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Effects of betaine supplementation during late gestation on colostrum and milk quality of Aberdeen Angus cows, and growth performance of their calves

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Abstract

This work studied the impacts of betaine (Bet) supplementation on colostrum and milk quality of Aberdeen Angus cows and growth performance of their calves under New Valley, Egypt conditions. Twelve pregnant cows were assigned randomly into two equal groups (6 cows each). Treatments included: control (CG) and Bet group supplemented with 30 g Bet/h/d. Colostrum samples were collected within one hour after parturition at 1st day and then daily till 5th day postpartum. After that, milk samples were collected biweekly till 14 weeks. The colostrum and milk samples were analyzed for chemical composition. Calves were placed next to their mothers for the first 5 days to ensure that they got enough colostrum. Birth weight was recorded. Thereafter, body weight of calves was recorded at day 7, 14, 21, 56, 90 day and at weaning age (105 day). Total gain and daily gain were calculated. The results showed a significant increase ($p<0.05$) in milk yield and fat % in either colostrum or milk in the Bet group compared to the CG. Birth weight of calves in Bet-treated cows tended to be heavier at the birth than CG calves (35.60 vs. 34.43 kg). The Average daily gains were higher ($p<0.05$) for calves in Bet group (0.691 kg) compared with (0.675 kg) extent of CG. The Weaning weight was lower in CG (105.33kg) compared with Bet group (108.12 kg) with no significant difference. The presented results concluded that Bet supplementation could enhance milk production and the growth performance of Aberdeen Angus during heat stress conditions of summer season.

Keywords: Betaine; Aberdeen Angus; Growth performance; Milk quality

Introduction

In subtropical countries, climatic conditions are the major constraint on animal production. Production, reproductive performance, growth and milk yield are impaired as a result of the drastic physiological changes caused by heat stress (HS) (**Soliman *et al.*, 2022**). The summer in New Valley has elevated temperatures, low humidity, and intense sun radiation; thus, agricultural animals endure significant climate stress for around six months annually (**Kassab *et al,* 2021)**. HS can impact milk composition and decrease milk production, especially in high-producing dairy cows, as highlighted by **Joksimović-Todorović (2011)**. HS leads to a decline in feed consumption in dairy cows, which subsequently reduces nutritional digestion and absorption, resulting in less nutrient availability to the udder. It is believed that around 50% of the decrease in milk output is due to reduced feed intake by dairy cows (**Elhendawy *et al.*, 2025)**. Furthermore, stress may induce apoptosis in certain cells **(Mohamed et al., 2024).** Through the environmental modification method, it is possible to increase the productive performance of farm animal, but its cost is expensive. Feed additives may serve as a cost-efficient method to mitigate the impact of HS in beef and dairy cattle, while also enhancing animal performance (**Kassab *et al.*, 2020; Soliman *et al.*, 2025**).

Betaine (Bet), and also named tri-methylglycine is a naturally occurring by-product of sugar beet processing (**Fernández *et al.*, 2009**). Recently, Bet has been evaluated as nutrients to potentially reduce the negative effects of HS in farm animals (**Shah et al., 2020; Soliman et al., 2023; Elhendawy *et al.*, 2025)**. Bet has two primary purposes in the body of the animal. The first, when a cell is under osmotic stress, this organic osmolyte serves to maintain enzyme performance, stabilise protein structure, and lessen dehydration. As a result, digestive health is enhanced while reducing maintenance energy expenditure (**Abhijith et al., 2024**). The second, being a methyl donor and an essential part of one-carbon metabolism are two other significant roles for Bet (**Bertolo and McBreairty, 2013**). Through the donation of a methyl group to the universal methyl donor S-adenosylmethionine, Bet supports a number of vital bodily processes, including growth, lactation, and liver health (**Abhijith et al., 2024**).

We hypothesize that Bet supplementation will reduce the effect of HS on cows performance and improve cellular thermo-tolerance by increasing heat shock protein. Moreover, this improvement in thermo-tolerance would result in greater performance of cows. Thus, this work aims to investigate the effect of Bet on colostrum and milk quality of Aberdeen Angus cows and growth performance of their calves under New Valley.

