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Effect of Dietary Slow-Release Urea Supplementation on Some Productive and blood Traits of Lambs

Ghassan Hameed Shehab Al-Jubouri[1]*, Asst. Prof. Dr. Mwaffuk Hussain Aljumaily[2]

[1,2] Department of Animal Production, College of Agriculture, Tikrit University, Iraq.
*Corresponding author: Email: Gassan.challenger94@gmail.com

Abstract
This study was conducted at the sheep farm of the Department of Animal Production, College of Agriculture, Tikrit University, during the period from **5/10/2025 to 5/1/2025**. The study aimed to investigate the effect of dietary supplementation with slow-release urea (SRU) on the productive performance of Awassi lambs. Fifteen Awassi lambs aged **3–4 months** with an initial body weight of **24 ± 26 kg** were randomly assigned to three dietary treatments. The first treatment served as the control group (without SRU supplementation), while the second and third treatments received diets containing **3%** and **5%** slow-release urea, respectively. The experiment lasted **12 weeks** and was conducted using a Completely Randomized Design (CRD). The results indicated that supplementation with slow-release urea had no significant effect on body weight gain during the early weeks of the experiment. However, the control group exhibited significantly higher body weights during the final weeks (weeks eleven and twelve) and consumed greater amounts of feed. Regarding low-density lipoprotein cholesterol (LDL-C), the second and third treatments showed significantly higher values than the control treatment, recording **64.40, 63.60, and 63.00 mg/dL**, respectively.

Keywords: blood traits; body weight; body dimensions; slow-release urea; lambs

Introduction

Animal productivity and growth are directly or indirectly influenced by numerous environmental factors. The magnitude of these effects varies among animals according to their genetic differences, resulting in variation in biological responses. Nutrition is considered one of the most important environmental factors directly associated with productive performance, as balanced nutrition contributes to reducing production costs by improving nutrient utilization efficiency (Al-Khafaf, 2024).

The protein content of the diet is a major determinant of productivity in ruminant animals and depends largely on the availability of rumen undegradable protein as well as the efficiency of microbial protein synthesis. Microbial protein synthesized in the rumen supplies approximately half of the protein requirements of ruminants (Al-Khafaf, 2024). Dietary protein plays a fundamental role in ruminant nutrition, serving not only as a source of essential amino acids but also as a nitrogen source for ruminal microbial protein synthesis. Owing to its high cost and physiological importance, dietary protein must be managed efficiently. Consequently, considerable research has focused on identifying economical alternatives that reduce feeding costs without adversely affecting productive performance.

In the rumen, urea is hydrolyzed to ammonia nitrogen (**N-NH3**), which is subsequently incorporated by ruminal microorganisms into amino acids and microbial proteins of high nutritional value for ruminants. The complex ruminal ecosystem, which contains a wide diversity of microorganisms with different nutritional requirements and metabolic pathways, facilitates this conversion efficiently (Geron et al., 2016).

Urea is widely used as a dietary supplement in ruminant rations to provide non-protein nitrogen. However, it is rapidly hydrolyzed in the rumen by the enzyme urease produced by ruminal microorganisms, resulting in ammonia release at a rate that often exceeds the microbial capacity for nitrogen utilization in microbial protein synthesis. Therefore, the efficiency of urea utilization largely depends on the rate of its degradation to ammonia in the rumen, necessitating strategies to reduce its rapid hydrolysis. One such approach involves coating or combining urea with gelatin or Minogen to produce **slow-release urea (SRU)**. This technology provides a gradual supply of nitrogen together with energy derived from the coating material, thereby supporting microbial protein synthesis. Previous studies have demonstrated that incorporating SRU into ruminant diets improves milk production and feed digestibility, although it has shown little effect on digestibility rate or carcass characteristics in animals fed low-concentrate diets (Rimbawanto et al., 2018).

The synchronization between the rate of carbohydrate degradation and nitrogen availability is one of the principal factors regulating ammonia utilization efficiency within the rumen. Such synchronization plays a pivotal role in enhancing microbial protein synthesis and improving nitrogen utilization efficiency. Consequently, the rate of ruminal carbohydrate degradation is considered a critical factor for maximizing nitrogen utilization. One practical nutritional

strategy involves supplementing diets containing slow-release urea as a non-protein nitrogen source with **non-structural carbohydrates**, which are rapidly digestible carbohydrates that are not components of the plant cell wall, such as barley and wheat (Sevim and Önol, 2019).

