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Effects of Sumac (*Rhus coriaria*) Seeds and Exogenous Fibrolytic Enzymes on Wool Growth of Awassi Male Lambs

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ABSTRACT

Nutrition can have a significant effect on animal production. In recent years, many compounds have been widely used as feed additives to stimulate animals' appetites and consequently improve animal productivity. Exogenous fibrinolytic enzymes are one of these feed additives, which have been used as a digestive stimulant in different types of animals. Sumac (*Rhus coriaria*) seeds and leaves have been widely used as an appetite stimulant. Therefore, this study aimed to determine the dietary effects of using 0.3% exogenous fibrolytic enzymes and 3% of grinds *Rhus coriaria* seeds on wool production and some physical traits of the Awassi lambs. Twenty-four male Awassi lambs with an average age of 4 months were randomly assigned to four dietary treatments, each containing six animals. The control group received a basal diet equivalent to 2% of body weight. The second group received the same diet supplemented with 3% sumac (*Rhus coriaria*) powder. The third group received the basal diet supplemented with 0.3% exogenous fibrolytic enzymes (protease, amylase, and cellulase). The fourth group received the basal diet supplemented with both 3% *Rhus Coriaria* powder and 0.3% exogenous fibrolytic enzymes. The experiment lasted 130 days in the animal house belonging to the College of Veterinary Medicine in Iraq. Some wool traits, including wool staple length, clean wool weight, greasy wool weight, wool fiber length, and wool fiber diameter, were measured. The results revealed significant differences in all measured wool quality traits among the treated groups compared to the control group. The group receiving the diet supplemented with a combination of exogenous fibrolytic enzymes and *Rhus coriaria* powder exhibited the most significant improvements in wool growth, overall wool production, and physical characteristics. These findings highlight the potential of using exogenous fibrolytic enzymes and sumac as effective appetite stimulants and enhancers of wool production in Awassi lambs.

Keywords: Awassi Lambs, Fibrolytic enzymes, Staple, *Rhus Coriaria,* Wool

INTRODUCTION

Nutrition plays a significant role in determining wool characteristics and quality in sheep, along with genetic factors (Safari et al., 2005). The type of feed provided to sheep can influence wool production patterns (Holman et al., 2014). Wool growth is influenced by the availability of feed resources relative to the sheep's energy and maintenance requirements, which can vary in different conditions, such as during transportation over long distances or lactation periods (Holman and Malau-Aduli, 2013). Improved nutrition through enriched feeds has been associated with increased wool production, including thicker wool fiber diameter and enhanced wool growth, which are influenced by both genetics and nutrition (Jamshed Khan et al., 2012). Some medicinal plants feed additives such as sumac (*Rhus Coriaria*) have positive effects on the digestive system and are often good sources of some minerals, vitamins, and organic acids, such as malice, citric and tartaric acids. In addition, *Rhus coriaria* has antiviral, anti-inflammatory, anti-gastric disturbances, antioxidant, antibacterials, and antidiarrheal effects (Duke et al., 2003; Khayatnouri et al., 2011).

Feed additives are commonly used in animal diets to improve metabolism and enhance palatability (Wafar et al., 2023) Some feed additives added are commonly used in animal diets to improve metabolism and enhance palatability (Khudhair and Al-Saadi, 2022; Wafar et al., 2023). These feed additives are frequently used in ruminants' diets to enhance digestion metabolism rate and are also used as growth promoters (Beauchemin et al., 2001). Some investigators revealed that fibrolytic enzymes, such as protease, cellulose, and xylanase increase, have been found to improve nutrient digestion and utilization as well as mitigate the negative effects of some types of feed certain feeds in both ruminants and monogastric animals (Salem et al., 2013). In normal cases, ruminal microflora produces sufficient amounts of enzymes that have important benefits for improving digestibility and enhancing animal performance by increasing feed consumption and feed conversion efficiency (Wang et al., 2012). So, the main objective of the current study was to

