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PRODUCTIVE PERFORMANCE OF BARKI EWES FED DIETS SUPPLEMENTED WITH SODIUM CARBONATE, SODIUM BICARBONATE OR ACID BUF UNDER SIWA OASIS CONDITIONS

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ABSTRACT: Twenty-eight Barki ewes were randomly assigned to evaluate the effects of various feed additives on productive performance. The ewes (during their final gestation phase and continuing through lactation) were distributed into four groups. The first group (control group) received a basal diet consisted of concentrate feed mixture and alfalfa hay (G1), the second group was given the control diet supplemented with 10 g/h/d of sodium bicarbonate and 10 g/h/d of sodium carbonate (G2), the third group was provided the control diet supplemented with 10 g/h/d of Acid Buf (G3). In comparison, the fourth group was fed the control diet supplemented with 10 g/h/d of sodium bicarbonate, 10 g/h/d of sodium carbonate, plus 10 g/h/d of Acid Buf (G4). The findings indicated that the supplemented ewes (G2, G3, and G4) had improved body weight and dry matter intake at different physiological stages compared to the control group (G1). Groups G3 and G4 demonstrated increased ($P < 0.05$) average daily milk yields of 21.5% and 20.2%, respectively, compared to the control group. The results of the lamb's performance showed that G4 had a notably greater ($P < 0.05$) birth weight, approximately 13.4% higher than that of the control group. The lambs in the control group exhibited lower total and average gain compared to those in the supplemented groups. The digestion coefficients for dry and organic matter were enhanced in all treated groups, with G3 (AB group) showing the highest value. The ruminal pH and blood hematological parameters were in the standard and healthy ranges for Barki ewes. In summary, certain feed additives such as sodium carbonate, sodium bicarbonate, and Acid Buf positively influence the productive performance of Barki ewes in desert environments.

Key words: Sodium carbonate, sodium bicarbonate, Acid Buf, productive performance, and Barki ewes.

INTRODUCTION

Barki sheep proudly stand among the trio of leading sheep breeds in Egypt, making up approximately 8% of the nation's sheep population (Sallam, 2021; Sallam *et al.,* 2019). It has several advantages, including being well-adapted to harsh environmental conditions, such as food supply and water resource shortages (Sallam, 2021). Furthermore, Barki sheep can produce a reasonable amount of meat, wool, and milk under these harsh conditions, such as high ambient temperatures (El-Wakil *et al.,* 2008). However, the reproduction phase can be a particularly daunting stage in the lives of lambs. This period is marked by numerous challenges, primarily due to the heightened nutritional demands required for fetal development and subsequent milk production. Sobiech *et al.* (2008) emphasize that a significant amount of energy and minerals are essential for the synthesis of milk. The milk produced by ewes is often considered the cornerstone of nutrition for newborn lambs, providing vital nutrients that support growth during their early lactation (Abousoliman *et al.,* 2020). This nourishing milk not only supports growth but also fortifies young lambs against infections and diseases (Kalyankar, 2016). Nonetheless, it is noteworthy that Abousoliman *et al.* (2021) pointed out a rather interesting fact: the milk production levels in Barki sheep tend to be lower than those of their counterparts, both other indigenous Egyptian breeds and their international

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counterparts. This has had a detrimental impact on lamb growth and survival, resulting in an increased mortality rate among lambs due to malnutrition (Sallam *et al.,* 2019).

Various nutritional strategies have been implemented to boost sheep productivity, including the use of feed additives. The European Commission has stated that feed additives provide multiple advantages, including boosting animal health and performance, as well as increasing nutrient digestibility (Animal Feed Additives, 2018, web source). Additionally, feed additives can help stabilize rumen pH (Alhidary *et al.,* 2019), promote growth in animals, and help combat various diseases (Specialty Feed Additives Report 2016; Nayel *et al.,* 2019). The significance of feed additives is increasing rapidly due to the incorporation of substances like carbonates, bicarbonates, and calcified seaweed (Acid Buf), which are known to provide beneficial effects and supply a variety of nutrients, including sodium, protein, calcium, and magnesium (Cruywagen *et al.,* 2015).

Some researchers have examined the existing information and noted a lack of adequate data concerning the impact of current experimental feed additives on the performance of small ruminants (Bodas *et al.,* 2009; Alhidary *et al.,* 2019). Farghaly *et al.* (2019) also highlighted this gap, particularly in dairy ewes. Thus, the primary objective of this study was to assess the impact of sodium carbonate (SC), sodium bicarbonate (SB), and Acid Buf (AB) on the productivity of Barki ewes during the gestation and lactation phases in desert conditions.