Recent studies have also demonstrated that diets formulated according to the principle of energy–nitrogen synchronization improve rumen stability and nutrient utilization efficiency, leading to increased live body weight and enhanced overall productive performance in sheep. Accordingly, nutritional synchronization has become one of the modern scientific principles in sheep-feeding strategies aimed at improving production efficiency while minimizing nutritional and economic losses (Broderick et al., 2019).

Coated urea also enhances the safety of urea utilization in ruminant nutrition by minimizing sharp postprandial increases in ruminal ammonia concentration, thereby reducing ammonia absorption into the bloodstream and decreasing the hepatic conversion of ammonia into urea. Consequently, the risk of ammonia toxicity is reduced. This protective effect becomes more evident when slow-release urea is incorporated into diets balanced in fermentable energy, where synchronization between nitrogen release and energy availability enhances microbial ammonia utilization for microbial protein synthesis and improves overall nitrogen-use efficiency (Gardinal et al., 2017; Kowalczyk and Wróbel, 2024).

Given the importance of slow-release urea and the limited number of studies investigating its application in ruminants, the present study was conducted to evaluate the effects of dietary supplementation with slow-release urea on body weight, body dimensions, and selected blood parameters in Awassi lambs.

Materials and Methods

The experiment was conducted at the sheep farm of the Department of Animal Production, College of Agriculture, Tikrit University, during the period from **(5/10)** to **(5/1/2025)**. A total of **15 Awassi lambs**, aged **3–4 months** and weighing **24–26 kg**, were used in this study. The animals were housed in semi-open pens with concrete floors and walls, covered by a metal roof, and equipped with individual feeders and drinkers to ensure accurate monitoring of daily feed intake. Each pen measured **2 m in length** and **1.5 m in width**.

The lambs were randomly allocated to **three experimental treatments**, with **five animals per treatment**, as follows:

1. **Control treatment (Control):** Basal diet without slow-release urea supplementation.
2. **Treatment 1 (T1):** Basal diet supplemented with **30 kg/ton** of slow-release urea.
3. **Treatment 2 (T2):** Basal diet supplemented with **50 kg/ton** of slow-release urea.

The amount of feed offered from the experimental diets was standardized for all animals and was provided in **two equal meals daily**, at **8:00 a.m.** and **3:00 p.m.**

Table (1). Chemical composition (NRC, 2007) and ingredients of the experimental diet.

Feed Ingredient	Percentage (%)
Crushed barley	%50
Wheat bran	%36
Soybean meal	5
Wheat straw	8%
Common salt	0.5
Limestone	0.5
Dry matter (DM)	88.27%
Crude protein (CP)	13.81%
Crude fiber (CF)	9.74%

Ether extract (EE)	2.69%
Nitrogen-free extract (NFE)	57.44%
Ash	5.03%
Neutral detergent fiber (NDF)	30.56%
Acid detergent fiber (ADF)	12.13%
Total digestible nutrients (TDN)	69.66%
Metabolizable energy (ME)	11.22 MJ/kg
Calcium (Ca)	0.296%
Phosphorus (P)	0.628%

The studied traits

Body Weight : The initial body weight of the animals was recorded on the first day of the experiment. Thereafter, body weight was measured weekly in the morning before the morning feeding, and the weights of each replicate were recorded to determine the weekly body weight gain of each animal throughout the experimental period.

Blood Parameters : A total of **10 mL** of blood was collected from the jugular vein of each replicate according to the procedure described by (Jain et al., 1987). Blood samples were transferred into test tubes containing heparin as an anticoagulant. The samples were then centrifuged at **3000 rpm** for **20 min** to separate the serum. The obtained serum was stored in glass vials at **−20°C** until chemical analyses were performed.
Rumen Fluid Characteristics : Rumen fluid samples were collected directly from the animals at two sampling times: **before feeding** and **1 h after feeding**. Samples were obtained using a suction pump connected to a rubber tube inserted through the animal's mouth into the rumen. The end of the tube positioned inside the rumen was fitted with a perforated copper strainer to prevent obstruction, while the outer end was attached to a large syringe used for sample aspiration after confirming the proper placement of the tube within the rumen. The collected rumen fluid was analyzed for selected characteristics, including **pH**, **ammonia concentration**, and **volatile fatty acid (VFA) concentration**, as follows:
a. **Twenty milliliters (20 mL)** of rumen fluid were transferred into a container, and **1 mL of HCl** was added for the determination of ruminal ammonia concentration.
b. Another **20 mL** aliquot was collected for the determination of **volatile fatty acids (VFA)**. The samples were subsequently stored at **−20°C** until laboratory analyses were conducted.

