Evaluation of hydroponic barley on productive performance: body weight, milk yield, and milk constituents of Awassi ewes

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Abstract

This study evaluated the effect of hydroponic barley on milk composition and body weight in Awassi ewes. during lactation eighteen ewes were divided into three dietary treatments: a control diet without hydroponic barely(T1), a diet containing 50% hydroponic barely (T2), and a diet containing 100% hydroponic barely (T3). The results showed that feeding 50% hydroponic barley improved milk composition, increasing fat (5.98 ± 0.26%), protein (4.45 ± 0.08%) and highest total solid content (15.14%), and supported higher milk yield (387 ± 28.44 ml). Additionally, 50% hydroponic barley maintained optimal body weight (50.31 ± 1.06 kg) throughout lactation. In contrast, 100% hydroponic barley had a negative effect on body weight (45.70 ± 1.24 kg). The study suggests that 50% hydroponic barley feeding provides an optimal balance of nutrients for improving milk composition and maintaining body weight in lactating Awassi ewes.

Key words: Hydroponic barley, Awassi ewes, body weight, milk production

* This paper is part of the MSc research of the first author

Introduction

Iraq's agricultural economy depends heavily on the livestock industry, with sheep and goats farming contributing significantly to the nation's milk and meat production. However, a significant obstacle to sustainable dairy farming methods is the lack of high-quality animal feed, especially in arid and semi-arid areas. Feed quality and quantity fluctuate due to the limitations of traditional fodder production methods, which include land shortage, water scarcity, and climate change. In areas with limited agricultural land and water resources, hydroponic fodder has become a viable alternative for providing high-quality feed in recent years [28,29,4].

Hydroponics is a soil-free farming method that provides precise control over environmental factors including temperature, humidity, and light. This approach has been shown to improve crop yields, nutritional quality, and water efficiency, which may appeal to dairy producers seeking to boost productivity and sustainability of their operations [16,9,11]. Research indicates that hydroponic barley (HB) is a preferred feed choice for dairy cattle due to its superior nutritional value and digestibility compared to conventional fodder [21,23]. Higher levels of

crude protein, metabolizable energy, and essential amino acids are among the nutritional benefits of hydroponic barely (HB) [9,16,8]. In hydroponic cultivation, the germination process enhances the bioavailability of nutrients, reduces anti-nutritional factors, and boosts the production of beneficial enzymes and bioactive substances [30,19,15]. By boosting dry matter intake, feed conversion efficiency, and body weight growth,

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hydroponic fodder particularly maize and barley improve animal performance [12,26]. Goats fed hydroponically grown barley fodder showed increased body weight gain, feed conversion efficiency, and total dry matter intake [12]. Hydroponic fodder's high moisture content and nutrient profile may increase microbial activity in the rumen, improving nutrient digestibility and live weight gain. With its many advantages for milk production and composition, hydroponic fodder has become a significant feed additive for dairy sheep [11,33].

Studies have repeatedly demonstrated that hydroponic fodder improves milk composition and yield, with improvements in milk production ranging from 3.9% to 16.5% [23,17,113]. Hydroponic feed's high protein, amino acid, and bioactive material content can improve ruminant digestion and absorption, resulting in increased milk output and quality [24]. This study aims to evaluate the effect of hydroponic barley on milk composition and body weight in Awassi ewes. Specifically, it seeks to assess how different levels of hydroponic barley feeding during the early postpartum period (15-60 days) impact body weight, milk yield, and composition in Awassi ewes at 15, 30, 45, and 60 days after giving birth.

Methods and Materials

This study was conducted at the University of Duhok's College of Agricultural Engineering Sciences, Animal Production project, in Duhok Province, over a period of 60 days postpartum.

Animals and Experimental Relationships

Eighteen Awassi ewes (2-3 years old) after parturition were divided into three groups of six ewes each to test varying percentages of HB in their diets. The ewes were housed in individual pens and fed according to AFRC [3] standards. Each group received a specific diet, as shown in Table 1, and the ewes were allowed to adapt to the new diet for one week before the start of the experiment.

Table 1. Chemical composition of concentrated diet.

Item %	Treatment 1	Treatment 2	Treatment 3
DM %	92	91	90
OM %	95	96	96
CP %	15.8	16	16.1
CF %	12	18	20
ME MJ/kg	12.82	12.3	12.1
MPG/kg	112	121	128

The diets were formulated to meet dry matter requirements, and their chemical composition, including dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), metabolizable energy (ME), and metabolizable protein (MP), was calculated according to [3].
T1: Control diet without hydroponic barley.
T2: Diet containing 50% hydroponic barley.
T3: Diet containing 100% hydroponic barley.
All diets consisted of a concentrate mixture supplemented with wheat straw as a roughage source. ME = 0.82 × DE. ME (MJ/kg DM) = 0.82 × DE (MJ/kg DM)
ME = Metabolizable Energy; DE = Digestible Energy. DE was estimated from the chemical

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composition of the diets using standard digestibility coefficients, and ME was calculated from DE using the AFRC [3] conversion factor.