Materials and methods

The study was performed from June to September 2020 at an animal production experimental farm, Faculty of Agriculture, New Valley University. The temperatures – humidity index (THI) were ranges between 70.08 to 74.78 at 08:00 am and 75.33 to 83.01 at 02:00 pm, indicated that animals were under HS according to **Armstrong (1994).**

Animals feeding system and experimental design

Twelve pregnant Aberdeen Angus cows, with an average body weight (BW) of 480 ± 10.45 kg, and their age ranging from 5 to 6 years, were distributed into two identical groups (6 animals each) according to their BW. Cows were randomly given one of the experimental rations. All cows were fed 60 % of their nutrient requirements as a CFM based on **NRC (2001)** guidelines, while wheat straw (WS) was given *ad lib* to cover the rest of the requirements. The ingredients of CFM and the chemical composition of CFM and WS are presented in Table (1). Cows in CG were fed their rations without Bet. While Bet group was supplemented with 30 g Bet /head/day. The Bet additive was mixed with CFM daily before feeding.

Table (1): Ingredients of CFM and chemical composition of CFM and WS (on DM basis)

Ingredients	%	Item	CFM	Wheat straw
Yellow Corn%	55	DM	88.76	90.35
Wheat bran%	21.5	OM	93.79	89.05
Soyabean meal%	20	CP	15.76	1.79
Limestone %	1.5	CF	14.12	38.71
Dicalcium phosphate%	0.5	EE	2.39	1.12
Yeast %	0.2	Ash	6.21	10.95
Bicarbonate %	0.3	NFE	61.52	47.43
Sodium chloride %	1			

Colostrum and milk samples and analyses

After parturition, colostrum samples were collected within one hour after parturition (first milking) at 1st day and then daily till 5th day postpartum. After that,milk samples were collected biweekly till 14 weeks. Milk yield of cows was recorded two times per day during am and pm milking.

The colostrum and milk samples were analyzed by Lacto-scan apparatus (Ultrasonic milk, Bulgaria) in triplicate for chemical composition at field level to determine milk constituents (fat, solid non-fat (SNF), protein, lactose and ash). Total solids were determined using the following equation:

$$TS = SNF\ (\%) + Fat\ (\%).$$

Milk calorific value (CV) was calculated according to **Salman *et al.* (2014)** using the following equation:

$$Kcal/100g = (protein\,\% \times 4) + (fat\,\% \times 9) + (lactose\,\% \times 4)$$

Calves growth performance

After parturition, calves were placed next to their mothers for the first 5 days to ensure that they got enough colostrum. Birth weight was recorded at the birth. Thereafter, body weight of calves was recorded at day 7, 14, 21, 56, 90 day and at weaning age (105 day) according to **Kišac *et al.*** (**2011**). Total gain and ADG were calculated.

Statistical analysis:

Data were statistically analyzed by one- way ANOVA using software (**SAS, 2009**). The following statistical model was used:

$$Y_{ij}=\mu+R_i+e_{ij}$$

Where: μ is the overall mean of Y_{ij}; R_i is the effect of treatment; e_{ij} is the experimental error

Duncan's new multiple range test **(Duncan, 1955)** was used to calculate differences between means.

Results and Discussion

Milk Yield

Data in Figure (1) showed an increase in the milk yield was observed in the Bet group than that in CG. However, Bet may be reduces the effect of HS on milk production in Aberdeen Angus cows as expected. Similarly, many studies performed on dairy cows confirmed higher milk production with Bet supplementation **(Dunshea et al 2019; Shah et al. 2020; Soliman et al., 2024).** Also, an improvement in milk production with 35 and 70 g Bet/cow/day was observed under thermo-neutral conditions by **Hall et al. (2016)**. In Bet group, rumen fermentation decreases Bet concentrations, with an increase in acetate concentrations (**Mitchell et al., 1979).** An increase in acetate was shown to increase the rate at which milk is synthesized in another study by **Purdie et al., (2008)**.