MATERIALS AND METHODS

Experimental location:

This study was conducted at Siwa city, Matrouh Governorate in Siwa Research Station, (Tegzerty Experimental Farm for Animal Production), which belongs to Desert Research Center, Ministry of Agriculture and Land Reclamation, Egypt. Geographically, Siwa Oasis lies as much as 18 m below sea level (Masoud & Koike, 2006) and is characterized by desert climate (Zidane, 2010).

Experimental additives

In the current study, three additives were used in the tested groups: sodium carbonate (SC), sodium bicarbonate (SB), and Acid Buf (AB). Sodium bicarbonate and sodium carbonate were obtained from the commercial market.

Acid Buf (AB) is manufactured from calcified marine algae (*Lithothamnium calcareum*) obtained from seaweed (which was obtained from the EGAVET company, located at 106 Faisal St., Giza Governorate, Egypt). The Acid Buf contained almost 95% ash, which composed of 30% calcium, 5.5% magnesium, 0.7% potassium, 0.15% sodium, 0.05% sulfur, and the rest of the product is made up of other trace minerals that ranged from 0.1 to 500 ppm (Cruywagen *et al.*, 2004; Beya, 2007; Enemark, 2008; Cruywagen *et al.*, 2015).

Feeding trial:

Twenty-eight Barki ewes in the last eight weeks of gestation, with an average body weight of 42.76 ± 0.68 kg and aged between 3 and 4 years, were housed indoors and randomly assigned to four dietary treatment groups (n=7) in a completely randomized block design, which continued through the end of the lactation period. A concentrate feed mixture (CFM) was formulated to include 42% corn, 27% wheat bran, 17% soybean meal, 10% discarded dates, 2.5% limestone, 1% salt, and 0.5% mineral and vitamin mixture. This mixture was offered to the animals based on their productive status and the recommendations of Kearl (1982). To meet 60% of daily nutrient requirements during pregnancy and 50% during lactation, the remaining requirements were covered with alfalfa hay as roughage.

Ewes were randomly assigned to evaluate the effects of various feed additives on the productive performance as follows:

Group 1: the basal diet without any additives as a control diet (G1).

Group 2: the basal diet supplemented with 10 g/h/d from of both sodium bicarbonate and sodium carbonate (G2).

Group 3: the basal diet supplemented with 10g/h/d from the Acid Buf (G3).

Group 4: the basal diet backed with 10 g/h/d sodium bicarbonate, 10g/h/d sodium carbonate plus 10g/h/d Acid Buf (G4). The concentrated ingredients were mixed carefully and supplemented with various types of experimental feed additives.

Milk yield estimation

Milk production was recorded biweekly using five ewes per group, starting from the second week postpartum and continuing through the 12th week of lactation. Hand-milking was performed after the lambs were separated from their dams. Ewes were milked twice daily, with a 6-hour interval between milking processes. The first milking, intended to empty the mammary gland, was discarded. The second milking was used to assess milk yield over the 6-hour interval. The amount of milk obtained was then multiplied by four to estimate the total daily milk yield (Ferreira *et al.,* 2018).

Digestibility trials

At the end of the feeding trial, digestibility trials were conducted using twenty ewes (n=5) with an average weight of 42.67 ± 1.02 kg and aged 3–4 years to evaluate dry matter and organic matter digestibility, as well as water utilization. The ewes were individually housed in metabolic cages and fed for 14 days as an adaptation period, followed by a 7-day collection period. Total fresh feces were collected and weighed daily, and a 10% subsample was taken each day, dried, and used to estimate nutrient digestibility. After complete drying, fecal samples from each animal were pooled and ground for proximate chemical analysis. Fresh water was provided ad libitum throughout the experimental period. At the end of the digestibility trials, rumen liquor samples were collected using a stomach tube (according to Ramos-Morales *et al.,* 2014)

Analytical procedures

Dry matter (DM), crude protein (CP), crude fiber (CF), ether extracts (EE), and ash were determined according to AOAC (2005), while differences were calculated as nitrogen-free extract (NFE). The pH value of rumen fluid samples was measured before feeding, and at 3- and 6-hours post-feeding using a Beckman pH meter.

Blood Sampling

Blood samples were collected (before feeding) at the end of the feeding trial from the jugular vein of ewes. Blood samples were analytically assessed to determine some hematological parameters, including the count of red and white blood cells (RBCs and WBCs). Hematocrit value (HCT) and hemoglobin (HGB) concentration in the whole blood were also assessed. Means of corpuscular hemoglobin concentration (MCHC), corpuscular hemoglobin (MCH), and corpuscular volume (MCV) values were calculated (Patterson *et al.,* 1960).

