Effect of Different Levels of Concentrated Feed and Hay in the Diet on Metabolic Hormones in Local Iraqi Goats

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Abstract
This research aimed to study the effect of feeding different proportions of concentrated feed and hay on metabolic hormones (leptin, ghrelin, thyroid hormones, and growth hormone) in Iraqi local goats. Due to the importance of goats in meat and milk production and their ability to adapt to the harsh environmental conditions in Iraq, the research seeks to determine the optimal balance between coarse and concentrated feed to improve the digestive and productive performance of the animals. The experiment was conducted on 18 Black Iraqi local goats, randomly divided into three groups fed with different proportions of concentrate and hay: Group I 80% concentrate + 20% hay, Group II 60% concentrate + 40% hay, Group III 40% concentrate + 60% hay, Blood samples were collected monthly to measure the concentrations of metabolic hormones. The data were analysed using Genstat statistical analysis software. The results showed a significant increase in the concentration of leptin in the first group (T1) fed with a high percentage of concentrated feed, indicating its association with the level of energy and nutrition in the body, and a significant increase in the concentration of ghrelin in the third group (T3) fed with a high percentage of hay, reflecting its role in the regulation of food intake and weight gain. There was a significant increase in the concentration of thyroxine and thyronine hormones in the first and second groups (T1 and T2), which were fed with higher percentages of concentrated feed, indicating the effect of highly concentrated diets on thyroid hormone levels, and a significant increase in the concentration of growth hormone in the second and first groups (T2 and T1), indicating the effect of concentrated feed on metabolic processes and muscle growth.
The results of the study indicate that balanced feeding based on specific proportions of concentrated feed and hay significantly affects metabolic hormones in Iraqi local goats. Good nutrition (T1 and T2) resulted in higher energy and growth hormones, reflecting a positive effect on the biological performance of the animals. In contrast, inadequate feeding (T3) reduced the levels of these hormones, indicating reduced metabolic performance and growth. This study demonstrates the importance of balanced nutrition in improving the productive performance of Iraqi local goats by influencing metabolic hormones. These findings can be used to develop improved feeding strategies that contribute to increasing meat and milk production and reducing production costs.

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Introduction

The goat is one of the most important meat- and milk-producing animals, as it is characterised by a high genetic capacity that makes it suitable for genetic improvement to fill the shortage in animal production. In Iraq, goats are adapted to harsh environmental conditions, making them an ideal choice to improve productivity (Alberto *et al*., 2018; Habib *et al*., 2022). Nutrition plays an important role in reducing production costs, as inexpensive coarse feeds can be used to maintain performance and reduce dependence on grains. However, excessively concentrated feeds may lead to nutritional disorders, so a balance between coarse and concentrated feeds is necessary to improve digestion and performance (Al-Jobbery and Noaman, 2021) [1].

Nutrition also affects blood components and levels of metabolic hormones such as leptin, which regulates metabolism and energy, and ghrelin, which stimulates growth hormone and thyroid (T3 and T4) hormones, as well as thyroid hormones, which reflect the nutritional status of the animal and affect its growth and reproduction (Yokus *et al*., 2006; Dhari and Kassim 2019) [32, 9]. Thyroid hormones are essential for the productive performance of pets, affecting growth and metabolic processes. Variations in serum thyroid hormone levels can indicate changes in thyroid activity which are closely related to the nutritional status of the animal. In ruminants, thyroid hormones enable animals to modulate their metabolism according to environmental conditions and nutrient availability. There is a significant positive correlation between circulating thyroid hormone levels and energy balance in various species, including cattle; for example, cows with a negative energy balance after calving typically show low levels of T3 and T4, along with an increase in reverse T3 (rT3) concentrations. This hormonal response reflects the metabolic adaptation of the animal to its energy status. (Shulhai *et al*., 2024) [22]. Given the role played by the blood in transporting the products of food digestion, hormones must be affected in one way or another by nutritional treatments, including certainly the ratio of concentrated to coarse feed in the feed provided to the animals (Babe *et al*., 2015) [4], so the study aimed to know the effect of concentrated feed and hay on metabolic hormones in local Iraqi goats.

Materials and Methods

This experiment was conducted in the animal field of the Faculty of Agriculture - University of Basra for the period from 1/11/2023 to 31/1/2024 (90 days). preceded by a preliminary period (10) days, (18) new goats were purchased from the local Iraqi black goat breed at the age of (5-6) months; the animals were divided into three treatments according to weight as follows: the first treatment with an average weight of (T1 18.11), the second treatment with an average weight of (T2 18.02) and the third treatment with an average weight of (T3 18.15) with 6 animals per group. Animals were housed in semi-shaded enclosures containing feed, plastic water drinking bowls and salt blocks and were subjected to veterinary care throughout the experiment.

