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The impact of feeding date palm by products on the reproduction of Awassi ewe in the Qatari environment

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ABSTRACT
The study aimed to examine the effect of feeding date palm with a product-based ration on the productivity of Awassi ewes raised intensively in the Qatari environment. The two matching total mixed rations consisted primarily of Rhodes and barely grains (CD), discarded dates, and crushed fronds (NCD). Forty-four Awassi ewes were divided into two matching groups. The groups were allocated randomly to the dietary treatments in a randomized block design experiment of 2 rams (mature fertile male sheep). Dates of service and lambing, ewes' weights at conception and lambing, and lambs' weights at birth and weaning (at 90 days of age) were registered. The type of diet had no effect on percentages of conceived and lambed ewes: gestation (150 ± 3.4 days), lambing interval periods (326 ± 17.4 days), litter size (117 ± 37.9 lambs/100 ewes), litter birth weight (3.9 ± 1.07 kg/lambing ewe), litter weaning weight (20.4 ± 5.83 kg/lambing ewe), weight of weaned lambs/ewe/year, weight of weaned lambs/kg of ewe weight/year, and weight of weaned lambs/kg$^{0.75}$ of ewe weight/year. The NCD group had higher feed intakes (dry matter, DM, metabolizable energy, ME, and crude protein, CP) than the CD group. However, in terms of cost, NCD had a low cost of daily feed intake (1.88 vs. 2.42 riyals/ewe/day) and a cost of one kilogram of weaned lambs/ewe/year (30.8 vs. 43.2 riyals). It was concluded that feed based on date palm byproducts provided a performance not different from conventional feed but at a low feed cost.

Contribution/Originality: The study highlighted the potential of date palm by-products as a satisfactory alternative when the supply of local feed resources is a limiting factor and as a substitute for conventional, high-priced imported sources. This study is the first to document the productivity of Awassi sheep in a Qatari environment.

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1. INTRODUCTION

Only natural vegetation may be able to meet the nutritional needs of ruminants in arid, semi-arid, and tropical regions. The scarcity of natural resources, particularly feed and water, challenges the productivity of the livestock sector in Qatar. According to the country's Department of Agricultural Affairs reports (Agricultural Bulletin, 2022), .forage crops available for consumption in 2021 were about 263 thousand tons, with a self-sufficiency ratio of 39%The aforementioned reference documents the presence of a total of about 1.7 million palm trees in Qatar. This amount of date palm trees may be a considerable source of roughages since a date palm tree can produce up to 20 kg of dry fronds annually (Pascual, Fernandez, Díaz, Garces, & Rubert-Aleman, 2000). Moreover, discarded date fruits have the ability to replace concentrates as energy sources in feed (Al-Dobaib, Mehaia, & Khalil, 2009).

According to reports of DAR (2022), the total livestock population was about 1.3 million heads, of which 64.8%, 25.8%, 7.1%, and 2.3% were sheep, goats, camels, and cattle, respectively. In Qatar, about 72% of local sheep flocks consumed red meat. This implies that enhancing the productivity of the national sheep herd is critical for national food security. Awassi was the most widespread breed of sheep in Qatar (Al Awad et al., 2022). There is a dearth of documented information about the reproductive performance of Awassi sheep under intensive management systems in Qatar.

Three indices are used to measure the annual productivity of ewes (Atta & Khidir, 2006; Sulieman, Sayers, & Wilson, 1990). These indices reflect the capacity of weaned litter size and the frequency of lamb production per year. These indices are calculated in terms of annual kilograms of weaned lambs' production per ewe, per postpartum weight of ewe or per metabolic postpartum body weight of ewe.

The purpose of the study was to investigate the effects of feeding Awassi sheep flocks feeds made from crushed palm fronds and discarded dates as opposed to feeds made from ground barley grains and dried Rhods on the flocks' ability to reproduce.

2. MATERIAL AND METHODS

2.1. Animals

The research used forty-four Awassi ewes, ranging in age from 1.5 to 2 years. The ewes were divided into two experimental groups of 22 animals each. They had a matching average body weight (47.8 vs. 47.7 kg). Each experimental group was divided into 11 subgroups, each composed of two body-weight-matched ewes. A 4 m2 pen accommodated each subgroup. The pens are supplied with watering and feeding troughs.

2.2. Experimental Diets

Two totally mixed iso-caloric and iso-nitrogenous diets based on barley grains and crushed Rhodes hay (conventional diet, CD) and on crushed palm fronds and date waste (non-conventional diet, NCD) were used. Table 1 shows the ingredient proportions, nutritional content, and feed cost of the experimental diets. The detailed nutritional value of the experimental diets had been described previously (Atta et al., 2018).