Statistical analysis

Data obtained in this study were statistically analyzed using one-way ANOVA in SAS software (SAS, 2002). The mathematical model was Yij = µ Ti eij, where Yij represents experimental observation, µ represents the overall mean, Ti represents the effect of treatment, and eij represents the experimental error. Differences between means were compared by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical Composition

Table 1 presents the chemical analysis of the experimental feedstuff, indicating that the CFM contained a satisfactory percentage of essential nutrients for sheep nutrition. The chemical composition of CFM is similar to Abo Bakr, (2025) who used CFM with the same ingredients.

Table 1. Chemical composition (g/kg DM) for a mixture of concentrate feed and alfalfa hay.

Items	DM	OM	CP	CF	EE	NFE	Ash
CFM	925.5	910.5	170.2	66.2	43.5	630.6	89.5
Alfalfa hay	909.4	870.5	155.7	284.7	16.9	413.2	129.5

In the current study, the chemical composition of alfalfa hay included 155.7g/kg DM for CP and 284.7g/kg DM for CF. These findings align with those of Sayed *et al.* (2021), who noted that the crude protein levels in alfalfa hay varied between 136.7 and 207.6 g/kg. Additionally, Arab *et al.* (2015) indicated that the crude fiber levels in alfalfa hay varied between 230.0-322.8 g/kg DM, while the ash levels ranged from 62.7-1344 g/kg DM.

Live body weight changes and feed intake of ewes during the late gestation period

Table 2 shows the changes in body weight and feed consumption of Barki ewes. The findings indicated no significant variations in initial or average body weights across the various treatment groups. Nonetheless, the body weights before parturition were significantly higher in the treated groups compared to the control group. The control group (G1) had the lowest weight, followed by the AB group (G3). These results align with the studies by Cruywagen *et al.* (2015) and Wu *et al.* (2015). The weights of ewes in this period varied from 46.1 to 49.6 kg, which aligns with earlier findings for Barki ewes (Abo Bakr, 2019; Abo Bakr *et al.*, 2023).

Concentrate, roughage, and total feed intake were nearly alike across various additive types and the control group. The results of the current study aligned with those of Alhidary *et al.* (2015), who noted that the addition of Acid Buf, whether alone or combined with sodium bicarbonate, did not significantly impact DMI. Wu *et al.* (2015) also noted that calcareous marine algae do not enhance DMI in dairy cows across various physiological stages. Typically, total dry matter intake as a percentage of live body weight falls between 3.62% and 3.83%, which reflects the suggested needs of Kearl (1982) for pregnant ewes.

Table 2. Body weight changes and feed intake of ewes during the late gestation period.

Items	G1	G2	G3	G4	±SE
Initial BW, kg	43.0	43.68	42.26	42.13	0.68
Average BW, kg during the gestation period	46.1	49.6	47.6	48.8	0.70
Average BW, kg Just before lambing	49.2^{b}	55.6^{a}	52.8^{ab}	55.3^{a}	0.98
Dry matter intake					
Concentrate intake, g/h/d	1011	1033	964	973	----
Roughage intake, g/h/d	754	824	762	790	----
TDMI intake, g/h/d	1765	1857	1726	1763	----
Total DMI as % of LBW	3.83	3.74	3.63	3.62	----

$^{a, b}$ means that in the same row with different superscripts are significantly (P<0.05) different.

G1: the basal diet without any additives as a control diet (CD).

G2: the basal diet plus 10 g/h/d from sodium bicarbonate and 10 g/h/d from sodium carbonate (SC+SB) group.

G3: the basal diet plus 10g/h/d from the Acid Buf (AB) group.

G4: the basal diet backed with 10 g/h/d sodium bicarbonate plus 10g/h/d sodium carbonate plus 10g/h/d Acid Buf (SC+SB+AB) group.

Ewes' body weight changes during different suckling periods

The changes in live body weight of ewes showed differences (P<0.05) between the various experimental groups solely after lambing (Table 3). The highest weight gain after lambing was observed in G4, followed by G2 and G3, while the control group had the lowest weight gain. Conversely, ewe weights at various stages of lactation demonstrated no significant differences. between the treatment groups (Table 3). Likewise, no notable disparities were found between pre- and post-lambing weights among the groups, although the control group (G1) exhibited the lowest weight loss. This reduction may be attributed to the lower birth weights noted in this group (Table 5). The findings of our research were consistent with previous studies on Barki ewes (Abo Bakr *et al.,* 2023; Kewan, 2021).

Table 3. Body weight changes and feed intake of ewes during the lactation period.

