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Effect of various levels of dietary whole cottonseed on blood parameters and performance of Awassi lambs under heat stress

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Abstract

This study was carried out to determine the effect of whole cottonseed (WCS) supplementation on finishing performance and blood parameters of Awassi lambs under heat stress. The compositions of diets for the various treatments were i) control: concentrate without WCS plus 15% wheat straw; ii) 8.5% WCS, 76.5% concentrate and 15% wheat straw; and iii) 17% WCS, 68% concentrate plus 15% wheat straw. Twenty seven male Awassi lambs (4 - 5 months old) were allotted to three dietary treatments in equal numbers for each diet in a completely randomized design. Following 15 days of diet adaptation, lambs were fed the experimental diets ad libitum for 56 days. According to the finishing trial, average daily gain (ADG), feed intake (FI), dry matter intake (DMI), feed efficiency and water consumption were not affected by the inclusion of WCS. Only numerical increment of daily gain, FI and DMI was observed in the 8.5% WCS group. Supplementation of WCS did not affect blood glucose, urea, total protein, albumin and potassium levels, but blood cholesterol level was increased. Changes in scrotal circumference were observed with supplementation of 17% WCS. As a result, WCS can replace concentrate up to 8.5% of diet without negative effects on finishing performance of Awassi lambs under heat stress conditions.

Keywords: Sheep, finishing, efficiency, gain, oil seed
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Introduction

Cotton is one of the main crops that are produced in Turkey. Following a cotton harvest, there may be by-products which are used as supplementary feeds for ruminants. The annual production of whole cottonseed (WCS) in 2016 in Turkey was approximately 1 580 000 t (TUIK, 2017). Increasing demands for energy and protein by high-producing ruminants increased the importance of WCS as an energy and protein supplement. Whole cottonseed is a unique feedstuff because of its high content of energy, mainly in the form of oil, moderately high levels of crude protein (CP) and high quality fibre (Adams *et al.*, 1995; Abel-Caines *et al*., 1997; Harvatine *et al*., 2002). The rumination of WCS, in contrast with the other processed cottonseed products, causes a slower release of the nutrients, and this makes the feeding of cottonseed even more beneficial to animals (Martin, 1990). Whole cottonseed is a potential feed source for sheep and goats owing to its rich nutrient contents. The energy in cottonseed is derived primarily from fat, which should not interfere with forage digestion when it is fed at recommended levels (Poore & Rogers, 1995). Whole cottonseed depresses fibre digestibility because of the content of unsaturated long-chain fatty acids, which have adverse effects on ruminal microbes (Palmquist, 1995). Warren *et al*. (1988) reported that feed intake (FI) and digestibility were decreased when more than 30% WCS was included in a diet. Additionally, Dayani *et al.* (2011) indicated that WCS in the diet of fattening lambs should be lower than 20%. Feeding WCS up to 20% of the diet decreased average daily gain (ADG) and feed conversion of fattening male lambs. Luginbuhl *et al*. (2000) reported that increasing WCS levels in diets of growing male goats increased serum urea nitrogen level quadratically. In contrast, Dayani *et al.*(2011) reported that adding 20% of WCS in the diet did not significantly affect blood urea concentration, but decreased significantly when the CP level was reduced to 12%.

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The effect of adding WCS to finishing Awassi lamb diets under heat stress has not been extensively investigated. Animals experience heat stress when body temperature exceeds the optimal range specified for normal activity because heat load is higher than heat dissipation (Bernabucci *et al*., 2010). McDowell (1972) indicated that notable changes in FI and physiological processes take place with temperatures higher than 25 °C. The addition of fat to the diet of heat-stressed dairy cows increases net energy intake because of higher energy density and its lower heat increment in comparison with fibre and starch (Baldwin *et al*., 1980; Morrison, 1983; Beede & Collier 1986; Knapp & Grummer, 1991). Therefore, the aim of this research was to determine the effect of WCS supplementation on finishing performance and blood parameters of Awassi lambs under heat stress.

