



EVALUATION OF VARIOUS LEVELS OF DIETARY GUAR (*CYAMOPSIS TETRAGONOLOBA*) MEAL ON GROWTH, NITROGEN BALANCE AND PROTEIN UTILIZATION, AMINO ACIDS AND SERUM BIOCHEMICAL PARAMETERS IN GROWING GOATS

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Abstract. This study evaluated the various levels of guar meal on growth, nitrogen balance, plasma amino acids, and blood biochemistry in goats. Sixty goats (7–9 months old, average initial weight 15.28 kg) were divided into four groups. T0 received 0% guar meal (control), while T1, T2, and T3 received 5%, 10%, and 15% guar meal, respectively, for 90 days. Final body weight increased from 23.54 kg in T0 to 25.78 kg in T3. Average daily gain also rose from 68.83 g/day in T0 to 87.5 g/day in T3. Dry matter intake remained unchanged across all groups. Protein efficiency ratio was highest in T1 (1.61) and lowest in T3 (1.14). Nitrogen intake increased with guar meal level, while fecal nitrogen decreased from 5.9 g/day in T0 to 3.9 g/day in T3. Urinary nitrogen first dropped, then rose to 5.9 g/day in T3. Nitrogen retention improved from 41.6% in T0 to 61.7% in T3. Apparent protein digestibility, biological value, and net protein utilization all increased with higher guar meal. However, all plasma amino acids (lysine, methionine, threonine, leucine, valine) decreased as guar meal increased, and globulin dropped at higher levels. Serum total protein and albumin dropped, while blood urea nitrogen increased at higher levels. In conclusion, guar meal at 5% improved protein efficiency, but levels above 10% reduced amino acid availability and altered blood biochemical indicators. Moderate inclusion of guar meal is recommended for growing goats.

Keywords: Guar meal, amino acid profile, growth, livestock

Introduction

Goats are important in the livestock sector due to their valuable traits and contribute to meat, milk, and fiber production (Dubeuf et al., 2023). It can thrive in harsh arid conditions and play an important role in the agricultural sectors of many developing countries (Ahmed et al., 2022). Goats are the oldest

domesticated animals that tolerate heat stress and survive on low-quality fodder (Silanikove, 2000; Parsad et al., 2025). It possesses a larger capacity for feeding on tree leaves and crop residues and is also regarded as a source of income (Liu et al., 2008). It also has a higher reproductive rate and provides animal protein to people (Zhu et al., 2020). Protein is important for development and is a critical nutrient in goats, directly affecting weight gain and body composition (Sahlu et al., 2004; Carmichael et al., 2012). In goats, it is also involved in enhancing muscle development and immune function (Wu, 2009; Huang et al., 2016).

The cottonseed cake, canola meal, sunflower meal, and soybean meal as a protein source can be used in the nutrition of goats (Silva et al., 2015). Sunflower meal is extensively used because it is cheaper than other nutrients for goats. However, it has limitations due to the imbalanced amino acids and high fiber content, which directly affect the growth of goats (Boudalia et al., 2024).

Sunflower meal contained a very low quantity of lysine used as an essential amino acid for goats (Cao et al., 2021). Rising prices of dietary nutrient components have made goat production less profitable, and an alternative to these conventional protein supplements is guar meal, which is recognized as a cost-effective protein source for livestock (Salem, 2010; Al Sulivany et al., 2024). Guar (*Cyamopsis tetragonoloba*) contains about 30 to 35 percent crude protein and is mainly cultivated in various regions and considered an essential source of protein for ruminants (Sher et al., 2022). It is a leguminous crop cultivated for its gum (Prajapati et al., 2013). After the removal of the gum from their seeds then residual seed meal is known as guar meal (Boudalia et al., 2024). Guar meal can be used in the animal's diet and can replace other protein sources without any bad effect on the animals. Goats have a larger capacity for employing high-fiber feeds and bear anti-nutritional factors (Monteiro et al., 2017).

Guar meal residual contains cluster bean secretion, which is a galactomannan polysaccharide that enhances the stickiness of digesta in the small intestine (Hindrichsen et al., 2004; Hafeez et al., 2026). It can decrease the absorption of nutrients and amino acids (Kotnala et al., 2024). Moreover, guar meal comprises inhibitors and anti-nutritional factors, which help in protein digestion (Salim et al., 2023). However, ruminants can tolerate these factors due to the bacteriological activity in the rumen (Monteiro et al., 2017; Parsad et al., 2025). The essential amino acids are mainly vital for growing animals, protein synthesis, and also play a role in antioxidant defense (Mazinani et al., 2022). Amino acids are also important for mucus production and gut health in muscles (Huang et al., 2016; Khan et al., 2024). It provides an indication of protein eminence and the tolerability of amino acid sources from the diet (Gao et al., 2024). Biological value is the indicator of protein quality, with a high biological value indicating improved essential amino acid balance, while net protein utilization provides a complete picture of protein value (Adhikari et al., 2022). Growth performance is also a direct indicator of feed utilization; it can be influenced by both the quantity and quality of protein in the diet (Belloir et al., 2017).

Blood biochemical characteristics are also indicators of protein absorption and health in animals (Cortese et al., 2019; Shafiq et al., 2025). Serum total protein concentration represented the protein status in the animal, while albumin described the nutritional protein status (Eckart et al., 2020). Moreover, the low serum albumin designates a protein deficiency. Globulins are involved in the

immune response, while the albumin-to-globulin ratio reflects the balance between nutritive and immune proteins (Ye et al., 2020). Blood urea nitrogen is considered a part of protein catabolism; a high level indicates poor protein utilization, while a low BUN level indicates insufficient protein intake (Gao et al., 2022). Therefore, the current study evaluated the effect of guar meal on the growth, plasma amino acid profile, biological value of protein, and blood biochemical parameters in goats.

Materials and Methods

Experimental Site and Animals

This study determined the effect of guar meal (*C. tetragonoloba*) on growth, nitrogen balance, amino acids, and serum biochemical parameters in goats. Sixty goats were taken and transferred to the special farm in Qushtapa, Erbil, Iraq. All the goats had an average initial weight of 15.28 ± 0.31 and an age of 7 to 9 months. Upon arrival, all animals were examined to ensure their health and found healthy with no infectious disease or abnormalities. A controlled environment with proper ventilation, drainage, and hygiene was provided during the whole study. Environmental parameters, such as temperature, were maintained between 23 and 26°C. The relative humidity (Hygrometer, EISCO, UK) ranged from 54–66%, and 12 h light and 12 h dark (44) was maintained. During the whole study, clean and dry bedding material was provided and replaced frequently, and water was provided ad libitum through individual automatic waterers.

Housing and Feeding Management

All goats were kept separately in metabolism cages (1.6 m × 2.1 m) equipped with separate feed racks and water nipples. Each cage had a slatted floor for the gathering of feces and urine. Before the start of the study, all the goats were acclimatized to individual housing and experimental diets for 14 days. During the collection period for nitrogen balance, goats were shifted to metabolism crates (1.2 m × 1.8 m) that were fitted with fecal collection trays and urine collection vessels, which comprised 10% sulfuric acid to prevent nitrogen loss. Feed was given daily individually and feed intake and feed refusals were recorded per animal.