Hydroponic Barley Production

Barley seeds were obtained from a local market, cleaned, and then soaked in water for (6-12) hours to initiate germination. The seeds were then transferred to a hydroponic tray within a greenhouse, where they received controlled lighting (55.6 W/m² light intensity) temperature (16-20°C) and humidity (65-70%) conditions to support optimal growth, with their roots developing in the hydroponic system. The hydroponic barley was harvested after approximately 8 days of growth, including both leaves and roots, and used as a nutritious feed source for the sheep [12].

Experimental Diets and Feeding Regimens

Three treatment groups participated in the experiment: (T1) Control, which was given a 50% concentrated barley diet and 0% HB, (T2) which was given a 25% concentrated barley diet and 50% HB, and (T3) which was given a 0% concentrated barley diet and 100% HB. For the duration of the trial, each group received a feeding schedule that satisfied their nutritional needs in accordance with AFRC (3) guidelines, with the specified % of HB included in each group's diet every day in two feedings (morning and evening).

Table 2. Diet Composition (% of dietary components)

Dietary components	Treatment 1 %	Treatment 2 %	Treatment 3 %
Barley seeds	50	25	0
Hydroponic barley*	0	50	100
Wheat bran	27	27	27
Soybean meal	13	12	11
Corn	10	11	12
Wheat Straw**	300 g	300 g	300 g

* Hydroponic barley was provided based on its dry matter content.

** Wheat straw was supplied to each animal at a fixed rate of 300g per head per day.

- T1 (Control): 50% Concentrate Barley, 50% Basal Diet

- T2: 25% Concentrate Barley, 50% HB, 25% Basal Diet

- T3: 0% Concentrate Barley, 100% HB

HB = Hydroponic Barley

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Estimates and Calculations

Ewes' milk samples were taken at 15, 30, 45, and 60 days after giving birth, up to two months during the lactation period. To facilitate milk letdown, an intramuscular oxytocin injection was administered. The samples were analyzed for fat content, protein content, lactose levels, salt, total solid and milk yield. Additionally, the body weights of the ewes were recorded weekly using an animal scale, starting from the day of experiment initiation.

Statistical Analysis

Statistical analysis was performed using GenStat 19th Edition (VSN International, Hemel Hempstead, UK). Data were analyzed using a repeated measure analysis of variance (ANOVA) to evaluate the effects of treatment and time. Mean differences were separated using Duncan's multiple range test, and statistical significance was declared at P<0.05. Results are presented as mean ± standard error (SE).

Results and discussion

Milk yield and its composition

The results of the present study demonstrated that incorporating HB into the diet of Awassi ewes had a notable influence on milk composition and production performance. Among the dietary treatments, the 50% HB group (T2) consistently showed superior outcomes compared to the control (0% HB; T1) and 100% HB (T3). As shown in Table 3, ewes receiving 50% HB produced milk with significantly higher fat and protein percentages (5.98 ± 0.26% and 4.45 ± 0.08%, respectively). The improved milk composition and yield in the 50% HB group can be attributed to the enhanced nutrient availability and utilization, as hydroponic barley is rich in degradable protein and total digestible nutrients [23]. The fiber content in hydroponic fodder also contributes to increased milk fat production through microbial fermentation [25]. These findings are consistent with previous reports indicating that sprouted or hydroponic grains can sustain or improve milk composition in dairy cattle [34,35]. Also 50% HB group had the highest total solid content (15.14%), significantly higher than the control group (12.82%) and 100% HB group (12.86%). Similarly, [20] reported an increase in TS content in sheep milk with hydroponic barley supplementation.

Table 3. milk composition of Awassi ewes fed different levels of hydroponic barely (Mean ±SEM)

Treatment	Fat %	Lactose %	Protein %	Salt %	Total solid %	Yield (gm)
Overall mean	4.85 ± 0.14	3.96 ± 0.06	4.21 ±0.06	0.59 ± 0.01	13.61	336.15 ± 15.04
0% HB	4.22 ± 0.10 b	3.89 ± 0.18 a	4.12 ± 0.10 b	0.60 ± 0.02a	12.82b	304 ± 22.84 a
50% HB	5.98 ± 0.26 a	4.13 ± 0.10 a	4.45 ± 0.08 a	0.58 ± 0.02 a	15.14a	387 ± 28.44 a
100% HB	4.36 ± 0.14 b	3.85 ± 0.10 a	4.05 ± 0.11 b	0.60 ± 0.03 a	12.86b	318 ± 24.32 a
P value	<.001	0.054	0.007	0.665	<.001	0.048

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HB. Hydroponic Barely. T1: Control diet (0% hydroponic barley).
T2: Diet containing 50% hydroponic barley.
T3: Diet containing 100% hydroponic barley.
Values are expressed as mean ± SEM. Different superscripts (a, b) within a column indicate significant differences ($P < 0.05$).

