The Effect of Protein Source and Formaldehyde Treatment on Growth and Carcass Composition of Awassi Lambs

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ABSTRACT : A trial with twenty-four newly weaned Awassi lambs (initial body weight=21.5±0.8 kg) was conducted using a 3×2 factorial design to study the effect of feeding three sources of protein supplements (soybean meal (SBM), sunflower seed meal (SSM), and cottonseed meal (CSM)), either untreated or formaldehyde-treated on the growth performance and carcass traits of Awassi lambs. Lambs were randomly assigned to one of the six diets (4 lambs/treatment diet) and were individually fed for a period of 107 days. Experimental diets were isonitrogenous and isocaloric. Final live weight and average daily gain (ADG) were affected by both source of protein and formaldehyde treatment (undegradable protein). Lambs fed untreated diets had better ($p<0.01$) daily gain compared to those fed formaldehyde-treated diets. Similarly total feed intake per animal was significantly ($p<0.05$) affected by protein source and formaldehyde treatment. Formaldehyde treatment caused a significant decrease ($p<0.01$) in feed intake compared to lambs fed untreated diets. Feed requirement per unit of gain was not affected by formaldehyde treatment during all periods of the experiment except for the second period (the second 28 day period), whereby untreated SBM, SSM and CSM had better feed conversion ratio (FCR) than the treated groups. Source of protein had a moderate effect ($p<0.10$) on FCR, but had a significant effect ($p<0.05$) on hot and cold carcass weight, digestive tract empty weight and liver weight, with lambs fed SBM having higher values than lambs fed SSM and CSM diets. Supplementation with undegradable protein had a significant effect ($p<0.05$) on dressing-out percentage ($p<0.05$), final live weight, and hot and cold carcass weight ($p<0.01$). The lower values pertain to lambs fed treated diets compared to lambs fed untreated diets. In general, there were no significant differences among all carcass linear dimensions, carcass cut weights and dissected loin tissue weights for both treatments (protein source and formaldehyde treatment). Supplementation with undegradable protein but not the source of protein resulted in significantly higher dissected leg total bone weight ($p<0.05$), tibia and femur weight ($p<0.05$), and femur length ($p<0.01$) at the same carcass weight. Results suggest that the treatment of SBM, SSM and CSM with formaldehyde did not improve efficiency of feed utilization, lamb performance or carcass traits and that the SBM diet resulted in an increase in lamb performance compared to other experimental diets. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 8 : 1080-1087)***

Key Words : Awassi, Formaldehyde, Bypass Protein, Carcass Composition

INTRODUCTION

Dietary protein is either degraded in the rumen or passed from the rumen as undegraded protein. Degraded protein is converted totally or partially to microbial protein (Chalupa, 1975; Kanjanapruthipong et al., 2002). The Quantity of microbial protein synthesized in the rumen is sufficient to a moderate level of productivity, while at high productivity level of milk production or growth rate, degradable protein is inadequate to supply sufficient quantities of amino acids (Chalupa, 1975). As a consequence, ruminants fed an undegradable source of protein often have increased growth rate (Beerman et al., 1986) and milk production (Ørskov et al., 1981). Protein is the most expensive component in the ration. Different methods have been used to protect it from microbial degradation in the rumen. Heat and formaldehyde treatments are the common used methods (Santos et al., 1998; Kanjanapruthipong et al., 2002). Nishimuta et al. (1974) found that soybean treated with heat or with formaldehyde increased the quantity of amino acids reaching the abomasum, while treatment with tannic acid had no effect.

Results of effect of formaldehyde treatment of protein sources in ruminant have been variable. Peter et al. (1971) reported a significant improvement in the performance of lambs fed soybean treated with formaldehyde, while others (Schmidt et al., 1973; Clark et al., 1974; Hassan et al., 1991) reported little or no effect of treating soybean meal with formaldehyde especially in those lambs fed a high-concentrate diet. Soybean treated with formaldehyde fed to steers did not improve daily gain; however it had a significant effect on improving the FCR (Spears et al., 1980). Formaldehyde treatment of barley decreased the degradability of both protein and starch. However, McAllister et al. (1992) reported that barley treated with formaldehyde fed to lambs had no effect on average daily gain or on carcass traits except that kidney fat was reduced significantly.