Study Design and Diet Preparation

Four dietary groups were designed in triplicate, such as T0, known as the control group, which was treated with the basal diet. Other groups, such as the T1, T2, and T3 groups, which contained 5%, 10%, and 15% guar meal, respectively. All sixty goats were distributed into four groups, and each of the triplicate groups contained 5 goats. This study lasted up to 90 days, and feed was given to groups twice daily. All the diets were formulated; the feed constituents were purchased from the local markets. All the ingredients were weighed by a digital balance and mixed for each group. The graded levels of guar meal were added to each diet. Moreover, the basal diet contained energy and protein-rich feed ingredients with balanced nutrition (Meli et al., 2023). The prepared feed was then stored in dry and ventilated containers (Table 1).

Table 1. Composition of experimental diets (g/kg) for goats

Ingredient (g/kg)	T0 (0% GM)	T1 (5% GM)	T2 (10% GM)	T3 (15% GM)
Wheat straw	400	400	400	400
Sunflower meal	200	150	100	50
Guar meal	0	50	100	150
Maize grain	270	270	270	270
Wheat bran	100	100	100	100
Molasses	19	19	19	19
Urea	6	6	6	6
Mineral mixture	3	3	3	3
Common salt	2	2	2	2
Total	1000	1000	1000	1000

Measurement of growth parameters

After the end of the study, the goats were kept under fasting for up to 10 hours to ensure the accuracy of the growth measurements. Final weights were measured by a weighing scale (Kern & Sohn, model: HCB 100K100, Germany). Dry matter intake (DMI) was calculated by recording the refusals and the amount of feed offered daily. Dry matter in the feed was assessed by drying samples at 105°C in an oven for 24 hours. Average daily gain (ADG), Total body weight gain (BWG), Feed conversion ratio (FCR), and Protein efficiency ratio (PER) were calculated as studied by Huang et al. (2024) and Owais et al. (2025).

Body Weight Gain (BWG)= BWG=FW-IW

ADG (g/day) = (Total body weight gain (kg) × 1000) / Number of experimental days (90 days)

DMI (g/day) = (Feed offered – Feed refused) × Dry matter percentage

FCR = feed given (g)/ Weight gain (g)

PER = Average daily gain (g/day) / Daily crude protein intake (g/day)

Nitrogen Balance and Protein Utilization

For the determination of nitrogen balance and protein utilization, the goats were kept in separate cages after the feeding trial. The feces and urine were collected, and the feed intake, feed refusals, fecal output, and urine excretion were measured daily during the collection period. Urine samples were kept up with sulfuric acid to avoid nitrogen damage through ammonia volatilization. Nitrogen content in feed, feces, and urine was determined using the Kjeldahl method. Nitrogen intake, fecal nitrogen, urinary nitrogen, nitrogen retention, nitrogen retention percentage, apparent protein gain (APG), biological value (BV), and net protein utilization (NPU) were calculated as studied by Chanjula et al. (2022).

Nitrogen intake (g/day) = Feed nitrogen × DMI

Fecal nitrogen (g/day) = Fecal nitrogen × fecal output

Urinary nitrogen (g/day) = Urinary nitrogen $\times$ urine output

Nitrogen retained (g/day) = N intake – (Fecal N + Urinary N)

Nitrogen retention (%) = (N retained / N intake) $\times$ 100

Apparent protein digestibility (%) = [(N intake – Fecal N) / N intake] $\times$ 100

BV (%) = [N retained / (N intake – Fecal N)] $\times$ 100

NPU (%) = (N retained / N intake) $\times$ 100

Plasma Amino Acid Analysis

At the end of the study, 10 ml of blood was taken from the jugular vein of the goats and was kept in heparinized tubes, then it was centrifuged at 3000 rpm for 15 minutes, and the plasma was then deposited at -20°C in labeled Eppendorf tubes until analysis. From the plasma, the protein was removed by mixing with sulfosalicylic acid and then centrifuging again. Clear liquid that contained free amino acids was mixed with a derivatizing reagent called OPA. The entire mixture was then injected into a high-performance liquid chromatography (HPLC) system associated with a fluorescence indicator and a C18 column. It separated the amino acids Lysine, methionine, threonine, leucine, and valine, which were recognized by associating their holding times with standard solutions. The concentration of each amino acid was calculated, and the process followed the method described by Shilwant et al. (2023).

Serum Biochemical Analysis

Blood samples were collected three times, firstly at the start of the study, secondly at mid-study (day 45), and thirdly at the end of the experiment (day 90). 10 ml of blood was also collected for serum biochemical analysis, and it was drawn into sterile tubes without any anticoagulant for serum separation. The blood in the tubes was centrifuged at 3000 rpm for 15 minutes and serum was collected with a micropipette and transported to Eppendorf tubes, then stored at -20°C until analysis. The Biuret method was used for the assessment of serum total protein; in this process, the purple color is formed, and its intensity was read at 540 nm using a semi-auto analyzer (Model: Microlab 300, Merck, Germany). The bromocresol green method was applied to serum albumin. In this technique, the albumin binds with green dye bromocresol to give a green color, and its absorbance is read at 628 nm. Blood urea nitrogen was assessed by the Urease-Berthelot method, in which Berthelot reagent and blue color are formed. Its absorbance was read at 580 nm. Serum globulin and albumin-to-globulin ratio was then calculated by following the formulas as described by Elgioushy et al. (2025).

Globulin = Total protein – Albumin

A: G Ratio = Albumin /Globulin

Variations in each parameter over time (Δ values) were calculated as: Δ = Value at day 90 – Value at day 0.

Statistical Analysis

Data were evaluated using a completely randomized design with the statistical model: $Y_{ij} = \mu + T_i + \epsilon_{ij}$, where T_i = fixed effect of treatment (0, 5, 10, 15% GM) and ϵ_{ij} = random error. The experimental unit was the individual goat for growth parameters ($n = 15/\text{treatment}$) and the pen for nitrogen balance ($n = 3/\text{treatment}$). One-way ANOVA using SPSS 26.0, R 4.2.1, and Tukey's HSD post-

hoc test was used for analysis of the data. Normality and homogeneity were also checked by Shapiro-Wilk and Levene's tests, respectively.

Results and Discussion

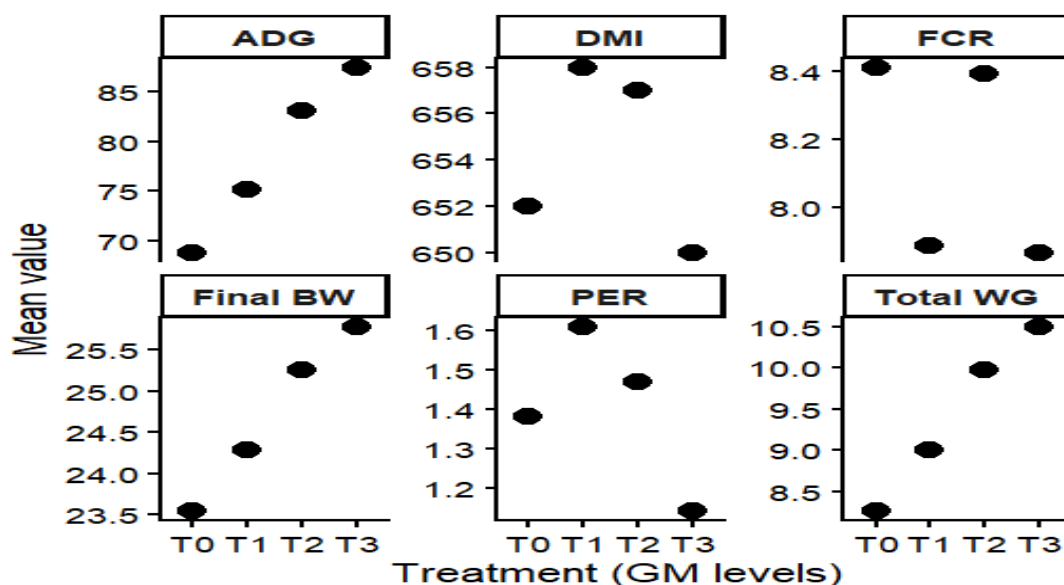
This study examined the effects of different levels of *C. tetragonoloba* on local goats in Qushtapa, including their effects on growth, essential amino acid profiles, and blood biochemical parameters.

