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Research Article

Effect of alfalfa substitution with grass pea hay on performance and carcass quality of Kurdish growing lambs

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ABSTRACT- During the recent decades, rain reduction and consequently water shortage in Iran had an impact effect on crop cultivation program. Therefore, considering these factors, it is necessary to plan for crop production, which needs less water. Grass pea (*Lathyrus sativus*), is a high-quality forage in animal feeding and has unique biological traits like drought tolerance. Hence, this experiment was conducted to study the effect of alfalfa substitution with grass pea hay on performance and carcass quality of Kurdish growing lambs. Twenty-four Kurdish male lambs with an average body weight of 30.23 kg and seven months age were used in this experiment. Experimental diets included: (1) diet without grass pea hay (control), (2) diet containing 10% grass pea hay, (3) diet containing 20% grass pea hay, and (4) diet containing 30% grass pea hay. The results showed that neutral detergent fiber, crude protein, and ash contents of grass pea hay were 32.67%, 19.66%, and 11.70% of dry matter, respectively. Experimental diets had no significant effect on dry matter intake and feed efficiency, carcass parameters, carcass cuts, and meat chemical compositions of the lambs ($P \geq 0.05$). Orthogonal comparisons showed that lambs fed diets containing grass pea hay had the higher average daily gain ($P < 0.05$). It was concluded that diet inclusion of grass pea hay up to 30% of dry matter, had no adverse effect on lambs healthy status.

INTRODUCTION

Forage and fibrous materials constitute the major part of ruminant feed (40-100%) and are vital for maintaining animal performance, production, and health since the digestive system of ruminants, especially the rumen, has a unique microbial ecosystem that take advantage of fibrous feed (Menke and Steingass, 1988; Adesogan et al., 2019). In addition, fiber stimulates chewing activity, saliva secretion, rumination, reduce the occurrence of rumen acidosis, and regulate feed intake (Adesogan et al., 2019). Alfalfa, corn silage, grain straw, and pasture plants are the most important forage sources in ruminant's diet. Climate changes during the recent decades, rain reduction, and consequently water shortage in our country have an impact effect on crop cultivation program. Therefore, considering these factors, it is necessary to plan for crop production, which consume less water. Planting legume forage such as alfalfa requires a lot of water (Arslan, 2017). On the other hand, the existing pasture have been subjected to severe destruction and erosion due to the excessive livestock grazing, droughts, and limited water resources. Livestock holders tend to feed animals with less cost and high-production items. Hence, it is very important to use alternative forage sources that are rich in protein, require less water, and are resistant to drought conditions. Grass pea (*Lathyrus sativus*), also known as cheap hay in Iran, is a high-quality forage in animal feeding. This plant has unique biological and agronomic advantages like drought tolerance, compatibility with all types of soils, resistance to insects and pests, helping to stabilize soil nitrogen, and high yield production with high protein percentage. Cultivation of rainfed grass pea is possible in areas that have at least 350 to 400 mm of rainfall with proper time distribution. The growth period of grass pea is relatively short, it takes 75 to 80 days from the time it turns green to reach the stage of flowering and forage harvest, therefore, the water requirement of this product is low in irrigated cultivation. Autumn cultivation of grass pea in the western regions of Iran for example, northern regions of Khuzestan province, Ilam, and some regions of Lorestan and Kermanshah provinces, which have mild winters and sufficient rainfall, has brought the highest yield (Razme Azar et al., 2013). However, due to insufficient knowledge of the nutritional value of this plant, it is not common feed in animal nutrition. Previous studies have showed that it could be replaced as a part of

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forage in ruminant nutrition (White et al., 2002). Grass pea is a high-quality forage with crude protein (CP) content about 24% and metabolizable energy content (average 2256 kcal/kg dry matter, DM) (Ibrahim and Sait, 2020; Vahdani et al., 2014). It has been reported that under drought condition and alfalfa shortage, it could be replaced by grass pea hay in the sheep nutrition (Vahdani et al., 2014) and grass pea hay is a suitable alternative to alfalfa hay in the diet of ruminants (Firuzi et al., 2012). Substitution of soybeans by grass pea seeds in lamb's diet increased feed intake and nutrient digestibility (Hozhabri et al., 1999). There are very few researches regarding the inclusion of grass pea hay in the diet of ruminants; hence, this experiment was conducted to study the effect of alfalfa substitution with grass pea hay on the performance and carcasses characteristics of Kurdish lambs.

