RESEARCH ARTICLE Asian Journal of Dairy and Food Research, Volume 44 Issue 4: 702-708 (August 2025)

Effects of Various Proportions of *Moringa oleifera* Supplementation on Productivity and Physiological Traits of Ewes and Lambs

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10.18805/ajdfr.DRF-433

ABSTRACT

Background: *Moringa oleifera* has garnered significant interest. This research evaluated the impact of different quantities of *Moringa oleifera* seed powder on certain productive and physiological characteristics in Awassi ewes. The research investigated the effects on lamb development and birth outcomes within a sheep herd managed by Rashidiyah Research Station, Agricultural Research Service, Ninawa Research Department, Mosul, Iraq.

Methods: Twenty ewes were divided into four groups of five ewes per group. Moringa seed powder was given to four groups: 0, 5, 10 and 15 (g/ewe/day). The weights of the newborns and mothers were recorded on the first day of the trial (0 days) and then the weights were taken at equal intervals of 15 days and on two consecutive days after the newborns were isolated from their mothers for 12 hours, these measurements continued the length of the trial. Blood tests were performed at the Physiology Laboratory of the Department of Animal Production Technologies at the Northern Technical University/Agricultural Technical College. cholesterol, triglycerides, glucose, urea, creatinine and liver enzymes including Aspartate alanine transferase (AST) and alanine aminotransferase (ALT).

Result: Results of this study revealed that moringa seed powder supplementation (0, 5, 10, 15 g/head/day) significantly reduced feed intake for both ewes (2.087, 2.020, 1.769, 1.849 kg/ewe/day) and newborns (0.803, 0.770, 0.744, 0.758 kg/newborn/day). Ewes fed moringa also showed significant weight gains, with final weights reaching 59.6, 62, 58.6 and 57 kg across groups, compared to the control. Blood analysis showed an increase in leukocytes (20.23, 21.93, 20.97 and 16.03 × 10^9/L) and lymphocytes, while granulocyte ratios remained similar. Total cholesterol significantly decreased in the moringa-fed groups (120.66, 86.54, 92.12 and 82.72 mg/100 ml), though triglycerides stayed stable (47.2-49.08 mg/100 ml). Glucose levels dropped with higher moringa doses (45.87, 45.28, 49.1 and 33.3 mg/100 ml). Urea levels decreased (46.93, 40.36, 43.44 and 47.05 mg/100 ml), while AST levels were lower in specific groups. ALT levels showed minimal change, with values between 15 and 19.2 IU/L across groups.

Key words: Awassi ewes, Lambs, *Moringa oleifera,* Seed, Supplements.

INTRODUCTION

Recently, there has been a rise in the utilization of medicinal plants, their extracts and agricultural by-products as feed additives in ruminant feeding systems. This is primarily due to their cost-effectiveness (Correddu *et al.,* 2020). Agricultural by-products contain significant amounts of biologically active substances, including polyphenols such as tannins and flavonoids. The compounds mentioned possess antimicrobial properties that enhance the immune system of animals and alleviate stress (Hao *et al.,* 2020; Correddu *et al.,* 2020). Medicinal plants have been found to improve animal health and enhance production performance, as indicated by Ullah *et al.* (2023) and Nabi and Arain (2022). These plants have the potential to treat diseases and promote growth (Marashi Sarai, 2007; Sultan *et al.,* 2020). Including medicinal plants with sufficient energy levels in the diet of Awassi ewes during lactation can lead to improvements in body condition, body weight, milk production and lamb growth (Parrague *et al.,* 2020).

Moringa oleifera has gained attention as a subject of interest (Santos *et al.,* 2017). The diverse chemical composition and potential health benefits of this substance have garnered increasing attention. It contains biologically active compounds such as flavonoids and alkaloids (Camilleri and Blundell, 2024). *Moringa oleifera* seeds contain a high concentration of phenolic acids and

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How to cite this article: Salih, W.M., Abdallah, M.N. and Al-Farha, A.A. (2025). Effects of Various Proportions of *Moringa oleifera* Supplementation on Productivity and Physiological Traits of Ewes and Lambs. *Asian Journal of Dairy and Food Research*. **44(4):** 702-708. doi: 10.18805/ajdfr.DRF-433.