The growth of the local goats was increased gradually with higher concentrations of guar meal. FWG increased in T3 (25.78 ± 0.31 kg), while the significantly ($p=0.004$) lowermost was observed in T0 (23.54 ± 0.24 kg) and T1, and T2 showed intermediate values. Total weight gain was also significantly ($p=0.003$) increased in T3 (10.5 ± 0.51 kg), while T0 showed 8.26 ± 0.17 kg, and T1 and T2 TWG were found between these values. Similarly, average daily gain followed an increasing trend, with T3 showing 87.5 ± 1.16 g/day, which was 27.1% higher ADG compared to the control (68.83 ± 1.33 g/day). The DMI did not change significantly ($p=0.134$) across treatments. The FCR in T1 (7.89 ± 0.81) and T3 (7.87 ± 0.16) was enhanced. FCR showed nearly similar results in T0 and T2 ($p=0.003$). PER was maximum in T1 (1.61 ± 0.03), and it was lowest in T3 (1.14 ± 0.03), while T2 and T0 recorded significantly ($p=0.002$) (Table 2, Figure 1).

This study demonstrated that guar meal is a substitute protein source; its moderate level enhanced growth and protein consumption, while the high level hurt amino acid and biochemical characteristics. This study observed improved growth with higher levels of guar meal supplementation, including significantly higher FBW, TWG, and ADG in goats receiving higher guar meal supplementation. Aruwayo et al. (2024) documented higher growth with groundnut cake in goats due to high crude protein content, which increases ruminal fermentation and nutrient consumption. Alcaide et al. (2003) conducted a study on Sunflower meal in goats and reported improvement in microbial protein fermentation in the rumen, which causes greater nutrient accessibility and tissue development due to higher amino acid absorption and protein deposition, resulting in better growth performance and body weight gain. Similar findings were also reported by Shweta et al. (2025), who recorded improved BWG and feed efficacy in goats with the guar meal diet, due to improved nutrient digestibility and protein consumption. Rufino et al. (2013) reported the influence on growth in small ruminants with the soybean meal diet, because of its high-quality protein and balanced amino acid profile. Coleman et al. (2010) reported no significant change in the dry matter intake, with no effect on feed intake, as the dietary treatment did not affect feed palatability or voluntary intake. Lokaewmanee et al. (2023) also documented better nutrient utilization efficiency in goats with the increased average daily gain and PER, owing to enhanced nutrient absorption and protein metabolism. Vidya et al. (2022) recorded improvement in FCR and weight gain with the supplementation of guar meal in small ruminants, due to improved feed conversion efficiency and nutrient digestibility. This study observed variable responses of PER and concluded a moderate level of guar meal effectiveness in protein utilization. These findings agreed with the findings of Zare et al. (2023), who reported the moderate response of PER with the moderate protein supplementation, because an optimum protein level supports efficient utilization without excessive nitrogen losses.

Table 2. Growth on various graded levels of guar meal in local goats

Parameter	T0 (0% GM)	T1 (5% GM)	T2 (10% GM)	T3 (15% GM)	P-value
Final body weight (kg)	23.54±0.24b	24.28±0.17a	25.26±0.23ab	25.78±0.31c	0.004
Total weight gain (kg)	8.26±0.17b	9.0±0.12a	9.98±0.16ab	10.5±0.51	0.003
Average daily gain (g/day)	68.83±1.33b	75.2±1.07a	83.16±1.43ab	87.5±1.16c	0.001
Dry matter intake (g/day)	652±7.4	658±6.9	657±8.1	650±6.8	0.134
Feed conversion ratio (FCR)	8.41±0.17b	7.89±0.81a	8.39±0.31ab	7.87±0.16c	0.003
Protein efficiency ratio (PER)	1.38±0.05b	1.61±0.03a	1.47±0.03ab	1.14±0.03c	0.002

**Figure 1.** Growth on various graded levels of guar meal in goats

This study reported nitrogen balance and protein utilization parameters and found that nitrogen intake increased from 15.9 ± 0.12 g/day in the control group (T0) to 17.6 ± 0.20 g/day in T3. This increase was due to the higher protein content of the guar meal compared with the control group diet (Table 3, Figure 2). Fecal nitrogen decreased across the groups: 5.9 ± 0.13 g/day in T0, 4.4 ± 0.14 g/day in T1, and reached the lowest value of 3.9 ± 0.13 g/day in T3. This may be due to higher protein digestibility in the guar meal diet compared with the control group. Urinary nitrogen was 4.7 ± 0.21 g/day in T0 and decreased to 4.1 ± 0.05 g/day in T1, indicating a decrease in protein absorption, which influences growth. However, it increased and reached 5.9 ± 0.31 g/day in T3. It was described that in T3, more protein is absorbed than is used for growth, but the extra nitrogen is excreted as urea. Nitrogen retained in the body increases with increasing guar meal. It was 6.9 ± 0.13 g/day in T0 and reached the highest level of 8.4 ± 0.13 g/day in T3. Nitrogen retention percentage increased from $41.6 \pm 0.76\%$ in T0 to $61.7 \pm$

0.87% in T3. It means that with an increase in guar meal, a large volume of nitrogen remains inside the body instead of being wasted. Apparent protein digestibility also increases with the increase in guar meal. It was $70.1 \pm 0.68\%$ in T0 and reached $81.0 \pm 0.68\%$ in T3. It is designated that the guar meal protein is more, and goats digest the protein in a better way. Biological value enhanced from $57.6 \pm 0.87\%$ in T0 to $66.3 \pm 0.78\%$ in T3, which also indicated the absorbed protein usage in the body. It was described that with the increase in guar meal, its usage increased significantly. NPU increased from $41.2 \pm 1.03\%$ in T0 to $59.3 \pm 0.76\%$ in T3 as it naturally increased with the increased of digestibility and biological value.