Table 1. Ingredients proportions of the experimental diets.

Ingredients proportion	Conventional diet (CD)	Non-conventional diet (NCD)
Date waste, g/kg	-	100
Palm fronds, g/kg	-	240
Urea, g/kg	-	5
Molasses, g/kg	-	200
Barley grains, g/kg	100	-
Rhodes, g/kg	300	-
Soybeans, g/kg	250	300
Wheat bran, g/kg	320	125
Calcium Diphosphate, g/kg	20	20
Common salt, g/kg	10	10
Cost of a ton of feed, Qatari Riyals/Ton*	1708	1145
Metabolizable energy, MJ/kg DM	10.4	9.7
Digestible crude protein, g/kg	191	197

Note: * Qatari Riyal = 0.27 USD.

2.3. Management

The ewes' subgroups were randomly assigned to the two experimental feed treatments. The amount of feed offered was adjusted weekly on the basis that the refusals represented approximately 10% of the offer. All animals always had access to clean drinking water and mineral licks. Each animal received 500 grams of fresh alfalfa once a week.

Two fertile rams were selected to join the ewes in a randomized block design experiment. Each ram was assigned a block. Six subgroups of CD treatments and five subgroups of NCD treatments make up the first block, while five subgroups of CD treatments and six subgroups of NCD treatments make up the second block. Daily in the morning, ewes of each block were exposed to their allocated ram for a 3-hour' period. During this period, we closely observed the ewes, who showed signs of oestrus and accepted the ram. We then exposed them to the ram again in the evening to ensure successful mating, and we recorded the date of service. Daily exposure to the ram continued until ewes showed signs of pregnancy (developed udders and an enlarged abdomen) and were exposed to the ram again one week after lambing. Gestation and lambing intervals were then calculated. Ewes were weighed on the day of service and lambing. After drying, the birth weight of each lamb was immediately recorded. Only during the first week of lambing were lambs permitted to freely suckle their dams. From the second week onwards, we kept the lambs away from their dams for 12 hours at night, ensuring the dams' feed was always available in front of them. At 90 days of age, we registered the lambs' weaning weight.

Productivity indices were calculated as follows (Atta & Khidir, 2006):

$$\text{Weight of lambs weaned per ewe (kg)} = \text{number of lambs weaned per ewe} \times \text{average lamb's weaning weight}$$

Index 1 (kg, weight of weaned lambs produced per ewe per year):

$$\text{Index1} = \frac{\text{weight of lambs weaned per ewe} \times 365}{\text{subsequent lambing interval period}}$$

Index2 (Weight of weaned lambs/kg of ewe weight/year):

$$\text{Index2} = \frac{\text{Index1}}{\text{ewe's postpartum weight}}$$

Index3 (Weight of lambs produced/kg of ewe metabolic weight/year):

$$\text{Index3} = \frac{\text{Index1}}{(\text{ewe's postpartum weight})^{0.75}}$$

2.4. Statistical Analysis

Using the statistical computer package STATISTICA (StatSoft Inc, 2011), the significance of the effect of dietary treatment on individual ewes-based data was tested by analysis of covariance, taking the number of days from the start of the experiment to successful service as a covariate. Whereas the significance of dietary treatment variations on flock-based data was examined by Chi square analysis. The tested individual ewes-based data were number of services per conception, gestation period, lambing interval, ewes' weight at conception and lambing, gestation body change, litter size, litter weight at birth and at weaning, productivity indices, feed intake, feeding cost, and cost of kg of weight of weaned lambs per year. The examined flock-based data were the rates of ewes' mortality, conception, lambing, twining, and lambs' pre-weaning mortality, as well as the male lambs' ratio.

3. RESULTS

Five ewes died of pneumonia: two from the CD group and three from the NC group. The number of conceived ewes was 15 and 14 from CD and NCD treatments, respectively. Fourteen and 12 ewes from the CD and NCD groups, respectively, successfully delivered. Twenty-nine lambs were born to the 26 ewes. Four lambs died before weaning. Tables 2 and 3 show the reproductive performance of the two experimental flocks. There were no differences ($P > 0.05$) between the two diet groups in terms of ewes' mortality, conception, lambing, twining, lambs' mortality rates, or male lambs' ratio.

Table 2. Reproductive performance of the flocks of the experimental diets' groups.