Submitted: 22-07-2024 **Accepted:** 12-11-2024 **Online:** 21-02-2025

flavonoids, including gallic acid, ellagic acid, quercetin and other compounds (Wang *et al.,* 2022). Both flavonoids and phenolic acids have demonstrated efficacy in combating aging, providing antioxidant benefits and exhibiting anti-cancer properties. Conversely, the primary active component of moringa is phenolic acid, which plays a crucial role in safeguarding the liver and combating inflammation (Giuberti *et al.,* 2021; García-Milla *et al.,* 2021).

The inclusion of moringa in the diets of sheep and goats has demonstrated positive effects on weight gain and milk production (Al-Maamari, 2023; Olvera Aguirrek *et al.,* 2020; Kumar *et al.,* 2024). However, there is a lack of research on the impact of varying seed amounts (15, 10 and 5 grams/ewe/day) on their productive characteristics. This article examines the impact of a specific factor on both blood characteristics and biochemical characteristics. It also provides an explanation of the significance of this factor in relation to animal health and production efficiency. This study aims to investigate the impact of incorporating varying proportions of *Moringa oleifera* seed powder into the diet on production characteristics, blood and biochemical parameters and the growth of lambs.

MATERIALS AND METHODS

A total of 20 pregnant Awassi ewes, all with close newborns, were chosen from the sheep herd of the Rashidiya Research Station/Agricultural Research Department/Ninawa Research Department/Mosul/ Iraq from November 2023 to April 2024. The ewes had an average starting weight of 57.35 and their ages ranged from 4 to 5 years according to available animals in the Agricultural Research Service.

The study groups and design

The ewes were randomly allocated into four groups, with each group containing five ewes. The ewes were provided with a diet comprising of barley, yellow corn, wheat bran, soybean meal, hay, lime and salt, as indicated in Table (1) for the four groups. The feed was freely available for animals and divided into three meals. Moringa was incorporated into the diet at three different levels, as outlined below.

The initial treatment involved providing the standard diet, which served as the control group. The second group involved providing the standard diet to the ewes and supplementing it with an additional 5 grams of moringa seed powder per ewe per day. The third group involved supplementing the standard diet with an additional 10 grams of moringa seed powder per ewe per day. Fourth group: administered the standard diet with an additional supplementation of 15 grams of moringa seed powder per ewe per day.

The weights of the newborns and mothers were recorded on the first day of the trial (0 days) and then the weights were taken at equal intervals of 15 days and on two consecutive days after the newborns were isolated from their mothers for 12 hours, these measurements continued the length of the trial.

The examined physiological parameters

Blood tests were performed at the physiology laboratory of the department of animal production technologies at the Northern Technical University/Agricultural Technical College. At the commencement and conclusion of the experiment, blood samples were collected from every animal in each group. Mothers' jugular vein was used to extract blood. A syringe was used to extract 10 ml of blood. Each medical sample, measuring 10 ml, was placed in a glass tube. One of the tubes contained an anticoagulant called EDTA, which was used to examine the blood image. The analysis was conducted utilizing a CBC using Auto Hematology Analyzer) Mindray, model BC-10 (China, which encompassed a thorough examination of the blood image, specifically focusing on white blood cells (WBC), lymphocytes (%) and monocytes. Percentage of granulocytes, hemoglobin (HGB), hematocrit (HCTP), red blood cells (RBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDWP), red cell distribution width (RDW-a), platelet count (PLT), platelet volume (MPV).

Biochemical test

For biochemical tests, the blood sample was collected in a tube without an anticoagulant and promptly transported to the laboratory. The serum was extracted from the samples by subjecting them to centrifugation at a speed of 3000 revolutions per minute (rpm) for a duration of 15 minutes. The obtained serum was stored in a cryogenic freezer at a temperature of -20°C. Subsequently, the serum was thawed to room temperature and analyzed using a

Table 1: Components of the dietary feed provided to the animals during the experimental period.

Ingredients	Percentage%
Malt	54
Spelt bran	20
Yellow corn	10
Soybeans	7
Adoption	8
Salt	0.5
Calcify	0.5

Table 2: Chemical analysis of the dietary components provided to the animals during the experimental period.

Ingredients	Percentage %
Fat	9.78
Cinders	25.97
Fiber	62.35
Protein	96.99
Nitrogen-free extract	362.18
Dry matter	89.68
Crude protein	13.19
Metabolic energy	2526

spectrophotometer. The conducted tests encompassed measurements of cholesterol, triglycerides, glucose, urea, creatinine and liver enzymes. Cholesterol levels were determined using the method outlined by Watson (1960), while triglyceride levels were also measured. Aspartate alanine transferase (AST) and alanine aminotransferase (ALT) were characterized in blood plasma, urea and glucose by Reitman and Frankel (1957), as documented by Barham and Trinder (1972).

