Research Article

Effect of Replacing Barley with Different Levels of Crushed Iraqi Barhi Date Pits, with or without a Nitrogen Source, on Performance Characteristics of Local Male Lambs

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Abstract | The aim of this study was to evaluate the effect of replacing barley with different levels of crushed Iraqi Barhi date pits, with or without a nitrogen source, on performance characteristics of local male lambs. The study was conducted at the Livestock Research Unit of the Agricultural Research Center – Scientific Research Commission over a period of 90 days. Sixteen local male lambs, aged 4–4.5 months with an average body weight of 21.64 ± 0.84 kg, were randomly divided into four groups. The experimental treatments were as follows: G1, a control group fed a concentrate diet without crushed Iraqi Barhi date pits; G2, a concentrate diet containing 15% crushed date pits with a nitrogen source (0.7% biuret powder); G3, a concentrate diet containing 30% crushed date pits with 4.1% biuret powder; and G4, a concentrate diet containing 45% crushed date pits with 1.2% biuret powder. At the end of the experimental period, the results showed a significant superiority ($P \leq 0.05$) of the control group (G1) in total and daily intake of concentrate and roughage feed compared with the other treatment groups. In contrast, significant differences ($P \leq 0.05$) were observed in favor of groups G3 and G4 for daily weight gain, total weight gain, feed conversion efficiency, and digestibility coefficients of ether extract, nitrogen-free extract, and total digestible nutrients compared with the remaining experimental groups. The study concluded that replacing barley with crushed Iraqi Barhi date pits, especially when combined with a nitrogen source, can improve growth performance, feed efficiency, and nutrient digestibility in local male lambs.

Keywords | Local lambs, Performance manifestations, Digestibility factor, Crushed Iraqi barhi date pits and Biuret

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INTRODUCTION

The scarcity of all types of fodder, due to limited grazing land or the restriction of agricultural land designated for concentrated and green fodder cultivation, has led to a reduction in sheep farming in Iraq. This is compounded by a decline in sheep productivity due to several adverse genetic and environmental factors, particularly the lack of sufficient feed sources to meet their nutritional needs (Besharati *et al*., 2022; Isabelle *et al*., 2020).

Sheep graze on the harvest residues of poor-quality crops for a significant portion of the year (Hassan, 2004). During the summer months, due to the absence of rainfall from June to November, sheep rely entirely on grazing crop residues such as barley and wheat, especially in dry regions. In contrast, during the winter months, heavy rainfall occurs during November and December, and sheep are kept in barns due to the scarcity of pasture fodder. They rely primarily on barley and various types of crushed hay for energy, in addition to limited natural grazing (Al-Jassim *et al*., 1996).

This traditional sheep feeding system in the country has revealed a significant deficit in energy and protein sources. Therefore, nutritionists and researchers in this field have focused on finding local feed alternatives using certain methods. Agricultural and industrial byproducts, such as date byproducts (Iraqi Barhi date pits) and their processing (date syrup production), are considered non-traditional animal feed, or locally available byproducts can be used to feed ruminants (Ahmed *et al*., 2001). Other industrial byproducts include dates unfit for human consumption and inexpensive dates that can be used to feed ruminants. These include damaged, poor-quality, or old dates, as well as palm byproducts such as fronds, trunks, and stems (Al-Saadi, 2004) and fresh date pits (Khalifa, 2005). It is worth noting that the Ministry of Agriculture has encouraged farmers and livestock breeders to use crushed date pits as animal feed, as part of its institutional support programs aimed at utilizing this valuable energy source (Maha Al-Ki *et al*., 2022). It contains relatively high energy compared to concentrated feeds, but has a low nitrogen content and a high fiber content (up to 19%), which limits its inclusion in feed (Boudechiche *et al*., 2009). Therefore, in the present study, non-protein nitrogen (NPN) additives or treatments are required to meet the protein requirements of ruminants (Selmi *et al*., 2011; Hashem and Tayeb, 2023). However, protein sources have become a global challenge, and the price of soybean meal (Alipour *et al*., 2020), which is a major conventional protein source, remains high, thereby increasing production costs for farmers. Consequently, identifying alternative protein sources to replace soybean meal in animal feed is essential. Non-protein nitrogen sources (Varezardi *et al*., 2023) are compounds that are not true proteins but contain nitrogen in their chemical structure. These include urea, ammonium salts, nitrates, alkaloids, asparagine, purines, choline, uric acid, amines, amides, amino acids, and nucleic acids (Zurak *et al*., 2023).