Item	CD	NCD
Initial no of present ewes	22	22
Number of dead ewes	2	3
Number of alive ewes	20	19
Number of conceived ewes	15	14
Number of aborted ewes	1	2
Number of lambed ewes	14	12
Number of ewes continued for the second lambing	9	7
Number of twining deliveries	2	2
Number of lambs born	15	14
Number of male lambs	3	6
Number of dead lambs	1	3

Table 3. Rates of reproductive performance of the flocks of the experimental diets' groups.

Item	CD	NCD	Pearson chi-square	*p*
Mortality percentage	9.1%	13.6%	0.226	0.635
Conception percentage of alive ewes	75.0%	73.7%	0.009	0.925
Lambing percentage of pregnant ewes	93.3%	85.7%	0.453	0.501
Twining percentage	13.3%	16.7%	0.059	0.809
Male lambs' percentage	20.0%	42.9%	1.77	0.184
Pre-weaning mortality percentage	6.7%	21.4%	1.33	0.249

Table 4 shows reproductive performance traits of ewes of CD and NCD treatments. Most of the dietary groups' traits were statistically similar. The NCD group excelled (*$P < 0.05$) against* their CD group mates on intake parameters. Whereas, the CD-fed group excelled the NCD-fed group on the daily and annual cost of feeding. The type of diet treatment in the present study did not affect total lamb birth weight or ewe.

Table 4. Reproductive traits of ewes fed CD and NCD treatments.

Traits	CD	NCD	SEM	*p*
Initial number of ewes	22	22		
Number of conceived ewes	15	14		
Number of lambed ewes	14	12		
Number of ewes continued for the second lambing	9	7		
Period to conception, days	117	95	29.1	0.467
Gestation period, days	151	149	0.88	0.105
Lambing interval, days	325	326	6.55	0.896
Number of services/Conceptions	2.3	2.4	0.14	0.121
Initial body weight, kg	47.8	47.7	2.20	0.984
Conception weight, kg	53.8	49.5	2.00	0.343
Weight at lambing, kg	61.7	57.1	1.75	0.194
Total gestation body change, kg	7.93	7.57	1.19	0.738
Daily gestation body change, g/Day	52.2	50.7	7.91	0.807
DM intake, kg/Day	1.43	1.58	0.033	0.005
DCP intake, kg/Day	0.273	0.301	0.006	0.005
ME intake, MJ/day	14.9	16.4	0.348	0.005
DM intake % of average body weight	2.57	2.94	0.080	0.003
Litter size, (lambs/100 ewes)	113	117	10.4	0.629
Litter birth weight, kg	3.98	3.91	0.308	0.935
Litter birth weight % of dam lambing weight	6.53	6.71	0.518	0.883
Daily cost of feed intake (Qatari Riyals/Ewe/Day)	2.42	1.88	0.079	0.001
Annual feeding cost (Qatari Riyals/Ewe/Year)	883	686	28.7	0.001

Note: SEM= Standard error of means.
DM= Dry matter.
DCP= Digestible crude protein.
CP= Crude protein.
ME= Metabolizable energy.
MJ= Mega joule.

Table 5 describes the productivity indices and traits of ewes fed with the experimental CD and NCD treatments. Most of the traits of the two dietary groups were statistically similar. However, the CD group outperformed the NCD group in terms of the cost per kg of weight of weaned lambs/ewe/year. The weight of litter lambs that were weaned per ewe and the three productivity indices were all the same between the experimental groups. This is because diet treatment has no effect ($P > 0.05$) on litter lambing interval, weight of postpartum ewes, or weight of weaned lambs. However, the feeding cost of kg of weight of weaned lambs/ewe/year of NCD ewes was less than that of CD ewes by 28.7% (30.8 vs. 43.2 Qatari Riyals)

Table 5. Productivity indices of ewes fed the CD and NCD treatments.

Traits	CD	NCD	SEM	*p*
Number of lambed ewes	14	12		
Number of ewes reached the 2nd lambing	9	7		
Litter weaning weight (kg)	19.3	22.0	1.83	0.333
Index1*	20.6	23.5	1.75	0.288
Index2**	0.343	0.417	0.033	0.149
Index3***	0.95	1.14	0.085	0.158
Cost of kg of weaned lambs' weight, Qatari Riyals	43.2	30.8	1.58	0.000

Note: *Index 1, total weight of weaned lambs/Ewe/Year = Total weight of weaned lambs×365/Lambing interval period.
**Index 2, the total weight of weaned lambs/kg of ewe weight/Year = Index1/ Postpartum ewe weight.
***Index 3, the total weight of weaned lambs/$kg^{0.75}$ of ewe weight/year = Index1/ Postpartum ewe $weight^{0.75}$.