Items	G1	G2	G3	G4	±SE
Average BW, kg Just after lambing	44.02[b]	48.1[ab]	46.8[ab]	50.2[a]	0.98
Difference between before and after lambing	5.2	7.5	6.1	5.3	0.40
During early lactation	41.5	45.4	43.5	46.6	0.90
During mid-lactation	41.2	43.48	41.26	42.8	0.75
During late lactation	41.5	39.8	40.73	41.4	1.03
Average BW, kg during the lactation period	41.4	42.8	41.8	43.6	0.79
Average feed intake g/h/d					
Average Concentrate intake, g/h/d	812	962	911	822	----
Average Roughage intake, g/h/d	883	1028	988	900	----
Average TDMI intake	1095	1990	1899	1722	----
Total DMI as % of LBW	4.01	4.65	4.54	3.95	----

[a, b] means that in the same row with different superscripts are significantly (P<0.05) different.
G1: the basal diet without any additives as a control diet (CD).
G2: the basal diet plus 10 g/h/d from sodium bicarbonate and 10 g/h/d from sodium carbonate (SC+SB) group.
G3: the basal diet plus 10g/h/d from the Acid Buf (AB) group.
G4: the basal diet backed with 10 g/h/d sodium bicarbonate plus 10g/h/d sodium carbonate plus 10g/h/d Acid Buf (SC+SB+AB) group.

The voluntary intake of concentrate and roughage was generally higher in Group 2. The results of the current research agree with those obtained by Bodas *et al.* (2009), who indicated that lambs given sodium bicarbonate ingested greater quantities of roughage dry matter. Total dry matter intake during various production phases was lowest in G1 when compared to the other groups that received feed additives. Cruywagen *et al.* (2015) also reported similar results, noting a non-significant rise in dry matter intake among dairy cows that were given diets enhanced with Acid Buf or sodium bicarbonate in comparison to the control group. In general, the total dry matter consumption as a proportion of live body weight varied between 3.95% and 4.65%, which is in close agreement with Kearl (1982) as guide nutrients for lactating ewes**.**

Milk yield performance

Information on milk production at various stages of lactation, total milk production (ml/head/day), is shown in Table 4. The greatest daily milk production was recorded in ewes consuming the AB-supplemented diets (G3 and G4), followed by those in the SC + SB group (G2). The least production was documented in the control group (G1). This can be linked to the feed additives boosting total volatile fatty acid (TVFA) production, especially by elevating ruminal acetate levels, which aids in milk production (Soliman, 2022). In this experiment, both varieties of additives enhanced daily milk production, with AB demonstrating the most substantial effect. These results were similar to those presented by Cruywagen *et al.* (2015). Similarly, Farghaly *et al.* (2019) discovered that adding sodium bicarbonate to ewes' rations enhanced milk production. Furthermore, the enhancement in milk production due to feed additives could be attributed to their beneficial impact on nutrient digestibility, as previously demonstrated in Table 6. This improvement in digestibility may have resulted in better feed efficiency, enabling a more efficient conversion of nutrients into milk production. In contrast, Cruywagen *et al.* (2007) found a non-significant effect of Acid Buf or sodium bicarbonate on milk production.

Table 4. Changes in milk yield (ml/h/d) of ewes affected by different types of feed additives.

Items	**G1**	**G2**	**G3**	**G4**	**±SE**
Milk yield, ml/h/d					
During early lactation	422.7^{b}	458.1^{ab}	473.8^{ab}	537.1^{a}	16.99
During mid-lactation	321.8	323.1	385.0	328.8	13.73
During late lactation	90.7^{c}	114.0^{bc}	156.2^{a}	138.5^{ab}	7.27
Average milk production	334.1^{b}	358.1^{ab}	406.1^{a}	401.8^{a}	11.71

[a, b] means that in the same row with different superscripts are significantly ($P<0.05$) different.
G1: the basal diet without any additives as a control diet (CD).
G2: the basal diet plus 10 g/h/d from sodium bicarbonate and 10 g/h/d from sodium carbonate (SC+SB) group.
G3: the basal diet plus 10g/h/d from the Acid Buf (AB) group.
G4: the basal diet backed with 10 g/h/d sodium bicarbonate plus 10g/h/d sodium carbonate plus 10g/h/d Acid Buf (SC+SB+AB) group.

Average daily milk yield showed increased (%) significant values of 21.5 and 20.2% for the AB group (G3) and G4, respectively, compared to the control group. It also varied from 334 to 406 (ml/h/d), and similarity with the previously noted values for Barki ewes identified by Abousoliman *et al.* (2021).

Lamb's performance

The body weight of newborn lambs from birth until weaning is displayed in Table 5. The findings showed that the group given the blend of feed additives (G4) had a significantly higher birth weight, approximately 13.4% higher than that of the control group. Nevertheless, there are no significant differences in average birth weight for supplemented groups (G2, G3, and G4).

Lowering birth weight in the control group (G1) could be linked to lower maternal body weight. Koritiaki *et al.* (2013) confirmed these findings, indicating that greater ewe body weight at gestation leads to higher birth weight and enhanced lamb survival. Additionally, the body condition score of ewes at the end of pregnancy is important, as highlighted by Pesántez-Pacheco *et al.* (2019). Thus, the nutritional management of ewes during gestation is crucial for fetal development (Caton & Hess, 2010).