Animals were fed on different proportions of concentrated feed and hay with two meals in the morning and evening: (T1) 80% concentrated feed + 20% hay (T2) 60% concentrated feed + 40% hay (T3) 40% concentrated feed + 60% hay; the above treatments were given at 3% of body weight, and Table (1) shows the components of concentrated feed.

Blood samples of 7 ml were collected from the animals once a month via the jugular vein using a sterile syringe (10 ml), and the animals were collected at two meals. Samples drawn before feeding were intended to measure the concentration of ghrelin hormone, while samples drawn after feeding (two hours after feeding) were intended to measure the concentration of leptin hormone only. All samples were placed immediately after withdrawal in glass test tubes with sealed nozzles without any anticoagulant material to allow the blood to coagulate to facilitate serum isolation, and using a centrifuge at 3000 r/min for 15 minutes, then the serum was kept frozen at -20 °C. 20°C until hormone analyses were performed. The results were analysed using Gendtat Gen Stat (2009) statistical analysis software.

$Yijk = \mu + Di + Ej + (DE)ij + eijk$

Yijk = Viewing value K for transactions i months j

μ = The overall average of the decade

Di= Effect of treatments i] = (80% concentrate feed + 20% hay, 60% concentrate feed + 40% hay, 40% concentrate feed + 60% hay)

Ej= months j] (November -December – January)

(DE)ij = Effect of overlap between coefficients and months

eijk = The experimental error inherent in any observation, which is normally and randomly distributed

Results and Discussion

Table 2 shows the effect of feeding on different proportions of concentrated feed and hay on leptin concentration. The results showed a significant increase ($p<0.01$) in the first treatment of leptin concentration with an increasing amount of concentrated feed; the concentrations reached 14.31 ng/ml and 11.81 ng/ml for T1 and T2, respectively, and reached 7.63 ng/ml in T3. The reason for this may be that leptin is usually related to the energy level in the body and the level of nutrition and energy stored in the body, this hormone is responsible for metabolic balance, and its secretion increases when the quantity and quality of feed consumption by the animal improves (Filier *et al*., 1997). In addition, increased feed consumption activates neural signals that stimulate white adipocytes to start secreting leptin, which is usually positively correlated with the abundance of metabolic fuel associated with high energy in the forage (Spiegelman and Flier, 2001) [23]. These results are consistent with Tsiplakou *et al*., (2012) [26] in their study on sheep and goats, who observed an increase in hormone concentration when animals were fed alfalfa hay and concentrate feed at ratios of 50:50 and 30: The results showed that the concentration of leptin in blood plasma was higher in the 130% concentrate group compared to the 30% hay and 70% concentrate group: 70% concentrate) and was higher in sheep fed 130% concentrate (2.22 ng/ml) compared to goats (1.57 ng/ml), indicating that ruminants fed concentrate feeds tend to have higher plasma leptin concentrations (Foote *et al*., 2015) [11].

The table also shows that the concentration of leptin significantly increased as the experiment progressed. The hormone concentration increased in the second and third months, reaching 11.42 and 11.74 ng/ml, respectively, compared to the first month (10.59 ng/ml). This may be due to increased energy stores and deposition of adipose tissue as the animals continued to feed on concentrated feed (Reist *et al*., 2003) [20].

Table 3 shows the effect of feeding on different proportions of concentrate and hay on ghrelin concentration. The results showed that there was a significant increase ($p<0.01$) in the third treatment of ghrelin concentration by decreasing the

proportion of concentrate and increasing the proportion of hay, with the highest values of ghrelin in the T3 treatment (9.00 ng/ml) and the lowest in the T1 treatment (4.03 ng/ml). This could be because ghrelin plays an important role in physiological energy balance by regulating food intake, weight gain and maintenance of glucose homeostasis (Diéguez *et al*., 2010) [8] and could be because ghrelin values were highest in the T3 treatment (9.00 ng/ml) and lowest in the T1 treatment (4.03 ng/ml). This could be because concentrated feed is rapidly digested in the rumen, and this rapid digestion leads to a rapid increase in blood levels of glucose and volatile fatty acids, which may inhibit ghrelin secretion and thus reduce hunger (Williams *et al*., 2003) [30]. Hay is a fiber-rich forage that is digested slowly in the rumen, and this slow digestion results in a continuous and slow release of energy, which may stimulate ghrelin release for a longer period and thus increase hunger and stimulate more food intake (Cummings *et al*., 2001) [7]. These results are consistent with Takahashi *et al*. (2008), who observed in their study on rams fed on two diets, concentrate and hay, that ghrelin levels after feeding in the concentrate diet were significantly lower than in the hay diet after feeding, with concentrations of 2.7 and 2.85 ng/ml, respectively.