Body Dimensions : Body dimensions were measured twice during the experimental period using a measuring tape. The first measurement was taken during the **fourth week**, and the second during the **eighth week** of the experiment. The following measurements were recorded:

1. **Head length:** measured from the anterior part of the forehead to the end of the neck.
2. **Body height:** measured from the highest point of the back to the ground.
3. **Chest height:** measured from the uppermost point of the chest to the ground.
4. **Chest circumference:** measured by wrapping a measuring tape around the thoracic region.
5. **Body length:** measured from the anterior part of the head to the end of the back.

Statistical Analysis : Data were statistically analyzed using the **Statistical Analysis System (SAS, 2001)**. Significant differences among treatment means were determined using **Duncan's Multiple Range Test** (Duncan, 1955).

Results

Body Weight : Table (2) shows that the mean weekly body weights of the experimental treatments did not differ significantly from the first to the **tenth week** of the experiment. However, during the **eleventh week**, a significant difference (**P≤0.05**) was observed, with the **control group** exhibiting a significantly higher body weight than the third and second treatments, recording the following values **(37.45, 32.52, and 31.18 kg)**, respectively. **Similarly, during**

the twelfth week**, the control group maintained a significantly higher body weight than both the third and second treatments, recording** (39.25, 33.50, and 32.90 kg)**, respectively.**

Table (2). Effect of Slow-Release Urea Supplementation on Lamb Body Weight (kg) (Mean ± Standard Error).

Traits Treatments	Mean Body Weight at Week 8	Mean Body Weight at Week 9	Mean Body Weight at Week 10	Mean Body Weight at Week 11	Mean Body Weight at Week 12
Control Group	2.24±34.42	2.40±34.95	2.56±37.07	2.30±37.45 a	2.93±39.25 A
T2	0.83±31.42	1.080±32.04	0.91±32.38	1.05±31.18 b	0.76±32.9 B
T3	1.25±31.10	1.73±31.46	1.72±32.34	1.70±32.52 b	1.61± 33.50 B
Significant Differences	N.S	N.S	N.S	*	*

Note :Different letters within the same column indicate significant differences.

Blood Parameters : The results presented in Table (3) **indicate that the second and third treatments exhibited significantly higher (**P≤0.05**) blood glucose concentrations than the control treatment, recording the following values** (71.00, 82.20, 93.60 DL/MG)**, respectively.**

Blood urea concentration was significantly lower (**P≤0.05**) in the second and third treatments compared with the control treatment, with the recorded values being **(41.40, 35.00, 39.20 MG/DL)**, respectively (Table 3).

The results also showed that the second treatment had a significantly lower (**P≤0.05**) serum creatinine concentration than the first and third treatments, recording **(0.82, 0.64, 0.78 MG/DL)**, respectively.

Blood cholesterol concentration was significantly increased (**P≤0.05**) in the second and third treatments compared with the control treatment, recording **(93.00, 108.00, 109.80 MG/DL)**, respectively.

For triglycerides, the second and third treatments showed significantly higher (**P≤0.05**) values than the control treatment, recording **(46.80, 53.60, 56.00 100 ml/g)**, respectively.

Regarding high-density lipoprotein cholesterol (HDL-C), the third treatment exhibited a significant increase (**P≤0.05**) compared with the first and second treatments, recording **(37.00, 35.00, 42.60 ML/DL)**, respectively.

The third treatment also showed a significant increase (**P≤0.05**) compared with the control treatment in very-low-density lipoprotein (VLDL), with the following values recorded **(9.60, 10.60, 11.40 ML/DL)**, respectively.

For low-density lipoprotein cholesterol (LDL-C), the results indicated that the second and third treatments were significantly higher than the control treatment, recording **(64.40, 63.60, 63.00 ML/DL)**, respectively.

Furthermore, the first and second treatments showed significantly higher (**P≤0.05**) total protein concentrations than the third treatment, recording **(67.60, 69.60, 61.80 G/L)**, respectively.