This study recorded positive effect on nitrogen intake with the guar meal. Similarly, Agwa et al. (2023) recorded increased nitrogen intake with the supplementation of Canola meal in the goat, due to its higher crude protein content and improved nitrogen supply. The reduction in fecal nitrogen in this study indicated better digestibility and absorption of dietary protein. This finding is similar to the outcomes of Alobre et al. (2025), who reported decreased fecal nitrogen in sheep with the supplementation of Sunflower meal, because of enhanced protein digestibility and nutrient absorption. Hussein et al. (2025) documented improved nitrogen digestibility with the high-protein diet, due to greater ruminal protein degradation and utilization. This study observed higher nitrogen retention and nitrogen retention percentage with the higher guar meal. Ali et al. (2025) described the better utilization of absorbed nitrogen for tissue synthesis and growth due to increased nitrogen retention and nitrogen retention percentage, as more absorbed nitrogen was retained for muscle protein synthesis. Te Pas et al. (2021) demonstrated the higher biological value and net protein utilization in cows with the guar meal, due to more efficient utilization of absorbed amino acids. Similarly, Zurak et al. (2023) found higher biological value and net protein utilization with the protein-rich diets in goats, because of improved protein quality and amino acid availability. APG and NPU in the cow increased with higher protein level supplementation (Amanlou et al., 2017), due to enhanced digestibility and efficient nitrogen utilization. Eckart et al. (2020) also reported higher APG and NPU in the camel with the increased protein source diet, due to improved protein digestion and metabolic utilization.

Table 3. Nitrogen balance and protein utilization parameters on various graded levels of guar meal in local goats

Parameter	T0 (0% GM)	T1 (5% GM)	T2 (10% GM)	T3 (15% GM)	p-value
Nitrogen intake (g/day)	15.9± 0.12	16.8±0.18	17.1± 0.11	17.6± 0.20	0.008
Fecal nitrogen (g/day)	5.9±0.13a	4.4±0.14b	4.2±0.13ab	3.9±0.13a	0.004
Urinary nitrogen (g/day)	4.7±0.21a	4.1±0.05b	4.5±0.42ab	5.9±0.31a	0.005
Nitrogen retained (g/day)	6.9±0.13b	7.8± 0.13a	8.2± 0.16ab	8.4± 0.13c	0.003
Nitrogen retention (%)	41.6±0.76 b	53.4±0.47 a	59.3± 1.03ab	61.7± 0.87c	0.003

Apparent Protein Digestibility (%)	70.1±0.68 b	75.6±0.69 a	78.7±0.76a b	81±0.68c	0.007
Biological Value (%)	57.6±0.87 b	63.2±0.75 a	64.3±1.07ab	66.3±0.78 c	0.006
Net Protein Utilization (%)	41.2±1.03 b	51.3±0.86 a	55.3±1.66a b	59.3±0.76 c	0.004

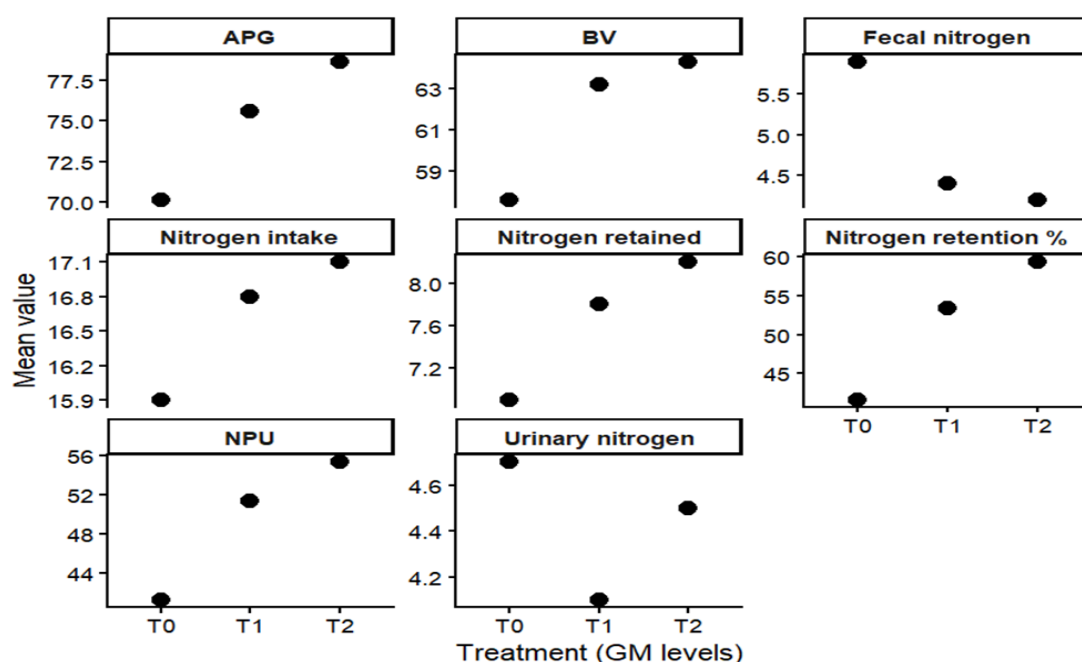


Figure 2. Nitrogen balance and protein utilization parameters on various graded levels of guar meal in goats

Table 4, Figure 3 shows the outcome of graded levels of GM on the amino acids in goats, and it indicates the significant influence on essential amino acids in all the groups. T0 (0% GM) showed the highest amino acid values, which indicated better amino acid retention in the control group. The highest lysine concentration was 27.3 ± 0.65 in T0, then it decreased in T1 (25.3 ± 0.61) and reached the lowest level in T3 (19.6 ± 0.53). Similarly, methionine also decreased from 6.1 ± 0.71 in T0 to 5.1 ± 0.41 in T3, which demonstrated that lower methionine levels were associated with higher GM levels. Threonine was also observed higher (19.7 ± 0.31) in the control group, while T2 (17.51 ± 0.31) showed a decrease with the increase of GM levels. The lowest threonine concentration was observed in T3 (15.3 ± 0.98), which shows the poor effect of higher GM. Leucine showed the maximum value of 33.3 ± 1.41 in T0, then it also increasingly decreased in T2 (28.6 ± 1.31), while T3 recorded the lowest level (24.3 ± 1.06). Valine also followed the same decreasing form, which was significantly reduced from 25.7 ± 0.56 in T0 to 20.6 ± 0.78 in T2 and 18.7 ± 0.61 in T3. These results demonstrated the negative effect on the amino acid level with the increase in guar meal level.

This study demonstrated the contracting response of amino acids with the guar meal supplementation. Lysine, methionine, threonine, leucine, and valine declined increasingly with the higher guar meal level. Similarly, Arif et al. (2023) documented the decline in essential amino acids with wheat grain in goats, due to increased amino acid utilization for tissue protein synthesis. Moreover, Shwerab et al. (2015) also studied the guar meal in goats and recorded decreased level of

amino acids, because of enhanced metabolic utilization of absorbed amino acids. Kholif et al. (2018) studied unconventional protein sources in the goats and recorded low levels of amino acids in the serum, due to greater incorporation of amino acids into body proteins. Prieto et al. (2000) also examined the increased dietary protein in animals and observed variations in amino acids and increased amino acid catabolism in the goats, due to excess dietary protein promoting amino acid degradation and nitrogen metabolism.