MATERIALS AND METHODS

This research was carried at Shirvan-Cherdavel research station (Agricultural and Natural Resources Research Center of Ilam Province) during the fall and winter 2023. Twenty-four Kurdish male lambs with an average body weight of 30.23 kg and seven months age were ear tagged and used in this study. All animals received anti-parasitic drugs (Albendazole tablets, 5 mg/ kg of BW, Niclosamide 9 mL/ head, and Iverclozantol injection 1.5 mL/head) on two occasions. Lambs were kept individually in stalls with dimensions of 2 × 1 meters and separate troughs and mangers. The experimental period was 100 days, with the first 20 days for adaptation. Grass pea hay was harvested (Shirvan-Cherdavel research station) in the flowering stage. Dried Alfalfa hay was cut into 3-5 cm pieces. Experimental diets included: (1) diet without grass pea hay (control), (2) diet containing 10% grass pea hay, (3) diet containing 20% grass pea hay, and (4) diet containing 30% grass pea hay. Diets were balanced according to the nutritional requirements of small ruminants (NRC, 2007) and they were isocaloric and isonitrogenous (Table 1). The lambs were fed total mixed rations (TMR) at three times (at 8:00, 15:00, and 22:00). Water was freely available. Lambs were weighted individually on days 0 (starting feeding experimental diets), 20, 40, 60, and 80 of experiment for measuring average daily gain. The amount of feed refusals of each animal were collected and weighted daily and feed efficiency was calculated. At the end of the experimental period, lambs were slaughtered and their components were weighed. The carcass was cut into six parts, including the neck, shoulder, breast flank, loin, leg, and tail (Colomer-Rocher et al., 1987). Chemical composition (moisture, CP, and ash contents) of meat was measured (AOAC, 2007).

Meat color was stated as L* (lightness), a* (redness–greenness) and b* (blueness–yellowness) values (Warner, 2024). Data were analyzed in a completely randomized design with four treatments (different levels of grass per hay) using the MIXED procedure of SAS by the following model:

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

where: Y_{ij} is the jth observation of the ith treatment, μ is the population mean, T_i is the effect of grass hay level, and ε_{ij} is the random error.

Orthogonal contrast was made between the control diet and the diets containing grass pea hay.

RESULTS AND DISCUSSION

Table 2 shows the chemical composition of grass pea hay and alfalfa hay. Dry matter content of grass pea hay in the current study (96.13%) is more than (87.4%) the other research (Poland et al., 2003).

Table 1. Ingredients and chemical composition of experimental diets

Ingredients (% of dry matter)	Experimental diets containing different levels of grass pea hay			
	0	10	20	30
Grass pea dry hay	30.00	20.00	10.00	0.00
Alfalfa hay	0.00	10.00	20.00	30.00
Wheat straw	5.00	5.00	5.00	5.00
Wheat bran	6.00	6.00	6.00	6.00
Barley grain	50.20	49.90	49.40	49.10
Ground corn grain	3.00	3.00	3.00	3.00
Soybean meal	3.10	3.40	3.70	4.00
Urea	0.70	0.70	0.70	0.70
Sodium bicarbonate	0.50	0.50	0.50	0.50
Calcium carbonate	0.50	0.50	0.70	0.80
Salt	0.50	0.50	0.50	0.50
Mineral and vitamin supplement [1]	0.50	0.50	0.50	0.50
Chemical composition (% of dry matter)				
Crude protein	15.14	15.15	15.13	15.13
Non-fibrous carbohydrates	46.09	46.85	47.67	48.42
Neutral detergent fiber	31.35	30.75	30.10	29.50
Calcium	0.67	0.61	0.62	0.59
Phosphorus	0.33	0.32	0.31	0.31
Metabolizable energy (Mcal/kg of DM)	2.55	2.55	2.54	2.53

1. Each kilogram of vitamin and mineral supplement contains 500,000 IU of vitamin A, 100,000 IU of vitamin D3, 100 mg of vitamin E, 180,000 mg of calcium, 90000 mg of phosphorus, 19000 mg of magnesium, 60000 mg of sodium, 2000 mg of manganese, 3000 mg of iron, 300 mg of copper, 3000 mg of zinc, 100 mg of cobalt, 100 mg of iodine, and 1 mg of selenium.