Urea is considered a practical source of non-protein nitrogen due to its low cost and its 46% nitrogen content, equivalent to 287.5% crude protein. However, urea is rapidly broken down in the rumen, releasing large amounts of ammonia in the urine, and reducing livestock productivity. Consequently, the energy expended by the animal's body to break down the ammonia exceeds the needs of the microorganisms, leading to ammonia poisoning and animal death. This is why urea compounds, such as those used in bioreactors, are used. Urea is a non-protein nitrogen compound that may be used in animal nutrition and can be combined with other mineral sources such as calcium salts, but it is not chemically bound to substances like chloride or calcium in its basic form (Huntington *et al*., 2006). Therefore, the idea of using biuret with the chemical formula ($NH_2CONHCONH_2$) was considered. Biuret is produced by condensing two molecules of urea at high temperatures (150°C) in the Bush-Maiser process (Hayes *et al*., 2011). It can be used as a slow-release source of non-protein nitrogen in ruminant feed. In the same context, biuret contains about 41% nitrogen (256% crude protein) and is broken down by microorganisms in the rumen at a slower rate than urea. Therefore, the aim of the present study was to investigate the effect of adding different levels of crushed Iraqi Barhi date pits (0, 15, 30, and 45%) in combination with non-protein nitrogen (biuret) at 0, 0.7, 1.4, and 2.1% in the ration on growth performance, feed conversion efficiency, and nutrient digestibility in local fattening lambs.

Materials and working methods

Experimental design

The present study was conducted at the ruminant farm of the Animal Production Research Department, Agricultural Research Center/Scientific Research Commission. Sixteen local male lambs were purchased from local markets. The study was carried out from November 7, 2025, to February 7, 2026, covering the rearing period as well as laboratory analyses and evaluations. The chemical composition of the experimental rations is presented in Tables 1, 2, and 3.

Table 1: Proportions of experimental ration components from raw materials (%).

Components	Diets			
	G1	G2	G3	G4
Barley (black barley)	57	38	19	0
Wheat bran	14	20	27	30
Yellow corn	11	8	4	3
Crushed date pits	0	15	30	45
Soybean meal	8	8	8	9
Barley straw	8	8.3	8.6	8.9
Biuret	0	0.7	1.4	2.1
Vitamins and minerals	2	2	2	2
Total	100	100	100	100

G1: Concentrated feed without crushed Iraqi Barhi date pits. G2: Concentrated feed containing 15% crushed Iraqi Barhi date pits replacing barley with 0.7% biuret powder. G3: Concentrated feed containing 30% crushed Iraqi Barhi date pits replacing barley with 1.4% biuret powder. G4: Concentrated feed containing 45% crushed Iraqi Barhi date pits replacing barley with 1.2% biuret powder.

The lambs were allocated to the following experimental treatments: G1, a control group fed a concentrate diet without crushed Iraqi Barhi date kernels; G2, a diet containing 15% crushed date kernels replacing barley with 0.7% biuret powder; G3, a diet containing 30% crushed date kernels replacing barley with 1.4% biuret powder; and G4, a diet containing 45% crushed date kernels replacing barley with 1.2% biuret powder. These rations were used to evaluate daily and total weight gain, feed intake, and feed conversion ratio.

Table 2: Chemical composition of raw feed materials and alfalfa hay (%).

Chemical/ composition	Black barley	Wheat bran	Yellow corn	Crushed date pits	Soybean meal	Alfalfa hay
Dry matter	90.20	97.10	92.05	86.35	90.41	97.92
Organic matter	78.22	89.67	83.33	83.44	84.16	86.97
Ash	11.98	7.43	8.72	2.92	6.25	10.94
Crude protein	11.15	14.85	9.12	5.08	44.00	19.94
Crude fiber	3.09	9.45	3.65	10.56	3.86	22.95
Ether extract	4.75	4.06	3.81	3.16	2.15	2.01
Nitrogen-free extract	59.23	61.31	66.75	64.64	34.15	42.07

Table 3: Chemical composition of the experimental concentrate diets (%).