Table 4. Amino acid concentrations on various graded levels of guar meal in local goats

Amino Acid	T0 (0% GM)	T1 (5% GM)	T2 (10% GM)	T3 (15% GM)	P-value
Lysine	27.3±0.65a	25.3±0.61b	23.4±1.04bc	19.6±0.53c	0.006
Methionine	6.1±0.71a	5.6±0.21ab	5.4±0.32b	5.1±0.41b	0.005
Threonine	19.7±0.31a	18.21±0.52b	17.51±0.31b	15.3±0.98c	0.007
Leucine	33.3±1.41a	30.4±0.71b	28.6±1.31b	24.3±1.06c	0.005
Valine	25.7±0.56a	23.3±0.72b	20.6±0.78c	18.7±0.61d	0.006

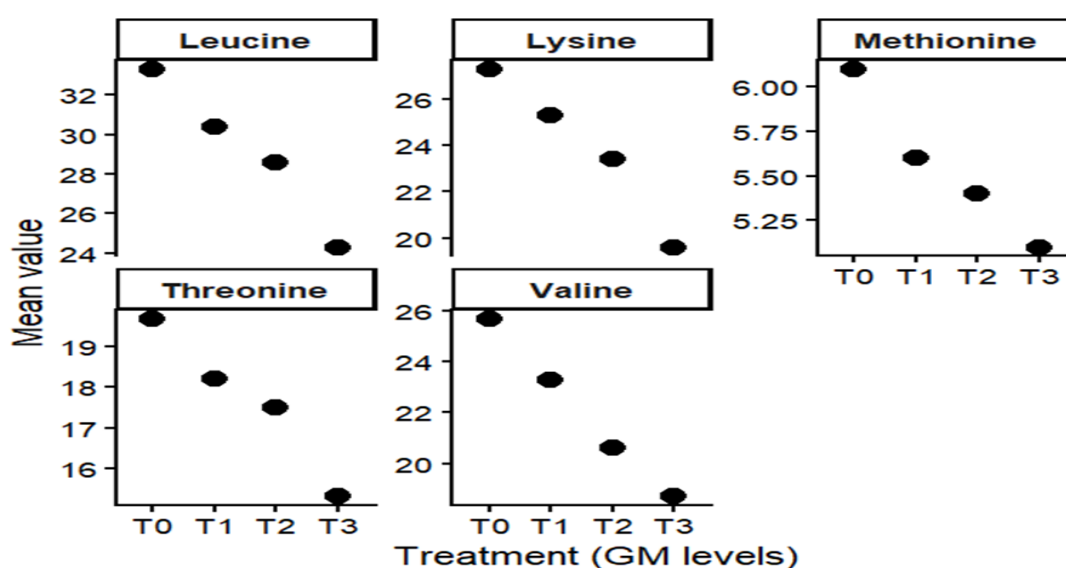


Figure 3. Amino acid concentrations on various graded levels of guar meal in goats

This study on serum biochemical parameters also recorded significant variation in the increasing level of guar meal. Serum total protein decreased with the increasing level of GM, and it was highest in the control group T0 (7.6±0.13 g/dL), while the lowest concentration was observed in T3 (5.6±0.21 g/dL). Similarly, the serum albumin level was also reduced from 4.2±0.04 g/dL in T0 to 3.1±0.05 g/dL in T3. In contrast, serum globulin displayed 3.4±0.07 g/dL in T0, whereas the lowest value was observed in T3 (2.5±0.07 g/dL). Subsequently, the albumin:globulin ratio changed with the higher GM levels; it was 1.23±0.03 in T0, while it was maximum (1.39±0.06) in T2. Blood urea nitrogen also increased from 13.3±0.67 mg/dL in T0 to 23.7±0.62 mg/dL in T3, which described the changed nitrogen metabolism at higher GM levels (Table 5, Figure 4).

The current study also recorded significant changes in serum biochemical parameters with the guar meal. The level of serum total protein and albumin was reduced in this study with the GM. Similarly, Dubeuf et al. (2023) recorded decreased total protein and albumin with the dietary protein in goats, due to increased utilization of circulating proteins for tissue synthesis. Serum globulin and urea nitrogen in the present study increased with the higher level of GM. Manat et al. (2016) described an elevated level of serum globulin and urea nitrogen with higher protein in goats and found that it increases the metabolic activity, because of enhanced protein metabolism and nitrogen turnover. Similarly, Gupta et al. (2018) reported higher urea nitrogen and serum globulin with the soybean meal diet in goats, due to greater dietary protein degradation and immune protein synthesis. This study also recorded a lower level of albumin: globulin ratio with the higher guar meal. This is also agreed with the study of Piccione et al. (2014), who also recorded a decreased A:G ratio in goats with the higher dietary protein level, due to relatively higher globulin production than albumin synthesis.

Table 5. Serum Biochemical Analysis on various graded levels of guar meal in local goats

Parameter	T0 (0% GM)	T1 (5% GM)	T2 (10% GM)	T3 (15% GM)	P-value
Serum total protein (g/dL)	7.6±0.13a	6.8±0.07ab	6.2±0.13b	5.6±0.21c	0.006
Serum albumin (g/dL)	4.2±0.04a	3.9±0.06ab	3.61±0.03b	3.1±0.05c	0.005
Serum globulin (g/dL)	3.4±0.07c	2.9±0.06c	2.59±0.06b	2.5±0.07a	0.004
Albumin:Globulin ratio	1.23±0.03a	1.34±0.06a	1.39±0.06b	1.24±0.03c	0.006
Blood urea nitrogen (mg/dL)	13.3±0.67c	15.9±0.65bc	17.43±0.34b	23.7±0.62a	0.007

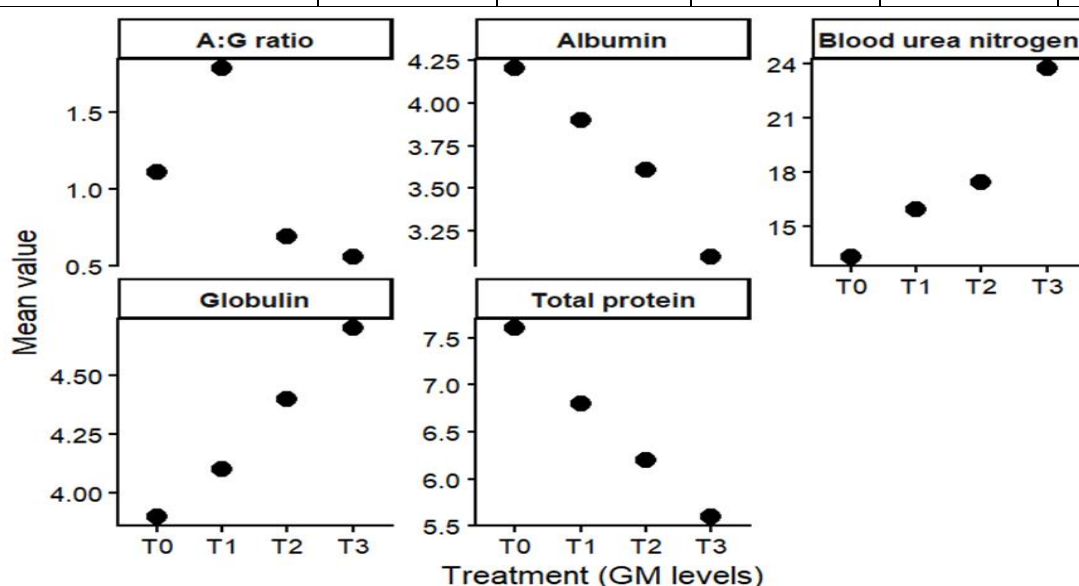


Figure 4. Serum biochemical parameters on various graded levels of guar meal in goats

Conclusion

This study concluded that guar meal at a moderate level improved growth and nutrient utilization without causing lethal changes in amino acid profile and serum biochemical parameters in goats. However, a higher level negatively affected the essential amino acid, as evidenced by changes in blood biochemical indicators. Therefore, moderate guar meal is suggested for better growth and protein utilization in goats.