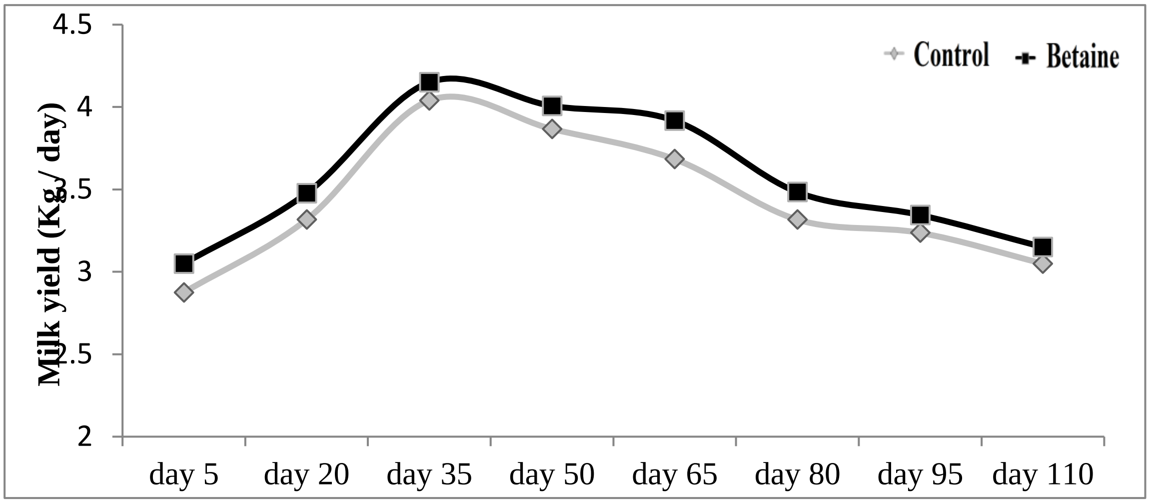

Figure (1): Effects of Bet supplementation on milk yield (Kg / day)

Colostrum and Milk Compositions

Data in Table (2) showed that total solids and fat percentage in either colostrum or milk were significantly increased (P<0.05) in Bet group. Similarly, **(Shah et al. 2020)** found that fat percentage of Bet group was significantly higher (p<0.05) than that in the other groups. Likewise, dietary Bet increased fat content of colostrum in Sanjabi ewes **(Shakeri et al., 2018).** Moreover, milk fat increased as a result of Bet in lactation dairy cows **(Wang et al., 2010)** and in goats **(Fernández et al., 2004)**. Within the rumen, microorganisms convert Bet to acetate (**Mitchell et al., 1979**) and acetate is directly correlated with milk fat (**Bauman and Griinari, 2003**).

Table (2). Effects of Bet supplementation on colostrum and milk compositions

Item	Treatments		P-value
	Control	Bet	
Colostrum compositions			
Total Solids (%)	14.41±0.62[b]	16.39±0.57[a]	0.005
Fat (%)	3.33±0.36[b]	5.28±0.24[a]	0.001
Solids not fat (%)	11.08±0.46	11.11±0.44	0.949
Milk protein (%)	4.14±0.19	3.95±0.12	0.147
Lactose (%)	5.98±0.22	5.97±0.18	0.954
Ash (%)	0.96±0.07	1.19±0.29	0.441
Calorific value (Kcal/100g)	70.40±3.80[b]	87.18±2.89[a]	0.001
Milk compositions			
Total Solids (%)	12.14±0.38[b]	12.55±0.40[a]	0.001
Fat (%)	2.07±0.19[b]	2.52±0.22[a]	0.001
Solids not fat (%)	10.07±0.23	10.03±0.22	0.739
Milk protein (%)	3.70±0.10	3.69±0.08	0.724
Lactose (%)	5.46±0.10	5.49±0.12	0.726
Ash (%)	0.88±0.04	0.85±0.02	0.329
Calorific value (Kcal/100g)	55.27±2.33[b]	59.35±2.57[a]	0.001

[a,b] *Means in the same row lacking a common superscript differ (P<0.05).*

In the present study, protein percentage in either colostrum or milk didn't show significant differences. Moreover, dietary Bet didn't influence milk protein % of goats **(Fernandez et al., 2004),** dairy cows **(Wang et al., 2019)** and buffaloes under HS conditions **(Shankhpal et al., 2019)**