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investigate the effects of feeding Awassi male lambs a diet supplemented with 0.3 % of% exogenous fibrolytic enzymes, including (Protease, Cellulase, and Amylase), and 3% (*Rhus coriaria*) ground sumac seeds, (*Rhus coriaria*), mixed or separately to the diet of the Awassi male lambs on their wool production and some of its physical characteristics (Khudhair and Al-Saadi, 2022). These feed additives are frequently used in ruminants' diets to enhance digestion metabolism rate and are also used as growth promoters (Beauchemin et al., 2001). Fibrolytic enzymes such as protease, cellulase, and xylanase have been found to improve nutrient digestion and utilization while mitigating the negative effects of certain feeds in both ruminants and monogastric animals (Salem et al., 2013). In normal cases, ruminal microflora produces sufficient amounts of enzymes that have important benefits for improving digestibility and enhancing animal performance by increasing feed consumption and feed conversion efficiency (Wang et al., 2012). So, the main objective of the current study was to investigate the effects of supplementing the diet of Awassi male lambs with 0.3% exogenous fibrolytic enzymes (Protease, Cellulase, and Amylase), and 3% ground sumac seeds (*Rhus coriaria*), mixed or separately to the diet of the Awassi male lambs on their wool production and physical characteristics.

MATERIALS AND METHODS

Ethical approval

The design and procedure of the current experiment were approved by the Scientific Research Committee of the Department of Public Health College of Veterinary Medicine (Iraq) for approval of the experimental protocols at the annual scientific meeting of Baghdad University on 12-2-2021 with project number (PNR/FSM/12/2/2021).

Study period and location

The current research was performed on a farm belonging to the College of Veterinary Medicine, University of Baghdad, Iraq. The experimental duration was 130 days, including 10 days adaptation period, from January to May 2021.

Ingredients of the diet

Table 1 shows the basal diets used in feeding Awassi sheep during the study with their chemical contents formulated according to the Nutrient Requirements of Beef Cattle.

Table 1. The ingredients and chemical composition of the diet for Awassi sheep in Iraq

Content of dry matter (gm /Kg)	
Barley grain	720
Wheat bran	140
Soya meal	120
Dicalcium phosphate*	10.5
Limestone	4.50
Vitamins - minerals mix	1.25
Salt	2.25
Sodium bicarb.	1.50
Chemical composition (DM %)	
OM	84.5
NFE	57.5
CP	16.5
ADF	24.5
NDF	53.5
CF	23.5
Ash	12.0
EE	1.8
Energy (MJ/Kg DM)	26.5

CP: Crud protein- TDN: Total digestible nutrient- NDF: Neutral detergent-fiber- ADF: Acidic detergent fiber- NFE: Nitrogen- free extract- EE: Ether extract-CF: Crud fiber- DM: Dry matter-OM: Organic matter- Dicalcium phosphate*- : 28% Ca, 19%P-(NRC, 2000).

Experimental design

A total of 24 Awassi male lambs, averaging 4 months in age and weighing 20 ± 0.5 kg, were included in this study. The lambs were provided with a concentrated basal diet (Table 1) and allowed to freely graze on Alpha-Alpha plants for 2-4 hours daily. Lambs were randomly divided into four dietary treatments, each consisting of six animals. To ensure accurate individual data collection and minimize experimental error, each treatment group was housed in a separate pen measuring 2.5 m × 2 m during feeding. The diet was formulated every 2 weeks. The first group was fed a 2% of body

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weight basal diet and regarded as the control group. The second group was fed the same percentage containing 3 % *Rhus coriaria* powder. The third group was fed the same percentage of basal diet per head containing 0.3% of exogenous fibrolytic enzymes, including Protease, Amylase, and Cellulase enzymes (Bioagripharm GmbH-56564-Germany, batchNo.21664). The fourth group fed the same percentage a head containing 3 % *Rhus coriaria* powder and 0.3%of exogenous fibrinolytic enzymes (Ikusika et al., 2019).