Table 5. Growth performance of lambs affected by different types of feed additives.

Items	G1	G2	G3	G4	±SE
Birth weight, kg	3.91[b]	4.22[ab]	4.20[ab]	4.55[a]	0.09
For the first 4 weeks, kg	10.42	10.57	11.08	10.30	0.38
For the second 4 weeks, kg	17.82	19.94	19.52	19.70	0.49
Weaning weight, kg	23.3[b]	27.25[a]	26.17[ab]	24.35[ab]	0.61
Total gain, kg	19.39[b]	23.03[a]	21.97[ab]	19.80[ab]	0.58
Average daily gain, g/h/d	203	197	213	205	5.30

[a, b] means that in the same row with different superscripts are significantly (P<0.05) different.
G1: the basal diet without any additives as a control diet (CD).
G2: the basal diet plus 10 g/h/d from sodium bicarbonate and 10 g/h/d from sodium carbonate (SC+SB) group.
G3: the basal diet plus 10g/h/d from the Acid Buf (AB) group.
G4: the basal diet backed with 10 g/h/d sodium bicarbonate plus 10g/h/d sodium carbonate plus 10g/h/d Acid Buf (SC+SB+AB) group.

The present results demonstrated that G2 significantly enhanced ($P < 0.05$) lamb weaning weights and average total weight gain in comparison to the control group. In general, both weaning weights and average total gains showed better improvement in all treated groups compared to the control, highlighting the beneficial effect of feed additive supplementation on postnatal growth performance.

Feed intake and nutrient digestibility

The data in Table 6 show that the daily concentrated intake of ewes fed a diet enriched with sodium carbonate and sodium bicarbonate (G2) was significantly greater, whereas G4 exhibited a significantly lower intake. A similar pattern was recorded for roughage and overall dry matter consumption.

The results of the current study's intake resembled those of previous studies (Bodas *et al.*, 2009; Wittayakun *et al.*, 2015; Farghaly *et al.*, 2019). Additionally, the study proposed that increased roughage consumption ($P < 0.05$) occurs due to the addition of NaHCO3 to diets. Conversely, other studies have indicated that the voluntary feed intake of animals is not altered by sodium bicarbonate supplementation. Santra *et al.* (2003) stated that the dry matter intake values were unaffected by the inclusion of sodium bicarbonate in diets. Consistent with our results, Wu *et al.* (2015) reported that calcareous marine algae (AB) did not improve the DMI in dairy cows during different production stages.

The impacts of various feed additives on the digestibility of dry matter and organic matter are presented in Table 6. Supplementation with various additives in treated groups enhanced both dry matter and organic matter digestibility compared to the control group. Group G3 showed the highest values, whereas the control group had the lowest values. These results agreed with those obtained by Kholif *et al.* (2020) and Cristobal-Carballo *et al.* (2021), who also found that feed additives can enhance nutrient digestibility in ruminants.

The enhancement of nutrient digestibility observed with AB supplementation (G3 and G4) may be attributed to various factors. One potential reason is the presence of chlorella growth factor, which has been shown to enhance digestibility (Kholif *et al.*, 2017). Furthermore, Tsiplakou *et al.* (2017) found that AB supplementation increases the numbers of beneficial rumen microorganisms, such as *Butyrivibrio fibrisolvens*, *Ruminococcus albus*, and *Clostridium species*. The presence of β-glucans in AB further enhances ruminal fermentation and digestion (Iwamoto, 2004). Additionally, incorporating sodium bicarbonate ($NaHCO_3$) into the diet may improve digestibility by increasing the total number of ciliate protozoa and cellulolytic bacteria in the rumen (Santra *et al.*, 2003).

Table 6. Feed intake and digestion coefficients as affected by different types of feed additives during the digestibility trial.

Items	G1	G2	G3	G4	±SE
Live body weight, kg	41	43.5	44.5	41.7	1.02
Concentrate intake					
g/h/d	464^{a}	544^{a}	490^{a}	320^{b}	22.86
g/kg BW	11.3^{a}	12.5^{a}	11.0^{a}	7.6^{b}	0.47
% of LBW	1.1^{ab}	1.3^{a}	1.1^{b}	0.8^{c}	0.04
Roughage intake					
g/h/d	379^{b}	536^{a}	398^{b}	210^{c}	27.62
g/kg BW	9.2^{b}	12.3^{a}	8.9^{b}	5.0^{c}	0.06
% of LBW	0.92^{b}	1.23^{a}	0.89^{b}	0.50^{c}	0.62
Total DM intake					
g/h/d	843^{b}	1080^{a}	888^{b}	530^{c}	48.65
g/kg BW	20.5^{b}	24.8^{a}	19.9^{b}	12.7^{c}	0.05
% of LBW	2.0^{b}	2.5^{a}	2.0^{b}	1.3^{c}	0.1
Dry matter digestibility, %	57.69^{b}	61.72^{ab}	64.62^{a}	59.73^{ab}	1.00
Organic matter digestibility, %	60.19^{b}	65.20^{a}	67.11^{a}	61.02^{b}	0.79

$^{a,\ b}$ means that in the same row with different superscripts are significantly ($P<0.05$) different.