With respect to serum albumin, the third treatment exhibited a significant increase (**P≤0.05**) compared with the first and second treatments, recording **(42.80, 45.80, 49.00 G/L)**, respectively. In contrast, no significant differences were observed among the treatments in serum globulin concentration.

Table (3). Effect of Slow-Release Urea Supplementation on Blood Parameters of Lambs (Mean ± Standard Error).

Traits	High-Density Lipoprotein Cholesterol (HDL-C)(mg/dl)	Low-Density Lipoprotein Cholesterol (LDL-C) (mg/dl)	Triglycerides (mg/dl)	Total Cholesterol (mg/dl)	Creatinine (mg/dl)	Blood Urea (mg/dl)	Blood Glucose (mg/dl)
Control Group	a0.510±9.600	b1.974±37.00	b0.970±46.800	b1.414±93.00	a0.040±0.820	a0.680±41.400	c0.710±71.00
T2	a0.510±10.600	b0.707±35.00	a2.380±53.600	a2.550±108.00	b0.024±0.640	c0.840±35.00	b0.840±82.200

T3	b0.510±11.400	a1.122±42.600	a1.790±56.00	a2.009±109.800	a0.037±0.780	b0.374±39.20	B a0.037±93.600
Significant Differences	*	*	*	*	*	*	*

Note: Different letters within the same column indicate significant differences.

Body Measurements and Dimensions

As shown in **Table (4)**, no significant differences were observed among the first, second, and third treatments in **head length**. Likewise, no significant differences were detected in **body height**, **chest circumference**, or **body length** among the experimental treatments.

However, **chest height** was significantly higher (**P≤0.05**) in the third treatment than in the second treatment and the control group, recording the following values **(36.75, 33.20, and 32.67 cm)**, respectively.

Table (4). Effect of Slow-Release Urea Supplementation on Body Dimensions of Lambs (Mean ± Standard Error) During the Fourth Week of the Experiment.

Traits Treatments	Body Length Cm	Chest Circumference cm	Chest Height cm	Body Height cm	Head Length Cm
Control Group	3.04±70.500	5.18±92.33	b1.83±32.670	1.64±66.833	1.800±25.33
T2	1.11±69.00	2.70±88.200	b0.600±33.200	0.58±66.00	2.08±27.600
T3	1.24±67.00	.39±92.500	a0.96±36.750	1.86±67.250	0.400±27.750
Significant Differences	N.S	N.S	*	N.S	N.S

Note :Different letters within the same column indicate significant differences.

Table (5). Effect of Slow-Release Urea Supplementation on Body Dimensions of Lambs (Mean ± Standard Error) During the Eighth Week of the Experiment.

Traits Treatments	**Body LengthCm**	**Chest Circumference cm**	**Chest Height cm**	**Body Height cm**	**Head Length Cm**
Control Group	3.049±68.00	5.182±84.400	1.833±33.400	1.643±64.00	1.800±32.800
T2	±66.200 1.113	2.709±82.800	0.600±31.600	0.583±63.800	2.083±35.200
T3	1.240±62.800	1.392±82.800	±32.800700.9	1.860±65.600	0.400±31.400
Significant Differences	N.S	N.S	N.S	N.S	N.S

Note :Different letters within the same column indicate significant differences.

Discussion

Body Weight

Referring to **Table (2)**, the elevated level of low-density lipoprotein cholesterol (LDL-C), particularly in the third treatment, may indicate hepatic stress resulting from the inclusion of the higher level of slow-release urea in the diet. This may explain the lower body weights observed in the treatment receiving the highest level of slow-release urea. These findings are inconsistent with those reported by (Fan et al., 2024), who demonstrated that polymer-coated slow-release urea was superior to conventional urea and starch in improving average daily weight gain. Fan et al. (2024) concluded that the gradual release of nitrogen from polymer-coated urea enhances the synchronization between nitrogen and energy availability, thereby improving feed utilization efficiency and promoting greater body weight gain.

Blood Parameters

Creatinine

Hashem and Tayeb (2023) reported no significant differences in serum creatinine concentration among the experimental treatments. Serum creatinine is considered an important indicator of renal function, and the absence of significant differences suggests that the different levels of dietary urea did not impose excessive stress on kidney function. They further explained that serum creatinine generally remains relatively constant because the kidneys maintain its concentration within a narrow physiological range, reflecting both muscle mass and renal function (Hashem and Tayeb, 2023).