Statistical analysis

The statistical analysis of the data was conducted at the beginning of the experiment to ensure there were no significant differences in body weight. Then, every 15 days, analysis was performed for the four treatments using a complete randomized design (CRD) through version 21 (2012) of the Statistical Package for Social Science (SPSS) for analyzing the studied parameters. The significant differences between the means of the studied traits were tested using Duncan's multiple range test, as indicated in the mathematical model:

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

Where,

Y_{ij} = Year of viewing j returning to i.

μ = General average of the class of study.

T_i = Effect of treatment i.

e_{ij} = The geometric error is distributed electrically and independently by an average of two zeros and by a Se.

Chemical analysis was based on previous studies conducted in Iraq (Al-Khawaja, 1978) (Table 2).

The dry matter was determined by analyzing the raw materials in the College of Agriculture laboratory and utilizing the AOAC method (2010).

RESULTS AND DISCUSSION

Feed consumption in ewes and newborns

The data presented in Table 3 demonstrate a significant reduction in feed consumption among ewes and their newborns in groups supplemented with moringa seed powder. The experimental groups, receiving 5 g, 10 g and 15 g of moringa seed powder per head per day, exhibited a marked decrease in feed intake compared to the control group. Feed consumption for ewes in these groups was recorded as 2.087, 2.020, 1.769 and 1.849 kg/ewe/day, respectively. Likewise, significant differences were observed in the feed intake of newborns, with consumption values of 0.803, 0.770, 0.744 and 0.758 kg/newborn/day, respectively, for the control and treatment groups. Chemical analysis was based on previous studies conducted in Iraq (Al-Khawaja, 1978) (Table 2). The dry matter was determined by analyzing the raw materials in the College of Agriculture laboratory and utilizing the AOAC method (2010).

Growth performance

As indicated in Table 3, the final weight, total weight gain and daily weight gain of ewes showed significant improvement (p d≤0.05) in the groups supplemented with moringa seed powder compared to the control. The final weights for the control, second, third and fourth groups were 57, 59.6, 62 and 58.6 kg, respectively. The corresponding total weight gains were 5.6, 7.2, 10.8 and 6.4 kg, while the daily weight gains were recorded as 0.09, 0.12, 0.18 and 0.1 kg/day, respectively.

The growth performance of newborns followed a similar trend. Statistical analysis revealed significant differences (p≤0.05) in the final weight of newborns, with the highest final weight observed in the fourth group (26.75 kg), followed by the second (24.2 kg), third (24 kg) and control group (24.2 kg). The total and daily weight gains for the newborns in the four groups were 15.05, 15.4, 15.6 and 17.75 kg and 0.25, 0.26, 0.26 and 0.30 kg/day, respectively.

Blood profile

The inclusion of moringa seed powder in the diet had a significant impact on the blood profile of the ewes. White blood cell (WBC) counts increased significantly (p≤0.05)

Table 3: Effect of the addition of *Moringa olifeira* seed powder in the passive ewe relationship on the consumption of feed and body weights (mean + standard deviation).

Groups / Parameters	T1	T2	T3	T4
	0 g (Moringa seed powder)	5 g (Moringa seed powder)	10 g (Moringa seed powder)	15 g (Moringa seed powder)
Quantity of feed consumed (kg) by ewes	2.087±0.51^{A}	2.020±0.00^{b}	1.769±0.16^{c}	1.849±0.10^{D}
Quantity of feed consumed (kg) by lambs	0.803 ±0.00^{A}	0.770 ±0.0.63^{b}	0.744±0.07^{d}	0.758 ±0.07^{C}
Average starting weight (kg) of ewes	51.4±4.72^{A}	52.4±1.82^{a}	51.2±5.36^{a}	52.2±4.6^{A}
Average final weight (kg) of ewes	57±1.87^{B}	59.6±0.55^{ab}	62±0.71^{a}	58.6±6.35^{Ab}
Rate of total weight gain (kg) for ewes	5.6±2.97^{A}	7.2±1.79^{a}	10.8±5.02^{a}	6.4±5.22^{A}
Average daily weight gain (G) for ewes	0.09±0.05^{A}	0.12±0.03^{a}	0.18±0.08^{a}	0.1±0.1^{A}
Average starting weight (kg) for lambs	9.2±1.1^{A}	8.6±0.89^{a}	8.6±0.89^{a}	9±0.71^{A}
Final weight rate (kg) for lambs	24.25±0.83^{B}	24±1.22^{b}	24.2±1.3^{b}	26.75±1.64^{A}
Rate of total weight gain (kg) for lambs	15.0±1.18^{B}	15.4±1.14^{b}	15.6±2.07^{b}	17.7±1.64^{A}
Average daily weight gain (kg) for lambs	0.25±0.02^{B}	0.26±0.02^{b}	0.26±0.03^{b}	0.3±0.03^{A}