Materials and Methods

Ethical clearance (19/2016) for this study was granted by the Dollvet Ethical Committee (a private vaccine company in Sanliurfa). Twenty-seven Awassi male lambs (4 - 5 months old) were randomly allotted to nine small pens, with three lambs each, and three pens for each treatment. Pens had a soil floor, were open-sided, naturally ventilated and equipped with adequate feeding and watering equipment. The compositions of experimental diets given to the various treatments were i) control: concentrate without WCS plus 15% wheat straw:, ii) 8.5% WCS, 76.5% concentrate and 15% wheat straw; and iii) 17% WCS, 68% concentrate plus 15% wheat straw. The feed ingredient and chemical composition of the diets are presented in Table 1. Following 15 days of diet adaptation, diets were fed on an ad libitum basis twice a day (105% of actual intake) at 06:00 and 18:00 for 56 days under heat stress conditions (average temperature of 30.8 °C with lowest 15.8 °C and highest 43.2 °C and average daily humidity 26.6% with lowest 24.2% and highest 32%). The amounts of feed offered per pen were recorded and adjusted according to feed refusals daily. Animals were weighed at two-week intervals throughout the trial. However, initial and final weights were taken on two consecutive days. Fresh clean water was available at all times and water consumption was recorded daily. Rectal temperatures of lambs were measured three times a day (before feeding, and two and four hours after feeding) at two-week intervals throughout the trial. Scrotal circumference and length were measured with a measuring tape at the start and end of the trial.

Table 1 Ingredients and chemical composition of Awassi lambs finishing trial diets

	Diets (% as fed basis)		
	Control	**8.5% WCS**	**17% WCS**
Ingredient composition			
Wheat straw	15	15	15
Whole cottonseed	0	8.5	17
Concentrate	85	76.5	68
Chemical composition			
Dry matter (DM)	91.50	91.35	90.90
ME (Mcal/kg DM)	2.554	2.559	2.564
Crude fibre	13.11	14.32	16.51
Acid detergent fibre	17.64	20.85	23.02
Neutral detergent fibre	39.25	43.14	47.04
Crude protein	15.07	15.88	16.74
Crude ash	8.95	8.57	8.33
Cost of diets $/kg	0.275	0.259	0.244

ME: metabolizable energy (calculated)

The diets were analysed for dry matter (DM), CP, crude fibre and crude ash by procedures of the AOAC (1990). Acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents of diets were measured according to the procedure of Goering & Van Soest (1970). Blood samples were collected from each lamb before morning feed on day 56 of trial. Blood samples (5 mL) were collected via jugular puncture into 10 mL heparinized tubes. Then they were centrifuged (4000 × *g*, 15 min) and analysed the same day by using a kit

with an auto analyser (Cobat Integra800). The analyses of blood testosterone and oestradiol concentrations were assayed in immunoassay analysers (Beckman-Coulter Dexl-800).

Data of the experiment were analysed in a completely randomized using the GLM procedure of SAS (1989). The means of treatment were compared using Fisher's least significant difference (LSD) test.

Results and Discussions

The effects of diets on ADG, FI, DMI, feed efficiency and water consumption are shown in Table 2. According to the finishing trial, ADG , FI, DMI, feed efficiency and water consumption were not affected by the inclusion of WCS (P >0.05) in the diet. The effect of diets on ADG was not significant, but the gain of the 8.5% WCS treatment was numerically higher (267 g/d) than the control group (248 g/d). Luginbuhl *et al*. (2000) indicated that increasing the WCS level in diet decreased daily gain and feed efficiency linearly in goats. On the other hand, Kandylis *et al*. (1998) reported higher ADG in fattening lambs fed diets containing WCS, while lambs' final weight and feed conversion were similar between the groups. Dayani *et al*. (2011) reported that feeding WCS up to 20% of the diet decreased ADG and feed conversion in fattening male lambs. Devendra & Lewis (1974) explained this reducing performance of WCS meal usage as coating of fibre by lipids, shortage of cations owing to formation of insoluble soaps, inhibition of rumen microbial activity and modification of the microbial population. In this study, the negative effect of WCS was not observed in Awassi lambs because low levels of WCS were used. The ADG of 8.5% WCS group (268 g/d) had similar values to former studies of Can *et al* (2004) and Can *et al* (2005) with the same breed under similar conditions.