Table 2. Chemical composition of grass pea and alfalfa hay (% of dry matter)

Feedstuff	Dry matter	Neutral detergent fiber	Crude protein	Ash
Grass pea hay	96.13	32.67	19.66	11.70
Alfalfa hay	96.05	39.07	15.90	11.00

Razm Azar et al. (2013), reported that the ash content of grass pea hay is 13.54, which was more than the results of the current study (11.70%). Basaran et al. (2011), Karadag and Buyukburc (2004), and Vahdani et al. (2014) have reported that the CP content of grass pea hay were 23.46%, 22.13%, and 23.24% of DM, respectively, which was higher than the current study. Furthermore, Poland et al. (2003), Razm Azar et al. (2013), and Tuna et al. (2004) have reported that the CP content of grass pea was 18.20%, 14.99%, and 16.35%, respectively.

Razm Azar et al. (2013) and Kiraz (2011) observed that the average NDF content of grass pea hay was in the range of 33.42-48.06%, that were more than the NDF values in the present experiment (32.67%). This discrepancy could be attributed to the different harvest time and ecological conditions (Basaran et al., 2011), climate, soil, and fertilization. Furthermore, forages quality and their nutritional value are affected by species (Paya et al., 2007).

Performance

Effects of different levels of grass pea hay on the performance of growing lambs are presented in Table 3. The effect of diets containing different levels of grass pea hay on the dry matter intake and feed efficiency of lambs was not significant ($P \geq 0.05$). However, the effect of diets containing different levels of grass pea hay on ADG were significant and orthogonal comparisons showed that lambs fed diets containing grass pea hay (all three levels) had the higher ADG in comparison with the control group ($P < 0.05$). In contrast to the current results, alfalfa replacement by grass pea had no significant effect on body weight and condition score (Poland et al., 2003). The amount and passage rate of dietary fiber through the rumen and feed palatability are important factors affecting the DMI in ruminant (Allen, 2000). Lack of difference in the DMI among treatments could be attributed to the same CP and energy contents of experimental diets (grass pea *vs* alfalfa hay). Lower NDF content of grass pea hay compared to alfalfa hay may increase ADG of the lambs fed diets containing different levels of grass pea hay in the present study, since fiber portion of diet has negative effect on the nutrients digestibility (Lattanzio et al., 2009).

Carcass characteristics

Table 4 shows the effect of grass pea hay inclusion on carcass characteristics of growing lambs and virtual water consumption. Replacement of alfalfa with grass pea hay had no significant effect on carcass characteristics ($P \geq 0.05$). Similar to this data, feeding lambs with diet containing grass pea seed had no significant effect on shoulder tissue composition (Friha and Majdoub-Mathlouthi, 2024). Furthermore, the lack of the effect of diets containing different levels of grass pea hay on the weight of carcass cuts, in our study, could be related to the lack of the effect of experimental diets on chemical composition of meat including moisture, protein, fat, and ash contents in the soft tissue of the carcass (Table 5). Virtual water consumption for each diet and carcass production are also presented in Table 4. The virtual water content is the total volume of water used in production. For animal products, this typically includes water supplied to animals for drinking, water used for washing and cleaning in the case of industrial farms as well as slaughterhouses and meat processing factories, and importantly the water loss through evapotranspiration by rangelands, pastures, and crops that are consumed by animals as they grow. The latter is overwhelmingly the largest component, representing potentially upward of 99% of the virtual water consumption (Ridoutt et al., 2012). Our results showed that diet containing 30% of grass peas hay had the lowest water consumption per treatment and per kilogram of carcass. Considering that, meat and dairy products are an important driver of global water scarcity (Ridoutt et al., 2012), current data showed that alfalfa substitution with grass pea hay resulted in less water consumption and better water efficiency for meat production.