Sampling

Three sampling periods were conducted between January 1 and May 10, 2021, with 2.5 months intervals. The first sample was taken at the beginning of the experiment on day 1, the second sample at day 75, and the third sample at day 130. Samples were collected from all sheep in the experimental groups. A 5x5 cm² area of wool was sheared from the right chest's last ribs to measure wool growth and physical characteristics such as greasy wool weight, clean wool weight, wool staple length, fiber length, and fiber diameter (Al-Saadi et al., 2012; Al-Saadi and Al-Zubiadi, 2016).

Statistical analysis

All results were documented using Microsoft Office Excel and analyzed statistically using the SPSS software, version 24. Data were analyzed with a complete randomized design method, and the Least Significant Differences (LSD). The level of significance was considered $p < 0.05$ to identify the differences between different groups (Chemezova and Zaykov, 2014).

RESULTS

According to Table 2, there was a significant ($p < 0.05$) increase in greasy wool weight for groups G2, G3, and G4 during the second and third sampling periods compared to the control group. However, there were no significant differences among the groups during the first sampling period. Similarly, clean wool weight followed a similar trend (Table 3). Group G4, which received a combination of feed additives, showed significantly higher levels, compared to both the *Rhus coriaria* and Exogenous fibrinolytic enzymes groups individually, as well as the control group ($p < 0.05$). These differences were particularly pronounced in the last two sampling periods. However, there were no significant differences between the groups during the first sampling period

The weight increase of wool fibers in all treated groups is closely related to the increase in wool fiber length, staple length, and wool fiber diameter. These changes were evident in the results presented in Tables 4, 5, and 6. All treated groups showed a significant increase ($p < 0.05$), with the mixed group (G4) demonstrating the highest levels compared to both the *Rhus coriaria* and exogenous fibrolytic enzymes groups, particularly during the third sampling period. The control group exhibited significantly ($p < 0.05$) lower levels, compared to all treated groups, especially during the last two sampling periods. However, there were no significant differences between the groups in the first sample.

Table 2. Effects of *Rhus coriaria* seed and exogenous fibrolyic enzymes on greasy wool weight (g) of Awassi male lambs in Iraq

Group	Control group	*Rhus coriaria* group	Enzymes group	Mixed group	LSD
First sampling	1.87 ± 0.94^{a}	1.86 ± 0.32^{a}	1.85 ± 0.42^{a}	1.84 ± 0.24^{a}	0.66
Second sampling	0.55 ± 0.73^{c}	0.93 ± 0.41^{b}	0.82 ± 0.67^{b}	1.10 ± 0.11^{a}	0.15
Third sampling	2.11 ± 0.45^{d}	2.68 ± 0.24^{b}	2.34 ± 0.47^{c}	2.84 ± 0.31^{a}	0.14

^{A,b,c} superscript letters in the same row means significant differences within groups at $p < 0.05$. The data expressed as means ± SE

Table 3. Effects of *Rhus coriaria* seed and fibrolyic enzymes on clean wool weight of Awassi male lambs (g) in Iraq

Group	Control group	*Rhus coriaria* group	Enzymes group	Mixed group	LSD
First sampling	1.47 ± 0.15^{a}	1.46 ± 0.33^{a}	1.48 ± 0.81^{a}	1.46 ± 0.21^{a}	0.25
Second sampling	0.50 ± 0.43^{c}	0.91 ± 0.75^{a}	0.75 ± 0.36^{b}	1.05 ± 0.44^{a}	0.15
Third sampling	1.65 ± 0.73^{c}	2.05 ± 0.54^{b}	1.98 ± 0.45^{b}	2.22 ± 0.15^{a}	0.14

^{A,b,c} superscript letters in the same row means significant differences within groups at $p < 0.05$. The data expressed as means ± SE

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Table 4. Effects of *Rhus coriaria* seed and fibrolyic enzymes on wool fibers length (cm) of Awassi male lambs in Iraq