Chemical/ composition	Experimental food groups			
	G1	G2	G3	G4
Dry matter	94.06	92.71	91.80	91.17
Organic matter	87.41	93.34	92.86	93.22
Ash	12.59	6.66	7.14	6.78
Crude protein	13.43	13.37	13.36	13.44
Crude fiber	7.93	7.51	7.89	7.38
Ether extract	3.84	3.44	3.61	2.95
Nitrogen-free extract	62.21	69.02	68.00	69.45
Metabolic Energy* (mg Jouless/kg dry matter)	11.68	12.70	12.63	12.62

*ME=0.012×CP+0.031×EE+ 0.005×CF +0.014× NFE (MAFF, 1975).

The lambs were individually housed in semi-open pens of equal size (2.5 × 4 m), each equipped with a feeding area measuring 2.5 × 10 m. Plastic feeders and waterers were provided. Concentrate feed was offered at 2.5% of live body weight in two daily meals at 7:00 a.m. and 4:00 p.m. Green fodder (alfalfa hay) was provided ad libitum during the day according to requirements, while mineral blocks were continuously available to all animals throughout the experimental period.

Digestion experiment

The digestibility coefficients of the experimental diets (concentrate feed and roughage) were determined using three animals randomly selected from each group during the fifth week of the study. Nutrient digestibility of the concentrate feed was estimated using the difference method. Digestibility coefficients were calculated for dry matter, organic matter, ether extract, crude protein, crude fiber, total digestible nutrients, and digestible crude protein.

Chemical analysis

All chemical analyses of the ration components, including raw feed materials and experimental diets, were carried out to determine crude fiber, crude protein, ether extract, ash, and ammonia nitrogen according to the methods of AOAC (1984).

Statistical analysis

The data were statistically analyzed using a completely randomized design (CRD) with the Statistical Analysis System (SAS, 2018). Significant differences among means were compared using Duncan's multiple range test (Duncan, 1955) at a probability level of $P \leq 0.05$.

RESULTS AND DISCUSSION

Dry matter intake

The results presented in Table 4 indicate that the inclusion of different levels (15, 30, and 45%) of crushed Iraqi Barhi date pits replacing barley, along with varying levels of biuret (0.7, 1.4, and 2.1%) as a non-protein nitrogen source, affected dry matter intake of concentrate feed and total dry matter intake (concentrate plus roughage). The control group (G1) showed a significantly higher ($P \leq 0.05$) intake of dry matter from concentrate feed, reaching an average of 81.00 kg, compared with G2, G3, and G4, which recorded averages of 74.70, 75.87, and 77.04 kg, respectively.

These findings are not consistent with those of Ahmed *et al.* (2001), who reported significant differences in roughage dry matter intake when different nitrogen sources were added to the diet, with higher roughage consumption observed in the control group compared to nitrogen-supplemented diets.

Similarly, these results differ from those of Homaam (2025), who observed significant differences in concentrate intake when different nitrogen sources were used with 25 and 50% replacement of barley with crushed date pits in Awassi sheep diets.

On the other hand, Clemens and Johnson (1973a) reported an increase in concentrate feed intake compared with roughage intake when biuret, as a non-protein nitrogen (NPN) source, was included at levels above 15% in sheep rations. This suggests that biuret can be effectively incorporated into sheep diets at different levels. This response may be attributed to the high nitrogen utilization efficiency of biuret due to its slow ruminal degradation, improved palatability, and reduced ammonia release in the rumen.

Table 4: Effect of adding different levels of crushed Iraqi Barhi date pits with different percentages of biuret on feed intake (kg) (Mean ± standard error).