In the current study no significant difference was observed in milk lactose and ash in either colostrum or milk. The results of the present study are in agreement with **Shankhpal et al. (2018)** who reported that milk lactose was not affected by adding Bet to crossbred cows under HS. In addition, dietary Bet didn't affect lactose content of colostrum in Sanjabi ewes **(Shakeri et al., 2018).**

The calorific value in either colostrum or milk was significant ($P<0.05$) higher in Bet than CG. The difference in CV might be attributed to the variation in lactose, fat and protein % in either colostrum or milk. In a retrospective study, **Ismail and Hamdon, (2017)** reported that Aberdeen Angus milk had a CV of 51.61 Kcal, and Aberdeen Angus milk had the lowest CV compared to Friesian and Baladi cows' milk (61.84 and 62.90 Kcal, respectively). In this study, bet supplementation increased the CV to 59.35 Kcal which was 1.15 and 1.07 folds of **Ismail and Hamdon, (2017)** and the CG of this study, respectively.

Calves Performance

Data in Table (3) indicated that calves from Bet-fed cows tended to be heavier at the birth than calves in the control group (35.600 vs. 34.433 kg). In addition, average daily weight gain was improved up to 105 days of age for calves from Bet-fed cows as compared to calves from control cows.

Table (3). Growth performance of Aberdeen Angus calves (kg)

Item	Treatments		P-value
	Control	Bet	
Birth weight	34.433 ± 0.62	35.600 ± 0.89	0.404
7th day	39.117 ± 0.84	40.517 ± 0.63	0.312
14th day	42.517 ± 1.04	44.500 ± 0.50	0.212
21th day	47.683 ± 0.45	49.600 ± 0.49	0.068
56th day	67.110 ± 1.32	69.083 ±0.61	0.308
90th day	94.300 ± 0.52	96.010 ± 1.14	0.302
105th day (Weaning weight)	105.333 ± 0.70	108.117 ±1.10	0.139
ADG	0.675 ± 0.001^{b}	0.691 ± 0.004^{a}	0.037
Total Weight gain	70.900 ± 0.09^{b}	72.516 ± 0.45^{a}	0.037

[a,b] Means in the same row lacking a common superscript differ ($P<0.05$) ADG, Average daily gains from birth to weaning

The results are in agreement with **Yarahmadi et al. (2020)** and **Sahraei et al., (2020)** those found that dietary supplementation of Bet was beneficial for improving lambs' birth weight in ewes. Calves born from Bet-fed cows were heavier than those born from control cows. Recently, a positive association has been reported between placenta concentration of Bet and embryo weight **(King et al., 2017),** which supports the role of Bet in promoting fetal growth **(Zhang et al., 2015).** However, the reason behind the relation between Bet and greater birth weight of calves in Bet-fed cows remained unclear. It might be due to enhanced transfer of Bet from the placenta to the fetus or / and due to the fact that Bet is a source of nitrogen. Betaine may also reduce osmotic stress **(Lever and Slow, 2010),** which could have contributed to the observed im-provements in placental efficiency. In Bet-fed cows, oxidation of Bet into di-methyl glycine might have improved the embryo growth. Betaine involves in production of glycine for glutathione synthesis and indirectly for embryo development **(Mutinati et al., 2013).**

Generally, average daily weight gain was improved up to 105 days of age for calves from Bet-fed cows as compared to calves from control cows. This could best be explained by the higher amount of milk and milk fat consumed by calves of Bet-fed cows as compared to calves from control cows **(Table, 2).** Daily gains of calves during the suckling period are dependent on the quantity and quality of milk available to the calf **(Krohn, 2001).** Calves fed more milk remained healthy and gained weight much more rapidly before weaning **(De Passillé, 2001).**

Conclusion

Supplementation of Bet had a significant effect on colostrum and milk composition of Aberdeen Angus cows and growth performance of their calves under environmental conditions New Valley government during HS of summer season. In conclusion, Bet supplementation during HS could be an effective strategy to enhance the productive performance without negative impact on the health of Aberdeen Angus cows under HS conditions.

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Conflicts of Interest/ Competing interest:

The authors declare that they have no competing interests.

Ethical statement

This experiment was performed in accordance with the internationally accepted standard ethical guidelines for animal use and care.

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