Author Contributions

Author 1: methodology; Author 2: writing original draft preparation; Author 3: Statistical data preparation; Author 4 and 5: proofreading and helping in making the final draft.

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Ethical approval

The study design and experimental procedures were approved by the ethical approval committee of Tikrit University with the code AGTU00001

Informed Consent Statement

No Informed Consent Statement.

Conflicts of Interest

No conflict of interest.

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References

- Adhikari, S., Schop, M., de Boer, I.J., & Huppertz, T. (2022). Protein quality in perspective: A review of protein quality metrics and their applications. *Nutrients*, 14(5): 947. <https://doi.org/10.3390/nu14050947>
- Agwa, H.M., Saleh, H.M., Ayyat, M.S., & Abdel-Rahman, G.A. (2023). Effect of replacing cottonseed meal with canola meal on growth performance, blood metabolites, thyroid function, and ruminal parameters of growing lambs. *Tropical Animal Health and Production*, 55(2): 122. <https://doi.org/10.1007/s11250-023-03532-0>
- Ahmed, M., Hayat, R., Ahmad, M., Ul-Hassan, M., Kheir, A.M., Ul-Hassan, F., & Ahmad, S. (2022). Impact of climate change on dryland agricultural systems: A review of current status, potentials, and further work need. *International Journal of Plant Production*, 16(3): 341–363. <https://doi.org/10.1007/s42106-022-00190-5>
- Al Sulivany, B. S., Owais, M., Fazal, R. M., Asad, F., Hussein, N. J., & Selamoglu, Z. (2024). Seasonal effects of protein levels on common carp (*Cyprinus carpio*) body composition. *Iraqi journal of aquaculture*, 21(2), 111.
- Alcaide, E.M., Ruiz, D.Y., Moumen, A., & García, A.M. (2003). Ruminal degradability and *in vitro* intestinal digestibility of sunflower meal and *in vitro* digestibility

- of olive by-products supplemented with urea or sunflower meal: Comparison between goats and sheep. *Animal Feed Science and Technology*, 110(1–4): 3–15. [https://doi.org/10.1016/S0377-8401\(03\)00200-1](https://doi.org/10.1016/S0377-8401(03)00200-1)
- Ali, A., Jabeen, N., Farruhbek, R., Chachar, Z., Laghari, A.A., Chachar, S., & Yang, Z. (2025). Enhancing nitrogen use efficiency in agriculture by integrating agronomic practices and genetic advances. *Frontiers in Plant Science*, 16: 1543714. <https://doi.org/10.3389/fpls.2025.1543714>
- Alobre, M.M., Alhidary, I.A., Qaid, M.M., Alharthi, A.S., Aboragah, A.A., Aljumaah, R.S., & Abdelrahman, M.M. (2025). Effects of dietary sunflower hulls on performance and rumen fermentation of pregnant Naemi ewes: A sustainable fiber source for arid regions. *Animals*, 15(24): 3569. <https://doi.org/10.3390/ani15243569>
- Amanlou, H., Farahani, T.A., & Farsuni, N.E. (2017). Effects of rumen undegradable protein supplementation on productive performance and indicators of protein and energy metabolism in Holstein fresh cows. *Journal of Dairy Science*, 100(5): 3628–3640. <https://doi.org/10.3168/jds.2016-11744>
- Arif, M., Iram, A., Fayyaz, M., Abd El-Hack, M.E., Taha, A.E., Al-Akeel, K.A., & Alagawany, M. (2023). Feeding barley and corn hydroponic-based rations improved digestibility and performance in Beetal goats. *Journal of King Saud University-Science*, 35(2): 102457. <https://doi.org/10.1016/j.jksus.2023.102457>
- Aruwayo, A., Nuhu, A., Junaidu, I., Rotimi, E.A., & Arowosegbe, T.O. (2024). Performance of Sokoto Red goat fed urea-treated groundnut (*Arachis hypogaea*) shell. *FUDMA Journal of Agriculture and Agricultural Technology*, 10(1): 61–69. <https://doi.org/10.33003/jaat.2024.1001.08>
- Belloir, P., Méda, B., Lambert, W., Corrent, E., Juin, H., Lessire, M., & Tesseraud, S. (2017). Reducing the CP content in broiler feeds: Impact on animal performance, meat quality and nitrogen utilization. *Animal*, 11(11): 1881–1889. <https://doi.org/10.1017/S1751731117000662>
- Boudalia, S., Smeti, S., Dawit, M., Senbeta, E.K., Gueroui, Y., Dots, V., & Symeon, G.K. (2024). Alternative approaches to feeding small ruminants and their potential benefits. *Animals*, 14(6): 904. <https://doi.org/10.3390/ani14060904>
- Cao, Y., Yao, J., Sun, X., Liu, S., & Martin, G.B. (2021). Amino acids in the nutrition and production of sheep and goats. In *Amino Acids in Nutrition and Health: Amino Acids in the Nutrition of Companion, Zoo and Farm Animals* (pp. 63–79). Springer. https://doi.org/10.1007/978-3-030-54462-1_4
- Carmichael, A.K., Kouakou, B., Gelaye, S., Kannan, G., Lee, J.H., & Terrill, T.H. (2012). Organ mass and composition in growing dairy goat wethers fed different levels of poultry fat and protein. *Small Ruminant Research*, 104(1–3): 104–113. <https://doi.org/10.1016/j.smallrumres.2011.12.005>
- Chanjula, P., Supapong, C., Hamchara, P., & Cherdthong, A. (2022). Blood metabolites and feed utilization efficiency in Thai-native-Anglo-Nubian goats fed a concentrate diet including yeast-fermented palm kernel cake instead of soybean meal. *Veterinary Sciences*, 9(5): 235. <https://doi.org/10.3390/vetsci9050235>