*Different letters horizontally indicate significant differences between the coefficients at the probability level (p≤0.05).

in the moringa-supplemented groups compared to the control, with WBC counts of 16.03, 20.23, 21.93 and 20.97× 10^/L, respectively, for the four groups. Lymphocyte counts also showed a significant increase in the second group compared to the control and other treatment groups, with percentages of 0.71, 0.56, 0.57 and 0.58%, respectively.

Absolute lymphocyte counts in the groups supplemented with moringa were significantly higher than in the control, reaching values of 0.06%,0.09%, 0.08% and 0.08%, respectively. In contrast, the granulocyte percentage remained unchanged across all groups, with values of 0.37%, 0.2%, 0.26% and 0.35%, although the second and third groups showed a decrease compared to the control.

Hematological parameters

The statistical analysis revealed no significant differences ($p \leq 0.05$) in red blood cell (RBC) counts, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW-SD), Red cell distribution width coefficient of variation (RDW-CV), mean platelet volume (MPV) and platelet distribution width (PDW) between the groups. However, the second group showed a marginal improvement in hemoglobin (HGB) and hematocrit (HCT) levels compared to the control, with HGB values of 88.67, 90.67, 88 and 79.33 g/L and HCT values of 0.24, 0.27, 0.26 and 0.24, respectively (Table 4).

Serum biochemistry

The inclusion of moringa seed powder resulted in a significant reduction ($p \leq 0.05$) in serum total cholesterol levels across all experimental groups compared to the control. Cholesterol levels in the control, second, third and fourth groups were recorded as 120.66, 86.54, 92.12 and 82.72 mg/100 mL, respectively. However, no significant differences were observed in triglyceride levels, with values of 47.2, 49.08, 47.28 and 48.8 mg/100 mL across the groups.

Serum glucose concentrations also decreased significantly in the groups supplemented with moringa seed powder, with values of 45.87,45.28, 49.1 and 33.3 mg/100 mL for the control, second, third and fourth groups, respectively. Additionally, urea levels were significantly lower in the second group (40.36 mg/100 mL) compared to the first and fourth groups (46.93 and 47.05 mg/100 mL, respectively), while creatinine levels showed a significant decrease in the moringa-treated groups compared to the control (0.83, 0.53, 0.56 and 0.53 mg/100 mL, respectively), (Table 5).

Liver enzymes

Regarding liver enzymes, no significant decrease ($p \leq 0.05$) was observed in aspartate aminotransferase (AST) levels in the groups supplemented with moringa seed powder compared to the control. However, the second and fourth groups exhibited significantly lower AST levels than the third group, with values of 144.2, 123.4, 169 and 119.2 IU/L, respectively. Alanine aminotransferase (ALT) levels showed a significant reduction ($p \leq 0.05$) in the second group compared to the first, third and fourth groups, with ALT values of 17.4, 15, 19.2 and 16.4 IU/L, respectively.

The objective of the study was to investigate the effects of varying doses of moringa seed powder on production traits, hematological parameters and biochemical characteristics in Awassi ewes.

The results showed that the use of moringa seed powder in sheep feed led to a decrease in the amount of feed consumed by the ewes, as well as a reduction in intake among the newborns that were fed on moringa seed powder. The reason may be that using moringa in ruminant

Table 4: Effect of adding different percentages of *Moringa oleifera* seed powder to the diet of Awassi ewes on some blood characteristics (mean+s.d).