4. DISCUSSION

4.1. Flocks' Reproduction Performance

The lack of effect of the present experimental dietary treatment on conception, lambing, twining, and pre-weaning lambs' mortality percentages may be due to the fact that feed intakes were quite sufficient to reach a suitable body weight at conception (51.7 ± 9.38 kg). The positive effect of supplying more energy and protein than required on Awassi sheep fecundity was due to its impact on body weight (Talafha & Ababneh, 2011). In the same context, (Kabaija, Akalework, & Leng, 1989) reported no difference in lambing percentage for ewes fed concentrates of molasses-urea blocks and/or noug oil cakes as a supplement to grazing, provided the conception weights were similar.

The conception percentage of the current ewes was similar to the range (66.7%–75%) reported for Awassi ewes mated at different months of the year in Turkey (Gül & Keskin, 2010). However, researchers noted that Awassi ewes' reproductive performance has been low in the semi-arid regions of the Near East countries (Hamadeh, Abi Said, Tami, & Barbour, 2001; Husein & Kridli, 2002). The values of the present twinging delivery percentages were within the range reported for Awassi sheep (Aktaş et al., 2015). For the CD and NCD groups, the current percentages of male lambs born were 20% and 42.9%, respectively. However, we found no evidence to support the impact of the ewe's breed or nutrition on this parameter. The death rate for pre-weaning lambs in this study was 6.7% for the CD group and 21.4% for the NCD group. This was similar to what was found for the same breed of sheep at 120 days old, when they were weaned (Aktaş et al., 2015). It was also compared favorably with that reported for Awassi (18.4%), Najdi (18.7%), and Hejazi (15.9%) lambs in Saudi Arabia (Gaili, Islam, & El-Naiem, 1994).

4.2. Ewes' Reproductive Traits

The average period from the start of the experiment at the beginning of March to conception (106 ± 78.9 days) indicated that the average conception month is about June and July. This aligns with the findings reported for Awassi sheep in Jordan (Abu-Zanat, Mekdadi, & Tabbaa, 2005). They reported that the natural breeding season of Awassi rams was mainly between late June and early September, which allowed ewes to lamb between late November and early February. The NCD group may have a tendency to consume more DM due to their slightly lower dietary ME concentration (9.7 vs. 10.4 MJ/kg DM). It is stated that animals eat to satisfy a constant level of digestible energy, so animals on a low-energy diet eat more to reach that level of satisfaction (Mohamed, 1986). The experimental groups' daily intakes of DM and ME were comparable to 1.5 kg DM/day and 16.3 MJ/day postulated for 60 kg live weight ewes (AFRC, 1993). Crude protein intake in the present study was higher than 115 g, as suggested by the same authors. The similarity of body weights at conception indicated that reproduction in sheep greatly depends on weight rather than type of feed consumed (Atti, Thériez, & Abdennebi, 2001). A comparable conception weight (52 ± 4 kg) was reported for Awassi ewes in Saudi Arabia (Gaili et al., 1994). The average conception weight of ewes in traditionally managed Awassi flocks was 47 kg (Kassem, 2005). The values of body weight gain during gestation for both experimental groups were comparable to those stated for ewes (Wilson & Brigstocke, 1981). These authors derived a general rule that ewes carrying single lambs should increase in body weight by about 10% and those with twins by 18% (the present study values were 14.7% and 15.3% for CD and NCD ewes, respectively). This indicated efficient utilization of DM and CP intakes for both experimental groups.

The current CP and ME intakes per metabolic body weight ($wt^{0.75}$) were higher than those required for maximum fetal growth (Moloney, Quirke, & Sheehan, 1988) (average of 0.731 MJ ME and 13.4 g CP vs. 0.5 MJ ME and 7g CP). They added that feeding pregnant ewes above this level will not add to the lamb birth weight. This led to the conclusion that the observed lamb birth weight is the maximum potential output of the current study. Consistently, the current proportion of birth weight to the dam's postpartum weight (6.6 ± 1.8%) was comparable to that reported for ewes of the same breed (7.44%) (Aktaş et al., 2015). Litter size for present Awassi ewes (1.17 lambs born/ewe lambing) was within the range of 1.05 to 1.20 lambs born per lambing ewe (Ahmed & Abdallah, 2012; Galal, Gürsoy, & Shaat, 2008). The gestation period did not show variation ($P > 0.05$) among dietary treatments (overall mean of 150.3±3.4). Similar observations were reported for Syrian Awassi sheep (Zarkawi & Al-Daker, 2018) (151 ± 3.0 days) and (Zarkawi, 2010) (151.0 days); for Afshari ewes in Iran (Aliyari, Moeini, Shahir, & Sirjani, 2012) (151 days).