- Coleman, J., Berry, D.P., Pierce, K.M., Brennan, A., & Horan, B. (2010). Dry matter intake and feed efficiency profiles of three genotypes of Holstein-Friesian within pasture-based systems of milk production. *Journal of Dairy Science*, 93(9): 4318–4331. <https://doi.org/10.3168/jds.2009-2906>
- Cortese, M., Segato, S., Andrighetto, I., Ughelini, N., Chinello, M., Schiavon, E., & Marchesini, G. (2019). The effects of decreasing dietary crude protein on the growth performance, feed efficiency and meat quality of finishing Charolais bulls. *Animals*, 9(11): 906. <https://doi.org/10.3390/ani9110906>
- Dubeuf, J.P., Genis, J.C., Morand-Fehr, P., & Morales, F.D.A.R. (2023). The contribution of goats in the future redesigning of livestock activities and value chains. *Small Ruminant Research*, 227: 107065. <https://doi.org/10.1016/j.smallrumres.2023.107065>
- Eckart, A., Struja, T., Kutz, A., Baumgartner, A., Baumgartner, T., Zurfluh, S., & Schuetz, P. (2020). Relationship of nutritional status, inflammation, and serum albumin levels during acute illness: A prospective study. *The American Journal of Medicine*, 133(6): 713–722. <https://doi.org/10.1016/j.amjmed.2019.10.031>
- Elgioushy, M.M., Hassan, W., Abdullah, S.M., Elsheikh, H.E., & Emam, M.H. (2025). Bovine coronavirus in diarrheic pre-weaned calves in Egypt: Prevalence, risk factors, and the associated biochemical alterations. *Tropical Animal Health and Production*, 57(2): 112. <https://doi.org/10.1007/s11250-025-04115-8>
- Gao, H., Wang, J., Zou, X., Zhang, K., Zhou, J., & Chen, M. (2022). High blood urea nitrogen to creatinine ratio is associated with increased risk of sarcopenia in patients with chronic obstructive pulmonary disease. *Experimental Gerontology*, 169: 111960. <https://doi.org/10.1016/j.exger.2022.111960>
- Gao, M., El-Sherbiny, M., Szumacher-Strabel, M., Cieślak, A., Yanza, Y. R., Irawan, A., ... & Liu, Y. B. (2024). Cutting-edge exploration of insect utilization in ruminant nutrition—Feature and future: A systematic review and meta-analysis. *Frontiers in Veterinary Science*, 11, 1484870.
- Gupta, M., Sharma, R.K., Rastogi, A., Varun, T.K., Bala, S., & Saharan, V. (2018). Effect of plane of nutrition on nitrogen balance, blood biochemical and serum enzymes in goats. *Indian Journal of Animal Research*, 52(11): 1603–1607. <https://doi.org/10.18805/ijar.B-3320>
- Hafeez, A., Akram, W., Naz, S., Khan, R.U., Maqbool, B., Razaq, A.H.A., & Alhidary, I.A. (2026). Dual processing of guar meal through fermentation and enzyme supplementation improves growth, nutrient utilisation, bone quality, and gut viscosity in broilers. *Journal of Animal Physiology and Animal Nutrition*, 110(1): 88–99. <https://doi.org/10.1111/jpn.14245>
- Hindrichsen, I. K., Wettstein, H. R., Machmüller, A., Soliva, C. R., Bach Knudsen, K. E., Madsen, J., & Kreuzer, M. (2004). Effects of feed carbohydrates with contrasting properties on rumen fermentation and methane release in vitro. *Canadian journal of animal science*, 84(2), 265-276.
- Huang, J., Jiao, J., Tan, Z.L., He, Z., Beauchemin, K.A., Forster, R., & Zhou, C. (2016). Inferring the skeletal muscle developmental changes of grazing and barn-fed goats from gene expression data. *Journal of Agricultural and Food Chemistry*, 64(36): 6791–6800. <https://doi.org/10.1021/acs.jafc.6b02188>

- Huang, J., Jiao, S., Fu, Y., Zhao, W., Diao, Q., Ma, T., & Zhang, N. (2024). Effect of feeding level on growth and slaughter performance, and allometric growth of tissues and organs in female growing Saanen dairy goats. *Animals*, 14(5): 730. <https://doi.org/10.3390/ani14050730>
- Hussein, S.N., Mohammad, A.M., Azeez, A.K., & Duru, A. (2025). Rumen fermentation parameters of Awassi lambs fed diets containing sesame and sunflower meals as alternatives to soybean meal. *Tikrit Journal for Agricultural Sciences*, 25(4): 206–216. <https://doi.org/10.25130/tjas.25.4.17>
- Khan, M. Z., Huang, B., Kou, X., Chen, Y., Liang, H., Ullah, Q., ... & Wang, C. (2024). Enhancing bovine immune, antioxidant and anti-inflammatory responses with vitamins, rumen-protected amino acids, and trace minerals to prevent periparturient mastitis. *Frontiers in immunology*, 14, 1290044.
- Kholif, A.E., Gouda, G.A., Olafadehan, O.A., & Abdo, M.M. (2018). Effects of replacement of *Moringa oleifera* for berseem clover in the diets of Nubian goats on feed utilisation, and milk yield, composition and fatty acid profile. *Animal*, 12(5): 964–972. <https://doi.org/10.1017/S1751731117002375>
- Kotnala, B., Panneerselvam, V., & Vijayakumar, A.K. (2024). Physicochemical, structural, and functional characterization of guar meal protein isolate (*Cyamopsis tetragonoloba*). *Heliyon*, 10(3): e24978. <https://doi.org/10.1016/j.heliyon.2024.e24978>
- Liu, H., Jiang, G.M., Zhuang, H.Y., & Wang, K.J. (2008). Distribution, utilization structure and potential of biomass resources in rural China: With special references of crop residues. *Renewable and Sustainable Energy Reviews*, 12(5): 1402–1418. <https://doi.org/10.1016/j.rser.2007.07.012>
- Lokaewmanee, K., Suttibak, S., Sukthanapirat, R., Sriyoha, R., Chanasakhatana, N., Baotong, S., & Trithalen, U. (2023). Laying hen performance, feed economy, egg quality and yolk fatty acid profiles from laying hens fed live black soldier fly larvae. *Czech Journal of Animal Science*, 68(4): 147–158. <https://doi.org/10.17221/169/2022-CJAS>
- Manat, T.D., Chaudhary, S.S., Singh, V.K., Patel, S.B., & Puri, G. (2016). Hematobiochemical profile in Surti goats during post-partum period. *Veterinary World*, 9(1): 19–24. <https://doi.org/10.14202/vetworld.2016.19-24>
- Mazinani, M., Memili, E., & Rude, B.J. (2022). Harnessing the value of rumen protected amino acids to enhance animal performance: A review. *Annals of Animal Science*, 22(1): 43–62. <https://doi.org/10.2478/aoas-2021-0058>
- Meli, G., Fumo, V., Giromini, C., Perricone, V., Sandrini, S., Agazzi, A., & Invernizzi, G. (2023). The use of co-products of the agri-food industry in feeding dairy ruminants. *Animals*, 13(23): 3678. <https://doi.org/10.3390/ani13233678>
- Monteiro, A., Costa, J.M., & Lima, M.J. (2017). Goat system productions: Advantages and disadvantages to the animal, environment and farmer. In *Goat Science* (pp. 351–366). <https://doi.org/10.5772/intechopen.70002>
- Owais, M., Mohammed, D. A., Mhammad, H. A., Al Sulivany, B. S., Dernekbaşı, S., & Fazal, R. M. (2025). The role of silica nanoparticles in modulating growth performance, enzyme activity, and heavy metal accumulation in muscle tissue of common carp (*Cyprinus carpio*. L). *Science Journal of University of Zakho*, 13(2), 197-205.