Although the difference in yield among treatments was not statistically significant, the 50% HB group produced the highest mean daily milk yield (387 ± 28.44 ml), followed by the control group (304 ± 22.84 ml) and the 100% HB group (318 ± 24.32 ml) **(**Figure 1**)**. This trend agrees with several studies that documented increased milk production following hydroponic barley feeding. Milk increases of 3.9% to 21% [13], 13.7% [23], and up to 16.5% [17], have been reported. The present results reinforce the notion that moderate inclusion of hydroponic barley specifically at the 50% level optimizes the nutrient balance needed for enhanced lactational performance.

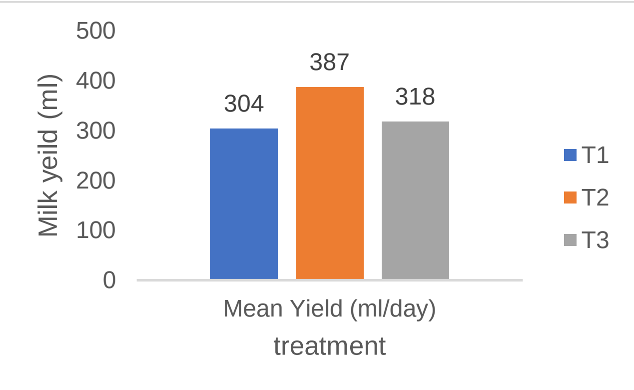

Figure 1. Effect of HB treatment on milk yield in Awassi ewes

The lactation curve (**Figure 2**) followed a typical pattern of early lactation rise followed by gradual decline. Peak milk production occurred at 15 days postpartum (396.11 ± 33.40 ml), after which output decreased to 356.94 ± 32.45 ml at 30 days, 318.89 ± 29.09 ml at 45 days, and 272.67 ± 16.46 ml at 60 days. The narrowing SEM at later stages indicates increasing uniformity among ewes as lactation progresses. Regardless of dietary treatment, all groups showed a similar decline pattern, reflecting the physiological trajectory of Awassi ewes. Analysis of the interaction between treatment and time showed no significant effects for fat ($P = 0.956$), lactose ($P = 0.083$), protein ($P = 0.542$), salt ($P = 0.665$), or milk yield ($P = 0.957$). This absence of interaction indicates that the influence of HB feeding was consistent over time and did not depend on the stage of lactation. Consequently, treatment effects can be reliably interpreted without considering temporal modification.

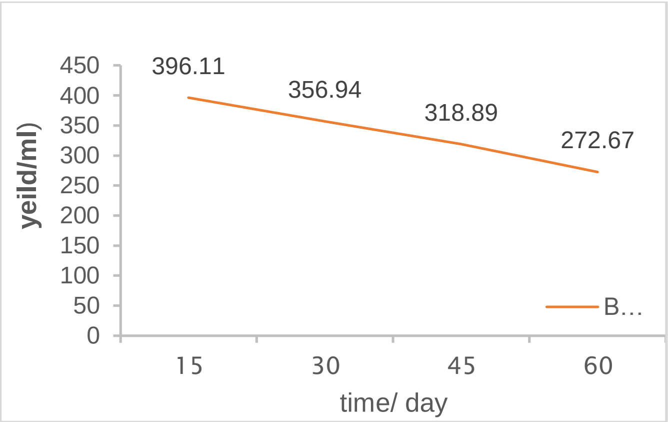

Figure 2. Milk Yield of Awassi Ewes Across Lactation Period

The overall findings suggest that feeding Awassi ewes with 50% hydroponic barley provides the optimal balance of nutrients necessary to improve both milk composition and production. This aligns with broader international observations on hydroponic fodder use. For instance, a 10.07% increase in milk yield was reported in cows fed green fodder [28]. Furthermore, Canadian dairy producers documented an average rise of 3.6 kg/day across the lactation period, and South African dairy farmers observed substantial production declines when hydroponic fodder was removed from the diet [22,31].