Soybean is commonly used as a source of protein, but it is expensive compared to other protein sources. Thus, it is important to improve the utilization of protein fed to animals and to use a more economic source of protein

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Received December 31, 2003; Accepted April 16, 2004

Table 1. Ingredients and chemical composition of the experimental diets (on DM basis)

	Control			Treated		
	SBM	SSM	CSM	SBM	SSM	CSM
Ingredients (kg/100 kg)						
Wheat straw	14	14	14	14	14	14
Barley	56	56	56	56	56	56
Wheat bran	12	12	12	12	12	12
Soybean	16	-	-	16	-	-
Cottonseed	-	-	15.6	-	-	15.6
Sunflower	-	15.4	-	-	15.4	-
Limestone	1	1	1	1	1	1
Urea	-	0.6	0.4	-	0.6	0.4
Dicalcium P	0.5	0.5	0.5	0.5	0.5	0.5
Salt	0.3	0.3	0.3	0.3	0.3	0.3
Trace minerals and vitamins*	0.2	0.2	0.2	0.2	0.2	0.2
Chemical composition (%)						
Dry matter	92	93	91.8	90.2	92.1	92
Organic matter	91.7	90.6	92	93.6	93.6	92.5
Crude protein	15.8	16	16.5	15.8	16.1	16
Crude fat	1.6	1.3	0.9	1.3	1.1	1
Ash	8.3	9.4	8	6.4	6.4	7.5
NDF	41	41.8	44.8	37	47.2	52.4
ADF	13.4	15.8	17.1	12.4	15.8	18.3

* Supplies per kilogram of feed: 4.9 mg of Zn, 4.05 mg of Mn, 0.45 mg of Cu, 0.075 mg of I, 0.1 mg of Se, 2.500 IU Vitamin A, 400 mg of Vitamin D, 2.5 IU Vitamin E.

compared to soybean.

Little information is available on the effect of feeding ruminally undegradable protein on performance and carcass trait of Awassi lambs. The objective of this experiment was to investigate the effect of source of protein and formaldehyde treatment on growth and carcass composition of Awassi lambs.

MATERIALS AND METHODS

Animals and diets

Twenty-four newly weaned Awassi lambs (initial body weight=21.5±0.8 kg) were used in a 3×2 factorial design to study the effect of feeding three sources of protein supplement (soybean meal (SBM), sunflower seed meal (SSM), and cotton seed meal (CSM)) either untreated or formaldehyde-treated on growth performance and carcass traits of Awassi lambs. Lambs were randomly assigned to one of the six diets (4 lambs/treatment diet) and were individually fed for a period of 107 days. Experimental diets were isonitrogenous and isocaloric. Ingredient and chemical compositions of the experimental diets are shown in Table 1. Formaldehyde treatment of SBM, SSM and CSM was conducted by spraying formaldehyde solution onto the meal at the ratio of 12 ml of 37% formaldehyde per 100 g SBM, SSM and CSM meal or 1.2 g formaldehyde/ 100 g crude protein (AL Jassim, 1985), then thoroughly mixed and packed in polyethylene bags. After 48 h of storing, at room temperature (25°C), bags were opened and meals were air dried to remove excess formaldehyde. Feed samples from each mixed ration (after mixing the treated meals with other ingredients) were taken continuously for chemical analysis. Proximate components were determined using the procedures described by AOAC (1984). Feed samples were ground by a Wiley mill through a 1 mm screen and analyzed for dry matter in a forced air oven at 100°C for 12 h. Crude protein was determined following the Kjeldahl method of nitrogen determination. The nitrogen content of feed samples were digested with H_2SO_4 at 400°C for 4 h, then analyzed by steam distillation using a Kjeltec 1030 Auto Analyzer following digestion. Nitrogen content was multiplied by 6.25 to determine crude protein content. Samples were burned in a muffle furnace at 550°C for 6 h to determine ash content. Concentrations for acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined according to Goering and Van Soest (1970).