G1: the basal diet without any additives as a control diet (CD).

G2: the basal diet plus 10 g/h/d from sodium bicarbonate and 10 g/h/d from sodium carbonate (SC+SB) group.

G3: the basal diet plus 10g/h/d from the Acid Buf (AB) group.

G4: the basal diet backed with 10 g/h/d sodium bicarbonate plus 10g/h/d sodium carbonate plus 10g/h/d Acid Buf (SC+SB+AB) group.

Water utilization

Table 7 presents the impact of experimental feed additives on different water utilization metrics relative to the control diet. Ewes receiving the basal diet enhanced with sodium bicarbonate and sodium carbonate (G2) exhibited significantly higher ($P < 0.05$) differences in the majority of water-related parameters compared to the other groups. Increasing free water intake may lead to greater dry matter consumption (Abo Bakr *et al.*, 2020), which likely increases crude protein consumption (Allam *et al.*, 2009). Furthermore, the type of experimental additives, especially those with elevated ash levels, may have led to higher ash intake, which in turn could have encouraged increased water consumption (Abo Bakr, 2006). A similar trend was observed for combined water intake, which was reflected in total water intake; accordingly, the SC + SB group recorded significantly higher ($P < 0.05$) values for these parameters

Table 7. Water metabolism as affected by different types of feed additives.

Items	**G1**	**G2**	**G3**	**G4**	**±SE**
Free drinking water					
ml/h/d	1511.2^{ab}	1861.2^{a}	1074.0^{b}	948.2^{b}	119.3
ml/kg BW	37.14^{a}	42.8^{a}	24.3^{b}	22.4^{b}	2.74
ml/g DMI	1.76	1.72	1.24	1.74	0.10
Combined water					
g/h/d	84.4^{b}	106.8^{a}	87.1^{b}	52.5^{c}	4.82
ml/kg BW	2.1^{a}	2.4^{a}	1.9^{b}	1.2^{c}	0.10
Total water intake					
ml/h/d	1596^{ab}	1968^{a}	1161^{b}	1001^{b}	122.89
ml/kg BW	39.3^{a}	45.3^{a}	26.3^{b}	23.7^{b}	7.82
Water excretion					
Urinary water					
ml/h/d	232.5^{b}	711.1^{a}	287.9^{b}	382.5^{b}	51.35
ml/kg BW	5.8^{b}	16.42^{a}	6.44^{b}	9.52^{b}	1.20
Fecal water					
ml/h/d	161.4^{b}	327.9^{a}	134.5^{b}	85.0^{b}	25.88
ml/kg BW	4.0^{b}	7.6^{a}	2.9^{b}	2.1^{b}	0.6
Total water excretion					
ml/h/d	393.9^{b}	1039.0^{a}	422.4^{b}	467.6^{b}	71.18
ml/kg BW	9.78^{b}	24.0^{a}	9.4^{b}	11.58^{a}	1.64
Water balance					
ml/h/d	1201.7^{a}	929.0^{ab}	738.4^{ab}	533.3^{b}	99.42
ml/kg BW	29.5^{a}	21.6^{ab}	16.84^{b}	12.14^{b}	2.34

[a, b] means that in the same row with different superscripts are significantly (P<0.05) different.
G1: the basal diet without any additives as a control diet (CD).
G2: the basal diet plus 10 g/h/d from sodium bicarbonate and 10 g/h/d from sodium carbonate (SC+SB) group.
G3: the basal diet plus 10g/h/d from the Acid Buf (AB) group.
G4: the basal diet backed with 10 g/h/d sodium bicarbonate plus 10g/h/d sodium carbonate plus 10g/h/d Acid Buf (SC+SB+AB) group.

Water excretion (fecal, urinary, and total water excretion) influenced by the type of experimental diets demonstrated a greater significant difference in the (SC+SB) group compared to the other groups. The increased urinary water in the treated groups (excluding the control) could result from the elevated ash content in different experimental feed additives. These findings aligned with those reported by Eid (2003), who stated that high ash content causes animals to produce more urine as a natural means of eliminating minerals.

Meanwhile, animals fed G2 showed the highest ($P<0.05$) value of total water excretion. It appears that total water loss was primarily influenced by total water intake, as both showed the same trend.