Groups / Parameters	T1 (0) g Moringa seed powder	T2 (5) g Moringa seed powder	T3 (10) g Moringa seed powder	T4 (15) g Moringa seed powder
WBC ^10g/l	16.03±0.61^{C}	20.23±0.4^{b}	21.931.11^{a}	20.2±0.99^{B}
Lymph%	0.56±0.03^{B}	0.71±0.07^{a}	0.57±0.02^{b}	0.58±0.05^{B}
mid%	0.06±0^{D}	0.09±0^{a}	0.08±0^{b}	0.08±0^{C}
Gran%	0.2±0.02^{C}	0.37±0.03^{a}	0.26±0.02^{b}	0.35±0.04^{A}
RBC	8.35±1.03^{A}	8±0.68^{a}	8.11±1.03^{a}	7.76±0.82^{A}
HGB g/L	88.67±3.21^{Ab}	90.67±2.08^{a}	88±5.57^{ab}	79.33±8.5^{B}
HCT	0.24±0.02^{Ab}	0.27±0.02^{a}	0.26±0.02^{ab}	0.24±0.01^{B}
MCV	29.4±1.0^{A}	34±3.29^{a}	32.73±2.63^{a}	33.13±1.5^{A}
MCH	10.23± 0.71^{A}	11.4±0.75^{a}	10.93±1.14^{a}	10.83±1.27^{A}
MCHC	347.33±5.69^{A}	335±16.46^{a}	335.67±12.22^{a}	331.67±5.86^{A}
RDW CV	0.2±0.02^{a}	0.19±0.01^{a}	0.2±0.01^{a}	0.18±0.01^{A}
RDW SD	19.93±2.27^{a}	22.13±2.8^{a}	2.58±21.93^{a}	3.94+20.4^{A}
PLT	449.67±31.9^{a}	370.67±19.55^{ab}	240.3±187.95^{b}	467.67±88.75^{A}
MPV	5.93±0.21^{a}	5.93±0.61^{a}	6.4±0.3^{a}	5.67±0.25^{A}

*Different letters horizontally indicate significant differences between the coefficients at the probability level ($p \leq 0.05$)

feed can increase feed utilization efficiency, improve energy efficiency, reduce the activity of methane-generating bacteria and consequently decrease methane gas emissions (Leitanthem *et al.,* 2023). The seeds possess antioxidant properties and contain essential nutrients, which can effectively modify rumen fermentation, leading to improved feed digestion and utilization to enhance productivity (Ebeid *et al.,* 2019). Our results were an approach to Rahmawati *et al.* (2024) when using *M. olifeira* leaves in feeding 15 thin-tailed javanese ewes at 2-3 years old. With an average weight of 23.4 kg for 60 days, the ewe was divided into three factors (0, 10 and 20% of the percentage of soybeans in Alaiba, each group contained 5 repeats and significant differences were observed in the feed accessible to the groups compared with the control (Salem and Makkar, 2009), when studying the effect of *M. olifeira's* lean seeds for 24 prairie sheep and the addition of Moringa in ratios 0 (control), 2 (low), 4 (medium) and 6 (high) grams/animal/day, for 45 days, showed significant disparities in Morieta-fuelled groups. While it did not agree with (Salih *et al.,* 2017) who did not find significant differences when feeding sheep on moringa. While an increase in body weight, daily weight gain and total weight gain was observed in ewes fed with moringa seed powder compared to the control group, the body weight and daily and total weight gain of the newborns whose mothers were fed the highest proportion of moringa seed powder (15 g/ewe/day) also increased in comparison to the control and other treatments. This may be because moringa seeds enhance digestive efficiency in the rumen and intestines, taking advantage of feed components that contain active substances such as alkaloids, glycosides, flavonoids, plant steroids and antioxidant functions. (Ali and Abbass, 2019), it is rich in protein and essential minerals such as calcium, magnesium, potassium, iron, zinc, phosphorus and contains good amounts of vitamins such as vitamin C, vitamin E, vitamin A and vitamin B (B1, 2 B and B3) and a source of amino acids, they possess good nutritional value leading to balanced nutrition (Singh Brajapal, 2024).