Groups	Concentrated feed		Roughage feed		Total feed (Concentrated and Roughage)	
	Total intake (kg)	Daily intake (kg)	Total intake (kg)	Daily intake (kg)	Total intake (kg)	Daily intake (kg)
G1	81..0±.0002^{A}	0.900±0.43	29.70±1.89	2.43±0.330	110.70±0.76^{A}	0.04^{A}±1.23
G2	74.70±0.09^{B}	0.828±0.47	29.88±1.47	1.40±0.332	104.58±0.88^{B}	1.16 ±0.07^{B}
G3	75.87±0.10^{B}	0.852±1.98	29.43±1.63	1.79± 0.327	105.30±0.90^{AB}	0.08^{AB}±1.18
G4	77.04±0.66^{AB}	0.840±1.92	1.65±26.98	1.32±0.320	0.92^{B}±104.02	1.16±0.07^{B}
Significant level	*	N.S	N.S	N.S	*	*

*Different letters within the same column indicate significant differences between the means at a significance level of (P≤0.05). N.S: Indicates no significant differences at a probability level of (P≤0.05). G1: Concentrated feed without crushed Iraqi Barhi date pits. G2: Concentrated feed containing 15% crushed Iraqi Barhi date pits replacing barley with 0.7% biuret powder. G3: Concentrated feed containing 30% crushed Iraqi Barhi date pits replacing barley with 1.4% biuret powder. G4: Concentrated feed containing 45% crushed Iraqi Barhi date pits replacing barley with 1.2% biuret powder.

Consequently, biuret enhances microbial adaptation and activity in the rumen, improving feed utilization efficiency (Varezardi *et al*., 2023).

Regarding total dry matter intake of concentrate and roughage feeds, the results presented in Table 4 showed significant differences (P ≤ 0.05) among the experimental groups. The control group (G1), which was free of both date pits and biuret, recorded higher average total dry matter intake values of 110.70 kg (concentrate) and 1.23 kg (roughage), compared with groups G2 and G4, which recorded averages of 104.58 kg and 104.02 kg for concentrate intake and 1.16 kg for roughage intake, respectively. These groups contained 15% and 45% crushed Iraqi Barhi date pits replacing barley, with biuret levels of 0.7% and 2.1%, respectively.

These results are consistent with those of Joudi (2011), who reported significant differences (P ≤ 0.05) in total dry matter intake in diets containing 30% and 60% crushed date pits supplemented with non-protein nitrogen sources. However, they disagree with Al-Ghazali (2009), who observed no significant differences in total feed intake when comparing diets containing 34% crushed date pits with control diets.

In contrast, Clemens and Johnson (1973b) reported an increase in total roughage intake compared with concentrate intake in sheep fed a low-quality diet based on yellow corn supplemented with 9.6% biuret.

These differences may be attributed to the ability of rumen microorganisms to adapt to biuret as a nitrogen source, particularly when diets contain varying levels of readily fermentable carbohydrates. The activity of biuret in the rumen has been evaluated *in vitro* by measuring its disappearance and ammonia release. Sheep have been shown to adapt rapidly to biuret when fed diets containing different levels of starch (Park *et al*., 2009).

Weight gain, and feed conversion efficiency

Table 5 shows the effect of replacing barley with different levels (15, 30, and 45%) of crushed Iraqi Barhi date pits combined with different levels of biuret as a non-protein nitrogen source in the rations. No significant differences were observed among the experimental groups in initial body weight prior to dietary treatments. However, the results indicated a significant effect on final body weight. Lambs in groups G3 and G4, which received 30% and 45% crushed date pits with biuret supplementation, showed a significant improvement (P ≤ 0.05) in final body weight, recording averages of 37.02 and 37.09 kg, respectively. In contrast, the control group (G1) recorded the lowest final body weight (33.79 kg), while G2 recorded an intermediate value of 35.41 kg. These findings indicate that barley can be partially replaced with crushed date pits in lamb fattening diets without negative effects on growth performance.

These results are consistent with those of Al-Ghazali (2009), who reported significant differences in Awassi lambs fed diets containing 34% crushed date pits supplemented with nitrogen sources. Similarly, Khalifa (2005) reported improved performance when barley was replaced with fresh date pits at a level of 50%. Abdou *et al*. (2011) also reported comparable results when evaluating different non-protein nitrogen sources, including urea and biuret, in lamb diets, indicating that biuret acts as a safe and slow-release source of nitrogen, particularly in low-quality roughage diets.