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Body weight

The effect of HB feeding on the body weight of Awassi ewes is shown in (Figure 3). Ewes in the control group (T1; 0% HB) had an average body weight of 49.65 ± 1.06 kg, while those fed 50% HB (T2) showed the highest mean weight (50.31 ± 1.06 kg). This indicates that moderate feeding with 50% HB supports optimal body weight and provides a nutrient balance comparable if not superior to the conventional diet. In contrast, ewes receiving 100% HB (T3) exhibited a significantly lower average weight (45.70 ± 1.24 kg; P = 0.002), suggesting that full replacement of the basal diet with hydroponic barley may negatively affect nutrient intake, digestibility, or overall energy availability.

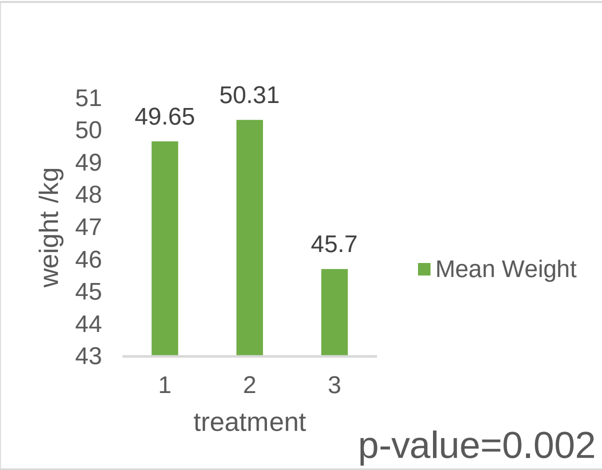

Figure 3. Effect of different level of hydroponic barely on the Awassi ewes body weight

These findings are consistent with several previous studies reporting reduced growth or feed intake at high levels of hydroponic maize or barley [2,11, 27,35]. Excessive inclusion of hydroponic fodder can dilute dietary dry matter due to its high moisture content, limiting effective energy and nutrient intake. However, the superior body weight in the 50% HB group reflects the well-documented nutritional advantages of hydroponic fodder, including high levels of soluble protein, vitamins (A, B, C), amino acids, enzymes, and crude lipids. These components enhance rumen microbial activity and nutrient utilization, supporting better growth performance [10,5,14]. Supporting this trend reported higher body weight gain in goat kids fed maize and barley, demonstrating the growth enhancing potential of hydroponic fodder when fed at moderate levels. [1,21,6].

Table 4: Changes in Body Weight of Awassi Ewes During the lactation Period.

Period /week	Body weight (Mean ± SEM, kg)	P-value
1	58.53 ± 1.76	a
2	52.71 ± 1.62	ab
3	49.36 ± 1.39	bc
4	48.14 ± 1.54	bc
5	46.10 ± 1.48	bc
6	44.91 ± 1.52	c
7	44.39 ± 1.60	c
8	44.30 ± 1.68	c
P value	<0.001	–

Values are expressed as mean ± SEM. Different superscripts (a, b, c) indicate significant differences between weeks (P < 0.05).

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Body weights were measured weekly for Awassi ewes under the experimental treatments:
T1: Control diet (0% hydroponic barley),
T2: Diet containing 50% hydroponic barley,
T3: Diet containing 100% hydroponic barley.

Table 4, shows the body weight of lactating Awassi ewes dropped significantly ($P < 0.001$) over the 8-week lactation period, starting at 58.53 ± 1.76 kg in Week 1 and decreasing to 44.30 ± 1.68 kg by Week 8. This decline is a normal response to the high energy demands of milk production, where the ewes mobilize their body reserves to compensate for the energy deficit a common phenomenon in lactating ruminants [23,7]. Interestingly, the ewes seemed to adapt to the demands of lactation, as their body weight started to stabilize from Week 6 onwards, indicating a better energy balance. This aligns with findings from [18], who showed that providing adequate dietary energy during pregnancy and lactation can support ewe growth and reduce excessive weight loss. The treatment × time interaction showed that the effect of HB supplementation on body weight depended on the stage of lactation. The 50% HB group (T2) maintained consistently higher weights throughout most of the 8-week period, demonstrating better resilience to lactation-related energy stress. In contrast, the 100% HB group (T3) experienced a pronounced decline, particularly after mid-lactation, suggesting insufficient nutrient density or lower dry matter intake when HB was offered as the sole feed source. The 0% HB group (T1) showed a moderate decline, performing better than 100% HB but not as well as the 50% HB treatment.

Conclusion

The study found that incorporating 50% hydroponic barley into the diet of lactating Awassi ewes produced the best results. This level of feeding improved milk composition, increasing fat, protein percentages and the highest total solid content, and supported higher milk yield without negatively impacting lactose or salt content. Additionally, 50% HB supplementation maintained optimal body weight throughout lactation, suggesting improved nutrient utilization and metabolic stability during periods of high energy demand. In contrast, replacing the entire diet with hydroponic barley (100% HB) had a negative effect on body weight, likely due to reduced dry matter intake and nutrient imbalance.

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