- Parsad, R., Ahlawat, S., Bagiyal, M., Arora, R., Gera, R., Chhabra, P., & Singh, A. (2025). Climate resilience in goats: A comprehensive review of the genetic basis for adaptation to varied climatic conditions. *Mammalian Genome*, 36(1): 151–161. <https://doi.org/10.1007/s00335-024-10167-0>
- Piccione, G., Monteverde, V., Rizzo, M., Vazzana, I., Assenza, A., Zumbo, A., & Niutta, P.P. (2014). Reference intervals of some electrophoretic and haematological parameters in Italian goats: Comparison between Girgentana and Aspromontana breeds. *Journal of Applied Animal Research*, 42(4): 434–439. <https://doi.org/10.1080/09712119.2013.875904>
- Prajapati, V.D., Jani, G.K., Moradiya, N.G., Randeria, N.P., Nagar, B.J., Naikwadi, N.N., & Variya, B.C. (2013). Galactomannan: A versatile biodegradable seed polysaccharide. *International Journal of Biological Macromolecules*, 60: 83–92. <https://doi.org/10.1016/j.ijbiomac.2013.05.017>
- Prieto, I., Goetsch, A.L., Banskalieva, V., Cameron, M., Puchala, R., Sahl, T., & Coleman, S.W. (2000). Effects of dietary protein concentration on postweaning growth of Boer crossbred and Spanish goat wethers. *Journal of Animal Science*, 78(9): 2275–2281. <https://doi.org/10.2527/2000.7892275x>
- Rufino, L.D.A., Pereira, O.G., Ribeiro, K.G., Valadares Filho, S.C., Cavali, J., & Paulino, P.V.R. (2013). Effect of substitution of soybean meal for inactive dry yeast on diet digestibility, lamb's growth and meat quality. *Small Ruminant Research*, 111(1–3): 56–62. <https://doi.org/10.1016/j.smallrumres.2012.09.012>
- Sahl, T., Goetsch, A. L., Luo, J., Nsahlai, I. V., Moore, J. E., Galyean, M. L., ... & Johnson, Z. B. (2004). Nutrient requirements of goats: developed equations, other considerations and future research to improve them. *Small Ruminant Research*, 53(3), 191-219.
- Salem, H.B. (2010). Nutritional management to improve sheep and goat performances in semiarid regions. *Revista Brasileira de Zootecnia*, 39(Suppl.): 337–347. <https://doi.org/10.1590/S1516-35982010001300037>
- Salim, R., Nehvi, I.B., Mir, R.A., Tyagi, A., Ali, S., & Bhat, O.M. (2023). A review on anti-nutritional factors: Unraveling the natural gateways to human health. *Frontiers in Nutrition*, 10: 1215873. <https://doi.org/10.3389/fnut.2023.1215873>
- Samsuzzaman, Islam, S., Ali, M.R., Dey, P.K., Bicomumpaka, E., Reza, M.N., & Chung, S.O. (2025). Quantification of light, photoperiod, temperature, and water stress symptoms using image features for smart vegetable seedling production. *Horticulturae*, 11(11): 1340. <https://doi.org/10.3390/horticulturae11111340>
- Shafiq, M., Al Sulivany, B. S., Albassam, N. H., Al-Tae, N. T. T. A. T. T., Shahid, A., HASSAN, A., ... & E Hassan, S. S. (2025). Comparative Impacts of Plant-Derived Functional Diets (Azolla, Duckweed, and Napier Grass) on Growth, Hematology, and Serum Biochemistry of Grass Carp (*Ctenopharyngodon Idella*). *Egyptian Journal of Aquatic Biology and Fisheries*, 29(6), 253-268.
- Sher, A., Calone, R., Sattar, A., Ijaz, M., Sarwar, B., Qayyum, A., & Barbanti, L. (2022). Growth, yield and quality attributes of guar (*Cyamopsis tetragonoloba* L.) genotypes grown under different planting dates in a semi-

- arid region of Pakistan. *Pakistan Journal of Agricultural Sciences*, 59(5): 757–763. <https://doi.org/10.21162/PAKJAS/22.1098>
- Shilwant, S., Hundal, J.S., Singla, M., & Patra, A.K. (2023). Ruminant fermentation and methane production *in vitro*, milk production, nutrient utilization, blood profile, and immune responses of lactating goats fed polyphenolic and saponin-rich plant extracts. *Environmental Science and Pollution Research*, 30(4): 10901–10913. <https://doi.org/10.1007/s11356-022-22779-8>
- Shwerab, A.M., Khalel, M.S., Khayyal, A.A., Hassan, A.A., & Yacout, M.H. (2015). Influence of different treatments of guar korma meal on sheep performance. *Egyptian Journal of Nutrition and Feeds*, 18(1): 49–63. <https://doi.org/10.21608/EJNF.2015.104669>
- Shweta, N., Rani, K.S., Kumar, D.S., & Illa, S.K. (2025). Guar meal as an alternative protein source: Effects on digestibility and growth performance of Nagavali ram lambs. *Tropical Animal Health and Production*, 57(8): 430. <https://doi.org/10.1007/s11250-025-04279-3>
- Silanikove, N. (2000). The physiological basis of adaptation in goats to harsh environments. *Small Ruminant Research*, 35(3), 181–193. [https://doi.org/10.1016/S0921-4488\(99\)00105-1](https://doi.org/10.1016/S0921-4488(99)00105-1)
- Silva, T.M., Medeiros, A.N., Oliveira, R.L., Neto, S.G., Ribeiro, M.D., Bagaldo, A.R., & Ribeiro, O.L. (2015). Peanut cake as a substitute for soybean meal in the diet of goats. *Journal of Animal Science*, 93(6): 2998–3005. <https://doi.org/10.2527/jas.2014-8570>
- Te Pas, M.F., Veldkamp, T., de Haas, Y., Bannink, A., & Ellen, E.D. (2021). Adaptation of livestock to new diets using feed components without competition with human edible protein sources—A review of the possibilities and recommendations. *Animals*, 11(8): 2293. <https://doi.org/10.3390/ani11082293>
- Vidya, B., Venkateshwarlu, M., Nagalakshmi, D., Sarat Chandra, A., Chinni Preetham, V., & Nalini Kumari, N. (2022). Effect of feeding of sorghum stover based complete feed blocks containing guar meal as protein supplement on reproductive efficiency, hormone profile and antioxidant status in Deccani ewes. *PLoS ONE*, 17(5): e0268893. <https://doi.org/10.1371/journal.pone.0268893>
- Wu, G. (2009). Amino acids: metabolism, functions, and nutrition. *Amino acids*, 37(1), 1–17.
- Ye, Y., Chen, W., Gu, M., Xian, G., Pan, B., Zheng, L., & Sheng, P. (2020). Serum globulin and albumin to globulin ratio as potential diagnostic biomarkers for periprosthetic joint infection: A retrospective review. *Journal of Orthopaedic Surgery and Research*, 15(1): 459. <https://doi.org/10.1186/s13018-020-02053-1>
- Zare, R., Devrim-Lanpir, A., Guazzotti, S., Ali Redha, A., Prokopidis, K., Spadaccini, D., & Aragon, A.A. (2023). Effect of soy protein supplementation on muscle adaptations, metabolic and antioxidant status, hormonal response, and exercise performance of active individuals and athletes: A systematic review of randomised controlled trials. *Sports Medicine*, 53(12): 2417–2446. <https://doi.org/10.1007/s40279-023-01929-5>

- Zhu, W., Xu, W., Wei, C., Zhang, Z., Jiang, C., & Chen, X. (2020). Effects of decreasing dietary crude protein level on growth performance, nutrient digestion, serum metabolites, and nitrogen utilization in growing goat kids (*Capra hircus*). *Animals*, 10(1): 151. <https://doi.org/10.3390/ani10010151>
- Zurak, D., Kljak, K., & Aladrović, J. (2023). Metabolism and utilisation of non-protein nitrogen compounds in ruminants: A review. *Journal of Central European Agriculture*, 24(1): 1–14. <https://doi.org/10.5513/JCEA01/24.1.3812>