In this study DMI was not influenced by dietary inclusion of WCS. A similar result was reported by Dayani *et al*. (2011). In contrast, Kandylis *et al*. (1998) reported an increase of DMI when WCS was fed up to 30% WCS of growing-fattening lambs diets. On the other hand, in some studies a decline in DMI was reported (Luginbuhl *et al*., 2000). The feed efficiency value of the current study was found to be higher than former studies of Can *et al*. (2004) and Can *et al*. (2005). This can be explained by different initial and final bodyweights of lambs and diet composition in their studies.

Table 2 Effect of diets containing whole cottonseed on finishing performance of Awassi lambs

	Diets			*P*
	Control	**8.5% WCS**	**17%WCS**	
Number of lambs	9	9	9	
Initial bodyweight (kg)	29.38 ± 0.813	29.29 ± 0.419	29.40 ± 0.184	0.989
Final bodyweight (kg)	43.27 ± 0.349	44.24 ± 0.428	42.91 ± 0.894	0.836
Average daily gain (g/d)	248 ± 8.533	267 ± 5.583	241 ± 13.078	0.223
Daily feed intake (g/d)	1559 ± 21.074	1570 ± 38.033	1564 ± 16.614	0.936
Daily dry matter intake (g/d)	1427 ± 19.283	1434 ± 34.744	1415 ± 15.103	0.861
Feed efficiency (kg feed DM/kg gain)	5.76 ± 0.119	5.37 ± 0.099	5.90 ± 0.315	0.242
Average water consumption (L/day)	6.52 ± 0.812	5.75 ± 0.168	6.00 ± 0.307	0.447

WCS: whole cottonseed

The effects of feeding WCS on blood serum parameters of the Awassi lambs are presented in Table 3. Replacing the concentrate with WCS in lamb diet did not affect plasma glucose, urea, total protein, albumin and potassium levels (P >0.05). Dayani *et al.* (2011) reported a similar result in that blood glucose and urea levels were not affected by feeding diets containing WSC to fattening lambs. In contrast to the current study, blood serum protein concentration increased linearly in goats as dietary WCS level increased (Solaiman *et al.,* 2009). Free gossypol of WCS depresses serum albumin and total protein concentrations (Risco *et al*., 1992). Additionally, Luginbuhl *et al*. (2000) reported that with increasing WCS level in diets of male goats, serum urea concentration increased. Glucose, urea and total protein levels of lambs were similar in a former study by Can *et al.* (2005).

The blood cholesterol concentrations of the lambs fed the diets containing WCS were significantly (P <0.05) higher than that of lambs fed the control diet. Similarly, Dayani *et al.* (2011) reported that blood cholesterol concentrations increased by feeding WCS owing to higher fat and fatty acid content of the diet

containing WSC. Potassium (K) concentration of blood serum was not affected significantly by the use of WSC in this study (*P* = 0.081). Likewise, Belibasakis & Tsirgogianni (1995) reported that serum K concentration was not significantly different with the addition of 25% of WCS to the diets of dairy cows. On the contrary, Colin-Negrete *et al*. (1996) reported linear increment of serum K concentration when WSC was included in the diet of growing heifers at levels of 15% or 30%.

Table 3 Effect of diets containing whole cottonseed on some blood serum parameters of finishing Awassi lambs

	Diets			*P*
	Control	8.5% WCS	17% WCS	
Glucose (mg/dL)	74.11 ± 3.061	69.33 ± 3.101	71.22 ± 2.587	0.542
Urea (mg/dL)	49.22 ± 2.924	56.89 ± 3.678	48.00 ± 0.771	0.120
Cholesterol (mg/dL)	47.33^{b} ± 2.607	72.78^{a} ± 1.177	72.00^{a} ± 5.332	0.003
Total protein (g/dL)	6.58 ± 0.230	7.28 ± 0.178	6.99 ± 0.259	0.166
Albumin (g/dL)	1.40 ± 0.019	1.43 ± 0.033	1.36 ± 0.029	0.220
Potassium (mmol/L)	4.79 ± 0.062	5.06 ± 0.190	5.28 ± 0.078	0.081

$^{a-b}$ Within rows, means with different superscripts are significant at *P* <0.05
WCS: whole cottonseed

Rectal temperatures of lambs are presented in Table 4. Replacing the concentrate with WCS in lamb diet did not affect their rectal temperatures (*P* >0.05). Can *et al.* (2005) reported similar rectal temperature values (39.7 - 39.8 °C) when Awassi lambs were fed with diets containing urea or fish meal under heat stress.