It was also observed from the table that there was a significant increase in the concentration of ghrelin as the experiment progressed, as the concentration of the hormone increased in the second and third months with concentrations of 5.37 and 6.43 ng/ml, respectively, compared to the first month (5.22 ng/ml) (Wertz- Lutz *et al*., 2006) [29]. This may be because feeding frequency, amount of food offered and animal size or age may affect the ghrelin response (Wertz-Lutz *et al*., 2006) [29].

Table 4 shows the effect of feeding on different ratios of concentrate and hay on the concentration of thyroid hormones thyroxine and thyroxine. The results showed that there was a significant increase (0.01>P) in the first and second treatments of thyroxine and thyronine by increasing the ratio of concentrate to hay. (0.01>P) in T1 and T2 for thyroxine and thyronine concentration by increasing the ratio of concentrate to hay, with the highest values for thyroxine in T1 (19.44 ng/ml) and T2 (44 ng/ml). 44 ng/ml) and T2 (18.97 ng/ml), while lower in T3 (12.40 ng/ml) and higher in T1 (1.314 ng/ml) and T2 (1.335 ng/ml) and lower in 0. This may be because thyroxine is the thyroid hormone responsible for metabolism, and thyronine is the active form of thyroid hormones and is associated with metabolic activity (Usai *et al*. This suggests that high-concentration diets can raise thyroid hormone levels in ruminants. This increase in T3 and T4 is associated with decreased serum triglyceride (TG) and free fatty acid (FFA) concentrations, as well as increased hepatic glycogen deposition. It is therefore likely that T3 and T4 levels are elevated when feeding on high-concentration diets due to increased energy intake and subsequent changes in metabolic processes. Metre *et al*. (2000) [19]. These results are consistent with what Antunović *et al*. (2019) [3] found in their study on ewes fed on concentrated feed and hay, where they observed an increase in the concentration of thyroxine T4 with concentrations of 91.74 and 96.14 ng/ml for the second group and 68.42 and 77.42 ng/ml for the third group. 42 ng/ml for the first group, respectively. A higher concentration of thyronine was also observed in the first group compared to the second group, with concentrations of 1.10 and 1.63 ng/ml for the first group and 1.09 and 1.54 ng/ml for the second group, respectively.

It was also observed from the table that there was a significant increase in the concentration of thyroid hormones as the experiment progressed. The concentration of thyroxine increased in the second and third months, and the concentrations reached 16.93 and 17.27 ng/ml, respectively, compared to the first month's 16.60 ng/ml, while the concentration of thyronine in the first and second months was 1.084 and 1.168 ng/ml, respectively, compared to the third month, 1.042 ng/ml. The reason for this may be due to seasonal changes, as thyroid hormone concentrations show seasonal differences that can affect the metabolic balance in ruminants; for example, during winter months with shorter daylight hours, hormonal activity tends to decrease, while summer months may show elevated levels due to increased feed intake and environmental conditions (Medrano & Hua, 2016) [18]. While long-term studies suggest that prolonged exposure to specific diets can lead to adaptations in thyroid function, one study noted that thyroid hormone levels may stabilise after several weeks of balanced feeding practices, allowing researchers to observe more subtle physiological responses. (Kholif *et al*., 2021) [16].

Table 5 shows the effect of feeding on different ratios of concentrate and hay on growth hormone concentration. The results showed a significant increase ($p<0.01$) in the second and first treatments of growth hormone concentration by increasing the ratio of concentrate to hay. The highest values of growth hormone were in T2 (11.46 ng/ml), followed by T1 (11.01 ng/ml) and the lowest in T3 (4.85 ng/ml). 46 ng/ml), followed by T1 (11.01 ng/ml) and the lowest in T3 (4.85 ng/ml). This may be because GH affects metabolic processes and muscle growth (Borromeo *et al*., 1994). The decrease in postprandial GH levels may also be due to increased plasma levels of short-chain fatty acids resulting from increased rumen fermentation and subsequent absorption of short-chain fatty acids into the blood (Ishiwata *et al*., 2000) [15]. These results are consistent with what Hagino *et al*. (2005) [14] reported in their study on sheep, where they observed that GH was significantly reduced in the 80% concentrate group and 20% roughage group: 20% roughage compared to 0% concentrate: 100% roughage and 40% concentrate: 60% roughage before feeding with concentrations of 7.5, 11.4 and 10.1 ng/ml, respectively. These differences persisted throughout the experiment. Overall, the GH concentration was significantly higher in the 0% concentrate:100% roughage group compared to the 0% concentrate:100% roughage group: 100% roughage compared to 40% concentrate: 60% roughage and 80% concentrate: 20% roughage over 24 hours regardless of pre- and post- feeding, and the concentrations were 10.4, 7.9 and 5.6 ng/ml, respectively.