Group	Control group	*Rhus coriaria* group	Enzymes group	Mixed group	LSD
First sampling	7.35 ± 0.57^{a}	7.92 ± 0.75^{a}	7.38 ± 0.61^{a}	7.74 ± 0.82^{a}	0.31
Second sampling	4.34 ± 0.22^{c}	4.99 ± 0.34^{b}	4.70 ± 0.74^{b}	5.41 ± 0.74^{a}	0.26
Third sampling	5.40 ± 0.13^{c}	6.08 ± 0.54^{b}	5.93 ± 0.36^{b}	6.89 ± 0.74^{a}	0.22

^{A,b,c} superscript letters in the same row means significant differences within groups at $p < 0.05$. The data expressed as means ± SE

Table 5. Effects of *Rhus coriaria* seed and fibrolyic enzymes on wool staple length (cm) of Awassi male lambs in Iraq

Group	Control group	*Rhus coriaria* group	Enzymes group	Mixed group	LSD
First sampling	7.38 ± 0.24^{a}	7.22 ± 0.32^{a}	7.27 ± 0.12^{a}	7.41 ± 0.78^{a}	0.33
Second sampling	4.40 ± 0.17^{c}	4.89 ± 0.54^{b}	4.72 ± 0.31^{b}	5.21 ± 0.44^{a}	0.25
Third sampling	5.22 ± 0.34^{d}	5.72 ± 0.24^{c}	6.70 ± 0.19^{b}	$6.\ 92 \pm 0.22^{a}$	0.17

^{A,b,c,d} superscript letters in the same row means significant differences within groups at $p < 0.05$. The data expressed as means ± SE

Table 6. Effects of *Rhus coriaria* seed and fibrolyic enzymes on wool fiber diameter (μ) of Awassi male lambs in Iraq

Group	Control group	*Rhus coriaria* group	Enzymes group	Mixed group	LSD
First sampling	29.15 ± 0.35^{a}	28.72 ± 0.25^{a}	28.65 ± 0.33^{a}	28.84 ± 0.15^{a}	0.38
Second sampling	30.21 ± 0.39^{c}	31.25 ± 0.14^{b}	31.54 ± 0.24^{b}	32.11 ± 0.30^{a}	0.15
Third sampling	31.54 ± 0.43^{d}	33.25 ± 0.58^{b}	32.65 ± 0.48^{c}	34.36 ± 0.30^{a}	0.46

^{A,b,c,d} superscript letters in the same row means significant differences within groups at $p < 0.05$. The data expressed as means ± SE

DISCUSSION

The results of the present study showed a significant difference regarding all investigated variables in all groups compared to the control group ($p < 0.05$), particularly in the group supplemented with 3% *Rhus coriaria* and 0.3% exogenous fibrolytic enzymes during the last two sampling periods. These positive effects can be attributed to the synergistic effects of both feed additives. It is likely that these additives acted as appetite enhancers and had high levels of vitamin C (Ascorbic acid), especially in *Rhus coriaria*, which is known for its antioxidant properties. Additionally, the exogenous fibrolytic enzymes improved rumen digestibility by activating microflora (Al-Saadi and Mohammed, 2022). These findings are consistent with previous studies conducted by various researchers (Rowe et al., 1989; Masters et al., 1998; Al-Saadi et al., 2012). These authors reported that some feed additives act as appetite promotors, and have positive effects wool growth and the quality of wool (Al-Saadi et al., 2012). nThe positive changes observed in this study could be attributed to increased blood circulation in the skin, leading to improved nutritional supply. This improvement is influenced by the type and nutritional value of the diet supplementation (Jamshed Khan et al., 2012). However, the levels of wool growth can vary depending on the sheep genotype, and is influenced by numerous physiological and dietary factors (Malau-Aduli et al., 2019). This suggests that feeding medicinal plants, such as *Rhus coriaria*, to animals can have stimulatory effects on their digestive system, which are considered a good source of protein, minerals, vitamins, as well as antioxidants, antibacterial, and antidiarrheal compounds (Reis et al., 1992). According to Malau-Aduli et al. (2019), the positive improvements in wool production and quality can be attributed to the increased absorption of specific amino acids, such as cysteine. Additionally, wool growth in certain sheep breeds, like Merino, responds to changes in nutrition throughout the year. Increasing essential nutrients during the appropriate seasons can lead to an increase in the rate of wool growth (Kott et al., 1999; Allden, 1979) reported the improvement of rumen digestive action as a result of sumacs and exogenous fibrinolytic enzymes supplementation (Kott et al., 1999). Furthermore, several authors have reported that supplementation of sumacs and exogenous fibrolytic enzymes can enhance rumen digestion (Kott et al., 1999). Similarly, numerous studies have demonstrated improved digestibility of fibrous diets in ruminants through the use of various biotechnological products such as direct-fed microbes, ionophores, and cell wall degrading enzymes. By supplementing fibrinolytic enzymes and incorporating sumacs as appetite promoters in the diets, viable rumen microflora and the growth and movement of ruminal microorganisms can be increased. This, in turn, leads to greater absorption of amino acids and minerals through the intestinal mucosa, thereby significantly influencing the metabolic protein resource available to the animal's tissues (Reis et al., 1992). Therefore, these feed additives that are supplemented in the diet of livestock can improve levels of wool growth production by an increase in protein rates and mineral resources (Nsereko et al., 2002; Al-Saadi and Al-Zubiadi, 2016).