Ruminal pH

Data in Table 8 showed that there were no significant variations in ruminal pH values among the experimental groups. These results agree with Bodas *et al.* (2009) and Cruywagen *et al.* (2015), both of which indicated that the addition of sodium bicarbonate or Acid Buf to the diet did not result in significant changes in ruminal pH. Nevertheless, Farghaly *et al.* (2019) noted that adding sodium bicarbonate to the diets of rams led to an increase ($P < 0.05$) in ruminal pH.

In this study, the average rumen pH values found are within the optimal range identified by Kachhadia *et al.* (2023), who indicated that the ideal rumen pH for dairy animals should lie between 6.2 and 6.8. A rumen pH lower than 5.8 negatively affects fiber degradation, resulting in decreased fiber digestibility. Moreover, excessively high levels of acidity can lead to undesirable changes that negatively impact animal health.

Table 8. Rumen pH as affected by different types of feed additives.

Items	G1	G2	G3	G4	±SE
pH					
Before feeding	6.78	6.91	6.65	6.94	0.05
Post 3 hr. after feeding	6.63	6.58	6.62	6.76	0.04
Post 6 hr. after feeding	6.68	6.68	6.67	6.69	0.02
Average	6.89	6.73	6.61	6.80	0.03

$^{a,\,b}$ means that in the same row with different superscripts are significantly ($P<0.05$) different.
G1: the basal diet without any additives as a control diet (CD).
G2: the basal diet plus 10 g/h/d from sodium bicarbonate and 10 g/h/d from sodium carbonate (SC+SB) group.
G3: the basal diet plus 10g/h/d from the Acid Buf (AB) group.
G4: the basal diet backed with 10 g/h/d sodium bicarbonate plus 10g/h/d sodium carbonate plus 10g/h/d Acid Buf (SC+SB+AB) group.

Hematological blood parameters

The impact of using various experimental feed additives in ewe diets on hematological blood parameters was presented in Table 9. The differences were not significant among the groups in hemoglobin (HGB), red blood cell count (RBC), and hematocrit (HCT) levels. These results are consistent with those reported by Bernard *et al.* (2014), who observed no significant variations in blood metabolites among lactating cows provided diets enhanced with similar additives, which were used in our study.

Hemoglobin (HGB) values for the various treated groups ranged from 7.90 to 8.36 g/dl, which is consistent with the range noted by Abo Bakr *et al.* (2023), who found HGB values from 7.80 to 10.89 g/dl in lactating ewes in desert environments. The numeric increase in HGB levels in the treated groups (G2 and G4) could suggest enhanced health and immunity, potentially reflecting sufficient nutritional status (Tambuwal *et al.*, 2012). The average RBC counts in the present study ranged from 7.36 to 8.68 × 10^6/μL and were close to the range of 6.30 to 8.29 × 10^6/μL reported by Egbe-Nwiyi *et al.* (2000).

Table 9. Some hematological parameters of ewes as affected by different types of feed additives.

Items	G1	G2	G3	G4	±SE
HGB (g/dl)	7.96	8.36	7.90	8.22	0.17
RBC (10^6 /mm^3)	7.36	8.64	8.46	8.68	0.29
HCT (%)	23.82	24.84	23.54	24.74	0.69
MCV (Fl=liter×10^{-15})	33.66	29.54	27.82	28.38	1.37
MCH (pg=10^{-12} g)	11.16	9.96	9.40	9.58	0.37
MCHC (%)	34.18	33.68	34.22	33.72	0.78
MCV/RBC	4.96	3.72	3.28	3.32	0.34
WBC (10^{-3} Cells/mm^3)	10.04^{ab}	7.66^{c}	11.48^{a}	8.78^{c}	0.41
Neutrophil (%)	53.76^{b}	48.11^{b}	50.97^{b}	60.90^{a}	1.41
Lymphocytes (%)	42.06^{ab}	50.09^{a}	43.55^{ab}	37.49^{b}	1.42
Monocytes (%)	3.45	3.09	2.61	2.88	0.35
Eosinophils (%)	0.72^{b}	0.70^{b}	2.85^{a}	0.71^{b}	0.29

$^{a,\,b}$ means that in the same row with different superscripts are significantly (P<0.05) different.
G1: the basal diet without any additives as a control diet (CD).
G2: the basal diet plus 10 g/h/d from sodium bicarbonate and 10 g/h/d from sodium carbonate (SC+SB) group.
G3: the basal diet plus 10g/h/d from the Acid Buf (AB) group.
G4: the basal diet backed with 10 g/h/d sodium bicarbonate plus 10g/h/d sodium carbonate plus 10g/h/d Acid Buf (SC+SB+AB) group.