It was also observed from the table that there was a significant increase in the concentration of growth hormone as the experiment progressed. The concentration of growth hormone increased in the third month and reached 9.67 ng/ml

compared to the first and second months 8.86 and 8.79 ng/ml, respectively. (Boisclair & Giesy, 2024) [5], the continuous presence of high-energy feed may enhance the sensitivity of the hypothalamic-pituitary axis to nutrient signals, leading to continuous or increased GH secretion; this adaptation is often necessary to maintain growth and metabolic health under intensive feeding regimes (Takemura *et al*., 2019) [24]. It may also be due to improved efficiency of nutrient absorption and metabolism, leading to increased availability of amino acids and glucose – both of which are potent triggers of GH release as ruminants digest these feeds – and the resulting rise in blood metabolites can promote GH secretion as part of the body's growth-promoting mechanisms (Ye *et al*., 2024) [31].

Conclusions

Good nutrition (T1) and (T2) led to higher energy and growth hormones, which had a positive effect on the animals' biological performance. Inadequate feeding (T3) reduced the levels of these hormones, indicating reduced metabolic performance and growth.

Table 1: Components of concentrated feed

Ingredients	Percentage%
Barley	% 58
Bran	% 36
Soybeans	% 8
Salts and vitamins	% 2
Table salt	% 1

Table 2: The effect of feeding concentrated feed and straw on the leptin hormone of local Iraqi goats during the experimental period (mean ± SEM)

Trait	Months \ Treatment	1	2	3	Treatment Impact Factor
Leptin Hormone Ng\ml	T1	13.40	15.22	14.32	14.31 a
	T2	11.23	10.90	13.29	11.81 b
	T3	7.13	8.14	7.62	7.63 c
	Monthly Impact Factor	10.59 b	11.42 a	11.74 a	0.353 SEM
	LSD Interaction	1.233			
	SEM Interaction	0.612			

Table 3: The effect of feeding concentrated feed and hay on the ghrelin hormone of local Iraqi goats during the experimental period (mean ± SEM

	Months \ Treatment	1	2	3	Treatment Impact Factor
Ghrelin Hormone Ng\ml	T1	3.46	3.31	5.32	4.03 b
	T2	3.75	3.48	4.75	3.99 b
	T3	8.46	9.34	9.20	9.00 a
	Monthly Impact Factor	5.22 b	5.37 b	6.43 a	0.293 SEM
	LSD Interaction	1.022			
	SEM Interaction	0.507			

Table 4: Effect of feeding concentrated feed and straw on thyroxine and thyronine hormones of local Iraqi goats during the experimental period (mean ± SEM)

Trait	Months \ Treatment	1	2	3	Treatment Impact Factor
Thyroxine Hormone Ng\ml	T1	20.13	18.30	19.88	19.44 a
	T2	18.15	19.27	19.48	18.97 a
	T3	11.52	13.22	12.46	12.40 b
	Monthly Impact Factor	16.60 b	16.93 b	17.27 a	0.484 SEM
	Interaction LSD	1.690			
	SEM Interaction	0.839			
Thyronine Hormone Ng\ml	Months / Treatment	1	2	3	Treatment Impact Factor

	T1	1.307	1.463	1.172	1.314 a
	T2	1.347	1.307	1.352	1.335 a
	T3	0.600	0.733	0.602	0.645 b
	Monthly Impact Factor	1.084 b	1.168 a	1.042 c	SEM 0.0637
	Interaction LSD	0.2223			
	SEM Interaction	0.1104			

Table 5: Effect of feeding concentrated feed and straw on growth hormone of local Iraqi goats during the experimental period (mean ± SEM)

	Months \ Treatment	**1**	**2**	**3**	**Treatment Impact Factor**
growth Hormone Ng\ml	T1	10.45	10.40	12.19	11.01 b
	T2	11.44	11.31	11.62	11.46 a
	T3	4.69	4.67	5.19	4.85 c
	Monthly Impact Factor	8.86 b	8.79 b	9.67 a	0.298 SEM
	Interaction LSD	1.041			
	Interaction SEM	0.517			

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