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It is noteworthy that these results are consistent with findings from other studies, where researchers observed clear improvements in the digestibility of neutral detergent fiber, organic matter, dry matter, and acid detergent fiber in sheep fed a diet enriched with fibrolytic enzymes. These improvements ultimately contributed to enhanced wool production overall (Titi and Tabbaa, 2004). However, data obtained from the current study revealed that the effects of *Rhus coriaria* seeds were more significant, compared to exogenous fibrolytic enzymes in the last two sampling periods and approximately in all parameters. This could be attributed to the appetite-enhancing properties of *Rhus coriaria*, as well as its rich nutrient content, including vitamins, minerals, and antioxidant substances. These findings align closely with previous studies. Jafari et al. (2004) and Allden (1979) reported similar observations, highlighting a positive linear correlation between feed intake, dry matter, and wool growth. In contrast to the present results, some researchers have reported no correlation between nutrient values and wool production (Moioli et al., 2015). On the other hand, other studies have suggested that wool growth levels are influenced by changes in body weight as a result of overall body growth (Kott et al., 1999; Al-Saadi and Al-Zubiadi, 2016). These findings have indicated that the effects of weight changes on wool production levels and the relationship between energy and wool growth remain unclear and require further in-depth investigation (Jafari et al., 2004; Titi and Tabbaa, 2004). Some researchers have determined that high level of wool production is related to an increase in dry matter intake (Malau-Aduli et al., 2019). This increase represented the increase in fiber size created in normal feed levels (Reis and Panaretto, 2001). Moreover, the present study aligns with other researchers who have suggested that wool quality and growth depend on the type of protein added to the diet and the amount provided (Masters et al., 1998). Certain types of protein are rich in amino acids, particularly cysteine, which significantly influence follicular uptake and wool fiber production (Li et al., 2008). Therefore, an increase in amino acid levels, especially those containing sulfur, leads to enhanced protein availability and improved nutrient uptake by wool follicles (Malau-Aduli and Holman, 2010; Malau-Aduli et al., 2019).

CONCLUSION

The positive effects of supplementing the diet of Awassi sheep with both sumacs and exogenous fibrolytic enzymes have been observed in terms of enhanced wool production and improved physical quality. These effects were observed when the additives were used separately or in combination. Based on these findings, it is recommended to further investigate the effects of seasons and different percentages of these feed additives. Additionally, studying the effects of supplementing minerals on wool production could also be beneficial.

DECLARATIONS

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Author's contributions

M.J.Al-Saadi developed the idea and conducted the laboratory work writing, editing, and creation of the final draft. The author read and approved the final draft.

Competing interests

The authors have not declared any conflict of interest.

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Availability of data and materials

All data are available on request.

Ethical consideration

The authors take steps to abide by all ethical standards related to plagiarism, publication approval, inaccuracies in data, multiple submissions, and double publication.

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