These additions also led to improvements in the blood profiles of leukemia and its cells and did not adversely affect (RBC, MCV, MCH, MCHC, RDW SD, RDW C, MPV, PDW, PLT), while there was an improvement in the HGB and HCT. Perhaps the reason for the seed containment is the compound Pyrrolidine butanoic acid which is involved in metabolism and the compound Benzothiazole which plays a role as an antifungal, on the carboxylic derivative of vitamin A. It is beneficial in growth, as well as vitamin E (Ali and Abbass, 2019). Or it may be down to the seed content of antioxidants: carotenoids, vitamin C, flavonoids such as appiin and lute, Olin, clycosinolate glucosinolate Saini *et al.* (2024). The results of the researcher Habeeb *et al.* (2023) came an approach to our finding that the treatment of passive ewes with 10 grams of moringa leaf powder led to an increase in some qualities (GHB, HCTP, RBC, MPV) and the remainder of qualities) WBC Gran, MCH, MCHC, RDWCV, RDWCD, PLT.

While the addition of moringa seed powder led to a decrease in the level of cholesterol, creatinine, urea, AST and ALT and glucose level with the highest proportion of moringa seed powder. This may be attributed to the fact that moringa contains all saturated and unsaturated fatty acids (Chukwuebuka, 2015) and Rizwan Nazish *et al.* (2024) reported that plant stroll has a cholesterol-like structure that enables it to prevent the absorption of cholesterol by inhibition and thus lowers cholesterol and moringa in all its parts possesses many therapeutic properties: Anti-diabetes and antibacterial, anti-inflammatory, anti-fungal, lowering blood pressure and heat, antioxidant and protective activities (Anwar *et al.,* 2007).

Researcher Shahbaz *et al.* (2024). Improvements in the level of enzymes in blood and liver (AST and ALT) may be the result of a dual mechanism in which seeds scan free radicals directly and promote antioxidants while reducing oxidative stress by activating effective compounds of moringa seeds and their ability to stimulate strong antioxidants to remove free radicals and protect liver cells from oxidation damage by raising levels of molecules and damage. Seeds are rich in the form of phenolic compounds

Table 5: Shows the effect of adding different percentages of *Moringa oleifera* seed powder to the diet of Awassi ewes on some biochemical traits (mean + standard deviation).

Groups / Parameters	T1 (0) g Moringa seed powder	T2 (5) g Moringa seed powder	T3 (10) g Moringa seed powder	T4 (15) g Moringa seed powder
Cholesterol	120.66±4.55^{A}	86.54±2.08^{bc}	92.12±6.45^{b}	82.72±7.04^{C}
Triglycerides	47.2±2.31^{A}	49.08±2.33^{a}	47.28±2.74^{a}	48.8±2.62^{A}
Glucose	45.87± 3.55^{A}	45.28±0.54^{a}	49.1±6.43^{a}	33.3± 3.47^{B}
Urea	46.93± 2.13^{A}	40.36±1.62^{b}	43.44±6.69^{Ab}	47.05±1.35^{A}
Creatinine	0.83±0.13^{B}	0.53± 0.03^{c}	0.56±0.05^{c}	0.53±0.05^{C}
AST	68.40±5.94^{a}	61.00±4.18^{b}	57±2.24^{b}	59.60±4.16^{B}
ALT	19.2±0.84^{a}	15±1.87^{c}	17.4± 0.89^{b}	16.4±0.55^{Bc}

*Different letters horizontally indicate significant differences between the coefficients at the probability level ($p \leq 0.05$).

of phenolics, flavonioid and phenolic acids, especially Galic polyphenols, elagic acid, curcitin and others, They contribute to reducing oxidative stress caused by free radicals (Wang *et al.,* 2022 and Hai, 2023). El-Badawi *et al.* (2023) also noted that the addition of Purinka Oliveira leaf powder to buffalo feed resulted in a significant decrease in the levels of urea, glucose, cholesterol, creatinine and liver enzymes (AST and ALT).

CONCLUSION

Moringa is a precious nutritional supplement in sheep nutrition. In the current study when adding (5,10,15) g/ewe/ day, we found that moringa can reduce feed consumption and increase body weight. It also led to improvements in blood and biochemical traits and lower cholesterol and glucose levels. Although its use and cultivation in the sheep breeding industry is currently limited, especially in Iraq, our study has yielded promising results. This is encouraging for farmers, sheep breeders and investors considering integrating moringa feed additives, especially into the Iraqi market. In addition, it highlights the need for further research on the remaining effects of moringa on sheep and the use of its leaves, seeds and stems in ruminants feeding.

ACKNOWLEDGEMENT

The present study was supported by Technical Agricultural College of Mosul, Northern Technical University.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this ~~a~~rticle. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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