Composition and color characteristics

Table 5 presents the effect of different levels of grass pea hay on meat chemical composition and color characteristics of growing lambs. Meat chemical composition, meat blueness–yellowness values (b*) immediately after slaughter, and lightness values (L*) 24 hours after slaughter did not affected by experimental diets ($P \geq 0.05$). While, lightness (L*) and redness (a*) values immediately after slaughter decreased in lambs received diets containing grass pea hay. In addition, lambs fed diet containing 20% grass pea hay had the highest amount ($P < 0.05$) of yellowness (b*) and redness–greenness (a*) values of the meat in 24 hours after slaughter. Myoglobin content, type, and physio-chemical conditions of other meat components affect the appearance of meat (Lavery and Ledward, 2006). Muscles can be classified as "red" or "white". The proportion of narrow fibres rich in myoglobin is higher in the so-called "red" muscles. This is despite the fact that wide and poor fibres have more myoglobin in the so-called white muscles. In red muscles, mitochondria, respiratory enzymes, and myoglobin are abundant, and have the tendency to act for a long time without rest. In contrast, "white" muscles have relatively small amounts of respiratory enzymes and myoglobin and the activity of lactic dehydrogenase is high. The oxidation state of the iron atom of myoglobin also plays a significant role in the color of the meat (Listart et al., 2016). Beef color immediately after cutting is purple, since water is bounded to the reduced iron atom of the myoglobin molecule. Within 30 minutes after exposure to the air, beef slowly turns to a bright cherry-red color in a process called blooming. Blooming is the result of oxygen binding to the iron atom (in this state the myoglobin molecule is called oxymyoglobin). After several days of exposure to air, the iron atom of myoglobin becomes oxidized and loses its ability to bind oxygen. In this oxidized condition, meat turns to a brown color. Although the presence of this color is not harmful, it indicates that the meat is no longer fresh. Oxymyoglobin and metmyoglobin of fresh meat myoglobin, color, and capacity of iron are variable, and this could be the reason for the change in the lightness (L*) and redness–greenness (a*) values of lamb meat immediately after slaughter in our study (Table 5). Furthermore, other reasons for meat color changes immediately after slaughter in the current study can be related to the cytochrome oxidase, which causes the oxidation of substances in the muscle in order to provide energy by linking oxygen with the electron transport chain. After slaughter, meat cytochrome enzymes are able to use oxygen for a while. Another reason for beef color change is pH changes. The red color of beef becomes darker due to the absorption of myoglobin and increasing the pH (Lawrie and Ledward, 2006). The surface of such meat, which has high pH, does not scatter light as much as the more open surface of meat with a low final pH, which makes it appears dark. Therefore, in our study, the decrease in the amount of redness–greenness (a*) in lambs fed with diet containing different levels of grass pea hay immediately after slaughter (Table 5) could be related to the decrease in meat pH of these lambs. Oxygen requirement in the lamb meat is higher than the beef meat, and this may be related to the greater tendency of this meat to the color change during storage as fresh meat (Jacob et al., 2014).

Table 3. Effect of different levels of grass pea hay on the performance of growing lambs

Performance	Grass pea level (% of dry matter)				SEM	*P*-value	
	0	10	20	30		Treatment	Orthogonal[1]
Dry matter intake (g/d)	1261.77	1519.10	1402.88	1292.12	107.87	0.36	0.22
Average daily gain (g/d)	188.63[ab]	224.88[a]	205.94[ab]	167.37[b]	17.80	0.04	0.04
Feed efficiency	0.15	0.15	0.15	0.13	0.01	0.08	0.11

[1] Comparison between diet without grass pea hay and diet containing different levels of grass pea hay.
[a-c] Means within a row with different superscripts are significantly different ($P < 0.05$).

