae-ro; cheongnyang-eup; Ulju Gun; Ulsan; South Korea) 5 and 10 mL per day per ewe after dilution 1:10 with distilled water and mixed with the concentrate feed daily in the second and third treatments, respectively. Ewes were fed ad-libitum twice daily with concentrate and wheat straw, according to the concentrate diet shown in Table 1. The residual was collected every morning to calculate actual feed intake; in addition to being offered fresh water and limestone continuously, the ewes were taken out to an artificial pasture for two hours daily.

2.3 Measurements

Milk yield was measured weakly after isolating the lambs from the ewes for 12 hrs and multiplied by two to calculate daily milk yield, milk composition was measured using the Lactoscac system (brand name: Lohan, Model: SP60); also, the body weight of ewes and lambs was measured weakly to calculate body weight change. Fat corrected milk (6%) and milk energy were calculated according to the following equations as described by Milis (2008).

6% fat corrected milk = milk yield kg/day × [0.472 + 0.0088×F (g/day)]

Milk energy kJ/kg = 39 × Fat (g/day) + 36 × SNF (g/day) - 1990. The values were converted to kcal per kg.

2.4 Statistical analysis

Analysis was performed using SAS (2011). The General Linear Model technique is used to do statistical analysis of the data for a random design using the following model:

$$Y = \mu + Ti + eij$$

Where μ is the overall mean and Ti is the fixed effect of dietary treatments. If the difference was greater than P 0.05, it was considered significant.

3. Results and discussion

3.1 Effect of dietary addition of acetic acid on body weight and milk yield

Table 2 indicates that total dry matter intake was close between treatments, which were around 1.75 kg daily, no significant was noted in the initial body weight 38.23, 36.96 and 37.70 kg. Ewes' weight after 45 days of study was 37.93, 40.41 and 41.11 kg, it notes that bodyweight is lower by 0.30 kg in the control treatment, while supplementation acetic acid with 5 and 10 mL/ewe/day in T2 and T3 increase body weight by 3.45 and 3.41 respectively. Lambs gain was decreased significantly in the T3, 2.41 kg compared to T1 and T2, 3.36 and 3.78 kg, respectively. Actual milk yield did not differ significantly as a result of acetic acid addition, while, fat corrected milk was higher ($p \leq 0.05$) in T3 at 390 g/day as compared to T2 with 323 g/day but did not reach to significance than T1 354. Previous studies (Senel and Owen, 1967; Urrutia and Harvatine, 2017;

Table 1. Components and chemical composition of concentrate diet.

Ingredients	%	Chemical analysis % of dry matter	
Crushed barley	65	Dry matter	92.34
Wheat bran	24	Organic matter	95.31
Soybean meal	8	Crud protein	15.26
Sodium bicarbonate	0.5	Crud fiber	9.58
Sodium chloride	0.75	Ether extract	1.97
Calcium carbonate	1	Non-fiber carbohydrate	59.66
Urea	0.75	Metabolizable energy MJ/kg	10.07

Chemical analysis of concentrate diet was measured according to AOAC (2000).

https://doi.org/10.26656/fr.2017.7(4).202

Table 2. Effect of dietary addition of acetic acid on body weight and milk yield.

Parameters	T1	T2	T3	p-value
Concentrate feed intake (kg/day)	1.25	1.25	1.25	-
Wheat straw intake (kg/day)	0.5	0.5	0.5	-
Total feed intake (kg/day)	1.75	1.75	1.75	-
The initial weight of ewes (kg)	38.23±4.36	36.96±3.03	37.70±2.53	NS
Ewes' weight after 45 days (kg)	37.93±2.09	40.41±1.75	41.11±2.44	NS
Lambs gain (kg)	3.36±0.35[a]	3.78±0.29[a]	2.41±0.23[b]	*
Milk yield (g/day)	367±11.93	357±16.04	381±23.19	NS
6% fat corrected milk (g/day)	354±10.01[ab]	323±9.09[b]	390±30.69[a]	*

Values are presented as mean/mean±SD. Values with different superscripts within the same row are statistically significantly different ($P \leq 0.05$). T1: Control, T2: AA 5 mL, T3: AA 10 mL, NS: Not significant