The counts of white blood cells (WBCs) were significantly higher (P < 0.05) in G3 compared to the other groups. The rise in WBCs seen in the AB group could be attributed to an increase in granulocyte percentage at the expense of lymphocyte and monocyte percentages (Abo Bakr *et al.*, 2020). Barsila *et al.* (2020) state that various factors, such as nutritional status, can influence changes in WBC counts. White blood cells are essential to the body's defense system, and increased levels might indicate heightened or activated immune activity (Egbe-Nwiyi *et al.*, 2000). Barsila *et al.* (2020) state that various factors, such as nutritional status, can influence changes in WBC counts. White blood cells are essential to the body's defense system, and increased levels might indicate heightened or activated immune activity (Egbe-Nwiyi *et al.*, 2000).

The higher lymphocyte percentage observed in ewes on the SC + SB diet may result from the capacity of these additives to activate lymphocytes and support immune cells. This stimulation can increase antibody production and subsequently boost cell-mediated immunity (Banji *et al.*, 2012).

In this study, the absolute counts of eosinophil ranged from 0.7 to 2.85 ×10^3/µL, consistent with the results of Borjesson *et al.* (2000), who noted that eosinophil counts in desert sheep varied from 0.0 to 2,500 cells/µL, compared to 0.0 to 1,000 cells/µL in domestic sheep.

Conclusion

In the context of Siwa Oasis, it is advisable to consider specific feed additives, including sodium carbonate, sodium bicarbonate, and Acid

Buf, to potentially improve digestion coefficients, water balance, milk yield, and body weight in both Barki ewes and their lambs. This is demonstrated by the elevated weaning weights of lambs and the enhanced productivity of the ewes.

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الأداء الإنتاجي لنعاج البرقي المغذاة على علائق مضاف إليها كربونات الصوديوم، بيكربونات الصوديوم، أو الاسيد بف في ظل ظروف واحة سيوة

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تم توزيع ثمانية وعشرين نعجة برقى (تتراوح أعمارها بين 3-4 سنوات، بمتوسط وزن 42.76 ± 0.68 كجم) عشوائيًا إلى أربع مجموعات متساوية لدراسة تأثير بعض إضافات الأعلاف على الأداء الإنتاجي لنعاج البرقي. قُسِّمت النعاج في آخر مرحلة الحمل واستمرت حتى نهاية موسم الرضاعة، وكانت المجموعات كالتالى:- المجموعة الأولى تغذت على العليقة الأساسية (مخلوط العلف المركز بالإضافة إلى دريس البرسيم الحجازي) بدون أي إضافات كعليقة ضابطة (مج1)، المجموعة الثانية تم تغذيتها على العليقة الضابطة مدعمة بـ 10جم من بيكربونات الصوديوم و10 جم من كربونات الصوديوم لكل نعجة فى اليوم (مج2)، والمجموعة الثالثة تم تغذيتها على العليقة الضابطة مدعمة بـ 10 جم/يوم/نعجة من الأسيد بف (مج 3)، والمجموعة الرابعة تم تغذيتها على العليقة الضابطة مدعمة بـ 10 جم/يوم/نعجة من بيكربونات الصوديوم و10 جم/يوم/نعجة من كربونات الصوديوم بالإضافة إلى 10 جم/يوم/نعجة من الأسيد بف (مج4). أظهرت النتائج أن النعاج التي تغذت على نظام غذائي مضاف إليه إضافات علفية مختلفة كانت أعلى في وزن الجسم وكمية المادة الجافة المستهلكة خلال المراحل الفسيولوجية المختلفة مقارنة بالنعاج التي تغذت على العليقة الضابطة. سجلت المجموعات المدعمة بالإضافات الغذائية (مج3 ومج4) زيادة معنوية في متوسط الإنتاج اليومي من الحليب بنسبة 21.5٪ و 20.2٪ على التوالي مقارنة بالمجموعة الضابطة. كشفت نتائج أداء الحملان أن المجموعة التي احتوت علائقها مخلوط الإضافات الغذائية (مج4) كانت أعلى في وزن الميلاد (P <0.05) بنحو 13.4٪ مقارنة بالمجموعة الضابطة. في حين أن المجموعة الضابطة كانت أقل في الزيادة الوزنية الكلية واليومية مقارنة بالعلائق الأخرى. أدت الإضافات المختلفة إلى تحسين معاملات هضم المادة الجافة والعضوية وكانت أعلى قيمة في المجموعة الثالثة (مجموعة AB) مقارنة بالمجموعة الضابطة. كانت درجة حموضة الكرش وبعض معايير الدم ضمن النطاق الفسيولوجي والصحي لنعاج البرقي. ومن خلال ما سبق، يمكن التوصية بإضافة كربونات الصوديوم وبيكربونات الصوديوم والأسيد بف إلى علائق النعاج البرقي لما لها من تأثير إيجابي على الأداء الإنتاجي لنعاج البرقي تحت الظروف الصحراوية.