Regarding total weight gain, the same table shows that groups G3 and G4 recorded significantly higher (P ≤ 0.05) values of 14.78 and 15.35 kg, respectively, compared with the control group (12.09 kg). These results are consistent with those of Al-Shanti *et al*. (2013), who reported improved performance when different substitution levels

Table 5: Effect of adding different levels of crushed Iraqi Barhi date kernels with different proportions of biuret on some productive traits (Mean ± standard error).

Groups	Initial weight (kg)	Final weight (kg)	Daily weight gain (gm)	Total weight gain (kg)	Feed conversion efficiency
G1	1.70±21.70	33.79±0.88^{B}	134.34±0.10	12.09±0.47^{B}	8.93±0.87^{B}
G2	1.59±22.12	35.41±1.18^{AB}	147.67±0.11	13.29±0.28^{AB}	7.55±0.90^{AB}
G3	2.23±22.31	37.09±0.73^{A}	164.23±0.32	14.78±0.78^{A}	7.12±0.66^{A}
G4	1.34±21.67	37.02±0.71^{A}	170.56±0.34	15.35±1.98^{A}	6.80±0.75^{A}
Significant level	N.S	*	N.S	*	*

*Different letters within the same column indicate significant differences between the means at a significance level of (P≤0.05). N.S: Indicates no significant differences at a probability level of (P≤0.05). G1: Concentrated feed without crushed Iraqi Barhi date pits. G2: Concentrated feed containing 15% crushed Iraqi Barhi date pits replacing barley with 0.7% biuret powder. G3: Concentrated feed containing 30% crushed Iraqi Barhi date pits replacing barley with 1.4% biuret powder. G4: Concentrated feed containing 45% crushed Iraqi Barhi date pits replacing barley with 1.2% biuret powder.

Table 6: Effect of adding different levels of crushed Iraqi Barhi date kernels with different percentages of biuret on the digestibility coefficient of different nutrients (%) (Mean ± standard error).

Groups	Dry matter	Organic matter	Crude protein	Ether extract	Crude fiber	Total of different nutrients
G1	80.29±0.17	70.63±1.65	72.59±1.70^{A}	49.82±0.11^{B}	79.44±0.75^{A}	55.41±0.33
G2	80.60±0.33	69.90±1.06	68.93±0.53^{AB}	53.71±0.02^{AB}	72.96±0.93^{AB}	57.47±0.30
G3	80.32±0.19	71.42±0.81	70.51±0.68^{AB}	58.13±0.15^{AB}	69.65±0.90^{AB}	62.28±0.15
G4	80.81±78.2	72.03±1.53	60.89±0.50^{B}	65.65±0.22^{A}	61.95±0.64^{B}	63.54±0.15
Significant level	N.S	N.S	*	*	*	N.S

*Different letters within the same column indicate significant differences between the means at a significance level of (P≤0.05). N.S: Indicates no significant differences at a probability level of (P≤0.05). G1: Concentrated feed without crushed Iraqi Barhi date pits. G2: Concentrated feed containing 15% crushed Iraqi Barhi date pits replacing barley with 0.7% biuret powder. G3: Concentrated feed containing 30% crushed Iraqi Barhi date pits replacing barley with 1.4% biuret powder. G4: Concentrated feed containing 45% crushed Iraqi Barhi date pits replacing barley with 1.2% biuret powder.

of crushed date pits replaced cereal grains in Awassi lamb diets. Similar findings were reported by Joudi (2011) and Clemens and Johnson (1973a), who observed improved performance when non-protein nitrogen sources were incorporated into diets containing agricultural by-products.

Furthermore, feed conversion efficiency showed significant differences (P ≤ 0.05), where groups G3 and G4 recorded the best values (7.12 and 6.80, respectively), followed by G2 (7.55), while the control group recorded the lowest efficiency (8.93). These findings are consistent with those of Al-Ghazali (2009), who reported significant improvements in feed conversion efficiency when crushed date pits were included in lamb diets with nitrogen supplementation. However, they are not consistent with the findings of Al-Owaimer *et al.* (2008) and Yagoub and Eleman (2012), who reported no significant improvements under similar conditions.