Table 4 Effect of diets containing whole cottonseed on rectal temperature (°C) of finishing Awassi lambs

Time of measure	Day of measure	Diets			*P*
		Control	8.5% WCS	17% WCS	
Before feeding	14	39.28 ± 0.116	39.33 ± 0.139	39.35 ± 0.147	0.920
	28	39.29 ± 0.120	39.30 ± 0.067	39.13 ± 0.084	0.400
	42	39.32 ± 0.080	39.41 ± 0.212	39.26 ± 0.019	0.746
	56	39.33 ± 0.019	39.21 ± 0.068	39.06 ± 0.039	0.176
2 h after feeding	14	39.71 ± 0.029	39.65 ± 0.073	39.68 ± 0.048	0.761
	28	39.55 ± 0.116	39.53 ± 0.062	39.61 ± 0.078	0.827
	42	39.80 ± 0.084	39.79 ± 0.106	39.69 ± 0.033	0.630
	56	39.45 ± 0.011	39.57 ± 0.058	39.46 ± 0.39	0.171
4 h after feeding	14	39.73 ± 0.153	39.63 ± 0.019	39.73 ± 0.077	0.734
	28	39.75 ± 0.062	39.69 ± 0.033	39.74 ± 0.195	0.938
	42	39.74 ± 0.111	39.75 ± 0.174	39.62 ± 0.056	0.716
	56	39.60 ± 0.084	39.57 ± 0.062	39.48 ± 0.068	0.500

WCS: whole cottonseed

The effects of feeding WCS on change of scrotal circumference and scrotal length, oestradiol and testosterone levels of the Awassi lambs are presented in Table 5. Usage of 17% WSC increased scrotal

circumference significantly (P <0.05). In contrast, Arshami & Ruttle (1989) reported that no effect on scrotal circumference was detected when sheep fed with WCS in their diet. On the other hand, Solaiman *et al*., (2009) reported that scrotal circumference decreased linearly in young bucks as the level of WCS increased in the diet up to 32.7%. Calhoun *et al*., (1990) indicated that mature cattle, sheep and goats can tolerate up to 30 mg/kg free gossypol of bodyweight per day for periods greater than 100 days without any clinical health signs. Testosterone and oestradiol hormone levels were not affected by the inclusion of WCS in diets. Former studies indicated a high correlation between scrotal circumference and sperm output (Willett & Ohm, 1957; Bitto *et al*., 2008). Scrotal circumference has been shown to relate favourably to growing rate from birth to adulthood (Lunstra *et al.*, 1988; Smith *et al.*, 1989).

Table 5 Effect of diets containing whole cottonseed on scrotal size, and oestradiol and testosterone concentrations of finishing Awassi lambs

	Diets			*P*
	Control	**8.5% WCS**	**17% WCS**	
Change of scrotal circumference (mm)	73 [a] ± 4.060	91 [ba] ± 3.061	107 [b] ± 7.360	0.032
Change of scrotal length(mm)	39 ± 3.061	38 ± 5.132	45 ± 2.549	0.804
Oestradiol (pg/mL)	20.78 ± 2.409	20.44 ± 1.472	19.22 ± 1.112	0.081
Testosterone (pg/mL)	4.52 ± 1.190	4.03 ± 0.394	3.82 ± 0.755	0.837

[a-b] For each column, mean values with different letters are significant at P <0.05
WCS: whole cottonseed

Conclusion

Feeding WCS up to 17% did not affect FI, DMI, feed efficiency and water consumption in finishing Awassi lamb diets under heat-stress conditions. Supplementation of WCS increased blood cholesterol and potassium levels. Changes of scrotal circumference were observed with supplementation of 17% of WCS. When the cost of WCS is less than that of the concentrate, WCS can replace the concentrate at up to 8.5% of diet without negative effects on finishing performance of Awassi lambs under heat stress conditions, and thus decreasing the cost of the daily gain of a lamb.

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Authors' Contributions

Equal.

Conflict of Interest Declaration

None.

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