The type of lambing (singles or twins) had no effect on the duration of pregnancy (Zarkawi & Al-Daker, 2018). Experimental groups did not exhibit variation ($P > 0.05$) for lambing interval (overall mean of 326 ± 17.4 days). The present values of lambing intervals were comparable to the 338 days reported for Awassi ewes (Ahmed & Abdallah, 2012).

A lambing interval of 282 ± 4 days was observed for Awassi ewes in Saudi Arabia (Gaili et al., 1994). The latter workers also reported lambing intervals of 245 ± 11 and 236 ± 8 days for Najdi and Hejazi, respectively. Values of 446 ± 26.0 and 361 ± 23.09 days were also reported as lambing intervals for Najdi and Harri ewes, respectively (Hussein & Khattab, 2013). Despite the high ($P < 0.05$) feed intake during gestation observed by NCD ewes, NCD treatment reduced feed cost during this period by 22.3% of that of CD treatment. Noteworthy, the experimental ewes' reproductive traits were the same.

4.3. Ewes' Productivity Indices

The values of the Awassi weaning weight of lambs/ewe obtained in the current experiment (overall mean of 20.4 ± 5.8 kg weaned lamb/ewe/year) were comparable to 24.6 ±1.41 and 20.1±1.37 kg weaned lambs/ewe/year, reported for Saudi Harri and Najdi sheep, respectively (Hussein & Khattab, 2013). But it was much higher than 16.3, 11.5, 11.9, and 9.9 kg/ewe, reported for multi-parous and primi-parous Sudan Nilotic ewes fed sorghum-based or molasses-based diets, respectively (Atta & Khidir, 2006). Sudan Nilotic sheep is a smaller breed compared to Awassi sheep; thus, litter weaning weight is lighter. The productivity indices of the current Awassi sheep were comparable to those of Sudan desert ewes when weaning lambs at 120 or 150 days of age (Sulieman et al., 1990). For the 120- and 150-day groups, respectively, they reported 16.8 and 18.5 kg of weaned lamb/ewe/year, 0.419 and 0.461 kg of weaned lamb/kg ewe's postpartum weight/year, and 1.14 and 1.25 kg of weaned lamb/kg metabolic ewes' postpartum weight/year. They observed that these indices increased as lamb weaning age increased. Sudan Nilotic sheep reported comparable values of index 1 (17.3–29.2 kg weaned lambs/ewe/year) (Atta & Khidir, 2006). However, the values of indices 2 and 3 reported for Nilotic ewes (0.623–0.998 kg weaned lambs per kg of ewe weight per year and 1.43–2.31 kg weaned lambs/$kg^{0.75}$ of ewe weight per year) were much higher than those reported in the current study. This is because of the short lambing interval of the Sudan Nilotic breed (201–216 days) compared to that of the current Awassi ewes (326 ± 17.4 days). High productivity indices were reported for Awassi sheep in Saudi Arabia (31

± 2 kg, 587 ± 5 g, and 1702 ± 155 g for index 1, 2, and 3, respectively) (Gaili et al., 1994). They also reported 33 ± 2 and 23 ± 2 kg index 1, 567 ± 6 and 638 ± 5 g index 2, and 1693 ± 102 and 1674 ± 117 g index 3 for Najdi and Hejazi sheep, respectively. They hypothesized that Index 1 would rank Najdi ewes as the most efficient lamb producers because they had the highest value, followed by Awassi and Hejazi ewes.

5. CONCLUSIONS

- Date palm fronds and discarded date-based feed provide reproductive and productive sheep flock performance that is not different from a diet based on barley grains and Rhodes hay.
- A date palm product-based diet is a reasonable, cost-effective substitute for barley grains and Rhodes hay diet. During gestation, NCD treatment decreased feed costs by 22.3% compared to CD treatment.
- The feeding cost of a kg of weight of weaned lambs/ewes/year of date palm product-based diet ewes was less than that of barley and Rhodes-based diet ewes by 28.7% (30.8 vs. 43.2 Qatari Riyals, equivalent to 8.32 vs. 11.7 USD).
- Awassi sheep has excellent adaptation to Qatari environmental conditions, as most of the studied traits match those reported for the same breed in other countries.

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Institutional Review Board Statement: The Ethical Committee of the Institutional Animal Care and Use Committee of the Ministry of Municipality and Environment, State of Qatar has granted approval for this study on 20 March 2016 (Ref. No. MME /IACUC Assurance: SCH-A-MME-004).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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