The observed improvements in growth performance and feed efficiency may be attributed to enhanced microbial protein synthesis in the rumen resulting from biuret supplementation. Biuret, as a slow-release non-protein nitrogen source, improves nitrogen availability for rumen microorganisms, thereby enhancing microbial activity and protein synthesis, which ultimately improves weight gain and feed conversion efficiency, particularly in groups G3 and G4.

Field digestibility coefficient of different nutrients

Table 6 illustrates the effect of replacing barley with different levels (15, 30, and 45%) of crushed Iraqi Barhi date pits combined with different levels of biuret as a non-protein nitrogen source on the digestibility coefficients of different nutrients. The results indicated no significant differences among all experimental groups in the digestibility coefficients of dry matter, organic matter, and ether extract.

However, significant differences (P ≤ 0.05) were observed in the digestibility coefficient of crude protein. The control group showed the highest crude protein digestibility, whereas the experimental groups recorded values of 68.93%, 70.51%, and 60.89% for G2, G3, and G4, respectively. These findings are consistent with those of Al-Banna *et al.* (2012), who reported significant differences in crude protein digestibility when crushed date pits were used as a replacement for barley at different inclusion levels. Similar

results were also reported by Clemens and Johnson (1973a), who evaluated the effect of biuret supplementation in diets containing agricultural by-products. However, these findings are not in agreement with Abdou *et al.* (2011), who reported no significant changes in protein digestibility when date pits were included in lamb diets.

Regarding crude fiber digestibility, significant differences ($P \leq 0.05$) were observed, with the highest value recorded in G4 (65.65%), followed by G3 (58.13%) and G2 (53.71%), while the control group recorded the lowest value (49.82%). These results are consistent with Abdou *et al.* (2011), who reported improved fiber digestibility with increasing levels of date pits in the diet. In contrast, McLaren *et al.* (1960) reported no significant differences in fiber digestibility when biuret was included in lamb diets.

For total digestible nutrients (TDN), significant differences ($P \leq 0.05$) were observed, with the highest value recorded in the control group (79.44%), followed by G2 (72.96%), G3 (69.64%), and G4 (61.96%). These results differ from those reported by Abdou *et al.* (2011).

Similarly, no significant differences were observed in ether extract digestibility, with values of 55.41%, 57.42%, 62.28%, and 63.54% for G1, G2, G3, and G4, respectively. These findings are in agreement with Samanta *et al.* (2003), who reported no significant changes in ether extract digestibility when non-protein nitrogen sources were used in goat diets.

The observed improvements in nutrient digestibility may be attributed to the inclusion of crushed Iraqi Barhi date pits combined with biuret, which enhanced rumen microbial activity. This improved fermentation efficiency, increased nutrient utilization, and enhanced dietary energy availability, thereby improving overall digestibility. These findings are supported by Al-Suwaiegh (2015). However, some variation compared with previous studies may be due to differences in diet composition, animal species, and feeding conditions (Al-Homidy *et al.*, 2011).

CONCLUSION

It can be concluded that the inclusion of crushed Iraqi Barhi date pits in the diets of local fattening lambs improved performance during periods of feed scarcity, thereby reducing the reliance on imported concentrate feeds, either partially or completely. This approach contributes positively to the national economy and promotes the utilization of agricultural by-products such as date processing residues. However, since these materials are relatively low in nitrogen, their effective use requires supplementation or treatment with non-protein nitrogen sources such as biuret to enhance their nutritional value and ensure balanced diets. It is recommended that further research be conducted to evaluate different inclusion levels of these by-products in ruminant diets and to better characterize their nutritional and metabolic effects under various feeding conditions.

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NOVELTY STATEMENT

This study highlights the effect of date pits and biuret supplementation on nutrient digestibility in lamb diets.

AUTHOR'S CONTRIBUTION

All authors contributed equally to the preparation and completion of this manuscript.

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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