Table 4. Effect of different levels of grass pea hay on carcass parameters of growing lambs and virtual water consumption

Carcass characteristic	Grass pea level (% of dry matter)				SEM	*P*-value	
	0	10	20	30		Treatment	Orthogonal[1]
Hot carcass weight (kg)	22.92	23.12	23.56	22.46	1.23	0.94	0.57
Dressing (%)	52.54	49.62	50.39	51.04	1.13	0.35	0.47
Carcass cuts (% of carcass weight)							
Neck weight	6.35	6.52	6.57	6.54	0.43	0.98	0.99
Shoulder weight	14.97	15.58	15.63	15.78	0.55	0.74	0.79
Breast flank weight	16.08	17.26	16.71	16.40	0.70	0.68	0.51
Loin weight	6.73	7.41	6.32	6.65	0.51	0.51	0.73
Leg weight	33.19	33.78	29.30	33.29	2.08	0.43	0.50
Tail weight	22.66	19.43	25.44	21.29	2.37	0.37	0.70
Virtual water consumption							
Virtual water/treatment (m^3)	167.63[a]	160.23[a]	119.38[b]	83.82[c]	5.18	< 0.01	<0.01
Virtual water/kg carcass (m^3)	7.43[a]	6.97[a]	5.09[b]	3.76[c]	0.35	< 0.01	<0.01

[1] Comparison between diet without grass pea hay and diet containing different levels of grass pea hay.
[a-c] Means within a row with different superscripts are significantly different ($P < 0.05$).

Table 5. Effect of different levels of grass pea hay on meat chemical composition and color characteristics of growing lambs

Property	Grass pea level (% of dry matter)				SEM	*P*-value	
	0	10	20	30		Treatment	Orthogonal[1]
Chemical composition (g/kg of meat)							
Moisture	29.25	29.24	29.00	28.75	1.17	0.99	0.80
Protein	21.58	22.66	21.91	21.78	0.60	0.59	0.50
Fat	5.92	5.84	5.08	5.47	1.55	0.98	0.99
Ash	1.75	0.75	2.00	1.50	0.55	0.45	0.85
Color characteristics (immediately after slaughter)							
Lightness (L*)	36.50[a]	25.71[b]	23.12[b]	22.50[b]	2.16	0.02	0.48
Redness–greenness (a*)	201.04[a]	151.92[b]	143.67[b]	165.71[ab]	13.19	0.04	0.29
Blueness–yellowness (b*)	207.79	159.17	151.04	185.79	18.51	0.17	0.20
Color characteristics (24 h after slaughter)							
Lightness (L*)	43.50	25.67	45.33	30.87	6.55	0.15	0.57
Redness–greenness (a*)	256.00[b]	191.17[b]	331.00[a]	245.17[b]	23.80	0.01	0.59
Blueness–yellowness (b*)	255.71[bc]	203.25[c]	373.67[a]	309.50[ab]	24.61	0.02	0.49

[1] Comparison between diet without grass pea hay and diet containing different levels of grass pea hay.
[a,b] Means within a row with different superscripts are significantly different ($P < 0.05$).

CONCLUSION

It was concluded that alfalfa substitution with grass pea hay had no significant effect on performance and carcass quality of fattening Kurdish lambs and it is recommended that diet inclusion of grass pea hay up to 30% of DM, had no adverse effect on health status of lambs.

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CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Conceptualization: Farshid Fatahnia, Hoshang Jafari; Methodology: Parisa Darat; Software: Hoshang Jafari; Formal analysis: Farshid Fatahnia, Hoshang Jafari, and Golnaz Taasoli; Resources: Farshid Fatahnia; Investigation: Parisa Darat, Hoshang Jafari, Seifali Varmaghani, and Jabar Jamali; Data curation: Parisa Darat and Hoshang Jafari; Writing—original draft preparation: Parisa Darat and Golnaz Taasoli; Writing—review and editing: Golnaz Taasoli; Supervision: Farshid Fatahnia, Hoshang Jafari, Golnaz Taasoli, and Seifali Varmaghani; Project administration: Farshid Fatahnia and Hoshang Jafari; Funding acquisition: Farshid Fatahnia and Hoshang jafari.

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DATA AVAILABILITY

Data will be made available upon reasonable request.

DECLARATION OF COMPETING INTEREST

None.

ETHICAL STATEMENT

This study was done according to the Iranian Council of Animal Care (1995).

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