Gualdrón-Durate and Alen, 2018), demonstrate that infusion of acetic acid did not affect milk yield in dairy cows. Robinson *et al.* (1994) noticed that including various levels of acetic acid-treated canola meal was not affect milk yield in dairy cows. Similarly, Izumi *et al.* (2019) noted that the inclusion of 1.1% of sodium butyrate as dry matter in low or high starch diets was not affecting the milk yield in the dairy cow. At the same time, other studies indicated a positive effect of adding acetic acid on milk production. Wilson *et al.* (1967) found that acetic acid significantly raised milk yield in dairy cows. Hurtaud *et al.* (1993) demonstrated that the addition of volatile fatty acids mixture as a source of energy to a low or high protein diet led to a significant increase in actual milk and 4% fat corrected milk. Ali *et al.* (2013) mentioned that using 1.5 mL of organic acids mixture/liter of water increase milk yield, and this enhancement in milk yield might be a result of increased microbial protein yield and efficiency of microbial protein production. Abbas *et al.* (2018) found significantly increased milk yield in dairy cows fed 65% and 100% treated Gur korma meal with acetic acid compared to 35% treated or untreated meal. Daniel *et al.* (2013) fed dairy cows with a diet consisting of 67% concentrate and 33% Bermuda hay as control or with an addition of 5% ethanol and acetic acid, cows fed acetic acid had higher milk yield/DMI as compared to those fed with control or ethanol addition. These studies agreed that the addition of acetic acid enhances the efficiency of feed for milk production, and this might be used as an energy source by tissues, this may explain the reason for an increased body weight of ewes fed with supplement acetic acid as compared to control in our study.

3.2 Effect of dietary addition of acetic acid in milk components

Table 3 shows that milk fat percentage increased (p ≤ 0.05) in T3 at 6.26% when fed with an addition of 10 mL of acetic acid as compared to T1 at 5.65% and 5 mL of acetic acid in T2 at 5.43%, likewise, fat milk yield was higher (p ≤ 0.05) in T3 which was 23.85 g/day as compared to T2 17.58 g/day but not with T1 20.54 g/day. Acetic acid did not affect milk protein, lactose as a percentage of yield and solid non-fat. Milk energy was significantly higher (p ≤ 0.05) in the ewes' milk fed with an additional 10 mL/day of acetic acid 953 kcal/kg compared to T2 858 kcal/kg. This result was constant with Robinson *et al.* (1994), who noted that milk fat decreased in cow fed diet containing 33% treated to 67% untreated with acetic acid of canola meal as compared to control. Similar results were obtained by Abbas *et al.* (2018), milk fat percentage and yield were significantly reduced in dairy cows fed 35% of Gur korma meal treated with acetic acid to 65% untreated than 65% and 100% treated (Wilson *et al.,* 1967; Hurtaud *et al.,* 1993; Daniel *et al.,* 2013) found no effect of acetic acid in milk composition in dairy animals. While others (Bai *et al.,* 2016; Urrutia and Harvatine, 2017; Izumi *et al.,* 2019;

Table 3. Effect of dietary addition of acetic acid in milk components.

Parameters	T1	T2	T3	p-value
Fat (%)	5.65±0.14[b]	5.43±0.13[b]	6.26±0.26[a]	*
Fat (g/day)	20.54±0.82[ab]	17.58±1.15[b]	23.85±1.42[a]	*
Protein (%)	4.40±0.09	4.49±0.09	4.40±0.07	NS
Protein (g/day)	16.12±1.16	15.77±2.18	16.96±2.28	NS
Lactose (%)	4.65±0.10	4.75±0.08	4.66±0.08	NS
Lactose (g/day)	17.50±1.32	16.94±2.17	17.94±2.50	NS
Solid non-fat (%)	9.79±0.22	9.97±0.22	9.81±0.18	NS
Milk energy (kcal/kg)	894±26.49[ab]	858±31.30[b]	953±16.59[a]	*

Values are presented as mean/mean±SD. Values with different superscripts within the same row are statistically significantly different ($P \leq 0.05$). T1: Control, T2: AA 5 mL, T3: AA 10 mL, NS: Not significant

https://doi.org/10.26656/fr.2017.7(4).202

Urrutia *et al.,* 2019; Matamoros *et al.,* 2021) report that acetic acid or sodium acetate increase milk fat probably because of the increased acetic acid supply for de novo synthesis of fatty acids up to 16 carbon and utilization of glucose to the mammary gland. Acetate was particularly effective in raising milk energy, according to Urrutia *et al.* (2019).

4. Conclusion

The study concludes that the addition of acetic acid to the concentrate feed of ewes at an early stage of lactation supports a new source of energy used in fatty acid synthesis and increases milk fat and body weight, this increase in the proportion of fat and the weight of ewes was the result of the increase of volatile fatty acids, which in turn increases metabolites for milk components production.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

The authors gratefully acknowledge to Department of Animal Production, Technical Agricultural College/ Northern Technical University/Mosul/Iraq, for supporting the requirements of the study. Also, the authors thank the College of Agriculture and Forestry, University of Mosul, for the opportunity to complete this work in cooperation with researchers at the Agricultural Technical College.

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https://doi.org/10.26656/fr.2017.7(4).202