Blood Urea
The significant differences observed in blood urea concentration may be attributed to the dietary protein source supplemented with slow-release urea and to the limited amount of urea absorbed within the rumen due to its gradual degradation (Alizadeh et al., 2020). Furthermore, supplementation with slow-release urea significantly (**P≤0.05**) affected several blood biochemical parameters in Awassi lambs, resulting in a significant reduction in serum urea concentration as the dietary level of slow-release urea increased (Al-Khafaf, 2024).

Blood Glucose
Blood glucose concentration is maintained by highly efficient homeostatic regulatory mechanisms that preserve relatively constant glucose levels regardless of dietary changes (Zhang et al., 2018).

Total Cholesterol
Hashem and Tayeb (2023) reported no significant differences in serum cholesterol concentration among the different treatments. They suggested that the lack of treatment effects reflects the fact that blood cholesterol concentration is primarily influenced by the animal's overall energy status and nutritional condition rather than by the type or source of dietary nitrogen. They also indicated that all experimental diets supplied similar levels of metabolizable energy because the diets were formulated to be isoenergetic, and therefore no differences in serum cholesterol concentration were expected (Hashem and Tayeb, 2023).

Triglycerides
Hashem and Tayeb (2023) suggested that the absence of significant differences in triglyceride concentration indicates that all dietary treatments supplied comparable amounts of energy, resulting in balanced lipid metabolism among the experimental groups. They further explained that the rate of nitrogen release from urea, whether rapid or slow, does not directly influence triglyceride synthesis because this metabolic process primarily depends on the availability of blood glucose and fatty acids rather than free nitrogen.
High-Density Lipoprotein Cholesterol (HDL-C)
Safvi and Chaji (2022) reported that dietary supplementation with slow-release urea had no significant effect on HDL-C concentration in sheep fed diets containing slow-release urea. These findings indicate that the use of different urea sources, whether rapidly or slowly degradable, does not markedly influence reverse cholesterol transport, the principal physiological function of HDL-C (Safvi and Chaji, 2022).

Total Protein
The findings reported by Al-Khafaf (2024) demonstrated a significant reduction in total serum protein concentration following supplementation with slow-release urea.

Lipoproteins
Supplementation with slow-release urea had no significant effect on serum lipoprotein profiles in fattening sheep. Serum cholesterol, triglycerides, and lipoprotein concentrations remained within comparable ranges among the different treatments (Safvi and Chaji, 2022). The absence of significant changes in lipoprotein concentrations may be attributed to the close relationship between ruminal ammonia concentration and blood urea nitrogen, as blood urea nitrogen is synthesized in the liver from ammonia absorbed from the rumen (Safvi and Chaji, 2022).

Low-Density Lipoprotein Cholesterol (LDL-C)
The inclusion of slow-release urea increased serum LDL-C concentration, which may indicate a degree of hepatic stress, particularly at the higher dietary inclusion level **(5%)**. However, Safvi and Chaji (2022) reported no significant effect of slow-release urea supplementation on LDL-C concentration. These findings suggest that the non-protein nitrogen sources evaluated in their study did not alter lipid metabolism in sheep, indicating metabolic stability in the synthesis and degradation of low-density lipoprotein cholesterol (LDL-C).

Albumin
Fan et al. (2024) reported significant differences (**P≤0.05**) in serum albumin concentration, demonstrating that lambs receiving polymer-coated urea had significantly higher albumin concentrations than the control group on day **86**. Albumin is considered a highly sensitive indicator of early nutritional status. The gradual nitrogen release from polymer-coated urea promoted better synchronization between nitrogen availability and microbial requirements, resulting in improved microbial protein synthesis and enhanced amino acid absorption (Fan et al., 2024).

Body Measurements and Dimensions
Saro et al. (2019) reported that supplementation with slow-release urea did not produce significant differences among treatments in the evaluated morphological body measurements. The inclusion of slow-release urea did not improve the principal body morphometric characteristics, either in pregnant cattle or in lambs. Nevertheless, Saro et al. (2019)

indicated that despite the absence of significant effects on body morphology, the use of slow-release urea offers clear economic advantages by reducing feeding costs.

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