Experimental procedures

Lambs were kept in individual pens (1.5×1.5 m) and were fed *ad libitum* in self-feeders. Following a 10 day period of adaptation, all lambs were fed twice daily in quantities according to NRC (1985) recommendations. The quantity of feed offered was adjusted weekly depending on the body weight. Amount of feed offered and refusal was recorded daily for each pen. Clean drinking water was available in plastic buckets. Body weights of lambs were recorded at the beginning and at the end of the feeding period, and subsequently at 14 day intervals after a fasting period of 12 h to determine lamb performance. Average

Table 2. Least-squares means for lamb performance on different treatments

Item	SBM		SSM		CSM		Significance				Cov[1]
	NT*	T	NT	T	NT	T	R^2 %	RSD	R	T	
No. of lambs used	4	4	4	4	4	4					
Initial live wt. (kg)	22.3	21.0	21.9	21.3	21.6	20.9	1.8	4.2	NS	NS	
Final live wt. (kg)	47.7^{a}	41.2^{bd}	43^{ab}	40.6^{bd}	41.3^{bd}	37.6^{cd}	81.7	3.5	*	**	***
Average daily gain (gd^{-1})	248^{a}	182^{bc}	202^{ab}	178^{bc}	183^{bc}	148^{c}	49	35	*	**	
Total feed intake per head/day (kg)	1.3^{a}	1.0^{b}	1.3^{a}	1.2^{ab}	1.1^{ab}	1.0^{b}	51	0.2	*	**	
Average feed conversion ratio (kg of feed/kg gain) for:											
The first 42 days	5.6	6.0	7.1	6.4	7.3	6.1	20	1.4	NS	NS	
The second 28 days	6.1^{b}	6.4^{ab}	6.5^{ab}	8.3^{a}	5.6^{b}	7.7^{ab}	35	1.9	NS	*	
The third 37 days	4.9	5.5	6.8	6.5	6.8	6.5	28	1.3	0.06	NS	
The period of 107 days	5.4	5.9	6.6	6.8	6.3	6.5	27	0.9	0.07	NS	

* NT: non-formaldehyde treatment, T: formaldehyde treatment, R^2: coefficient of determination, RSD: residual standard deviation, R: ration.
NS: p>0.05, * p<0.05, ** p<0.01, *** p<0.001. [1] The covariate was initial live weight for final live weight.

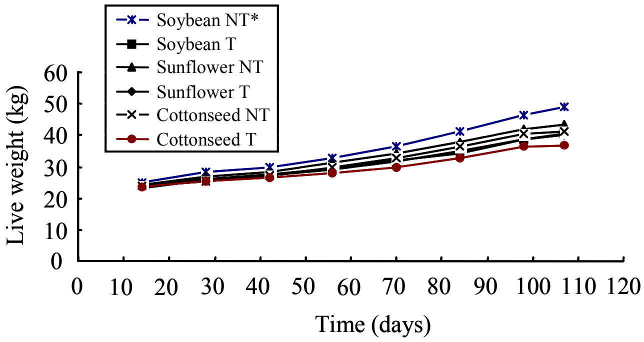

Figure 1. Live weight gain (kg) of Awassi lambs fed rations with different sources of protein of different degradability. Note: The significant differences (F test) for overall experiment were: 1. Among rations, * p<0.05, 2. Among treatments, ** p<0.009, 3. Among weeks, *** p<0.0001, 4. Ration×treatment, NS: p>0.05, 5. Rep (ration*treatment), ** p<0.01, * NT: non-formaldehyde treatment, T: formaldehyde treatment.

daily gain (ADG) and feed conversion ratio (FCR, kg of feed/kg of gain) were determined for each period.

After a period of 107 days, all animals were slaughtered and dressed immediately after weighing following normal commercial procedures as described by Abdullah et al. (1998). Lambs were fasted for 17 h before slaughter, but allowed access to water. All non-carcass components were weighed and recorded immediately after removal from the body. Carcasses were weighed before and after being chilled overnight at 1 to 4°C. Tail fat was then determined after being separated from the area around the hind legs of the carcass. Carcasses were then cut into four units (shoulder, rack, loin and leg). The shoulder was separated from the rack by first cutting with a knife along a line against the caudal edge of the 7^{th} rib on each side, and then the vertebra was sawn through. The rack was separated from the loin by cuts against the caudal edge of the 12^{th} rib, the ventral edge of the costal cartilage, and through the intervertebral joint between the 12^{th} and 13^{th} thoracic vertebrae. The leg was separated by cutting between the last and second to last lumbar vertebrae. The measurements of fat depths and dimensions on the transverse section of *M. longissimus thoraces* between ribs 12 and 13 were also made as described by Kadim et al. (1989). The right hind leg and loin were dissected into bone, intermuscular fat, subcutaneous fat, muscle and other tissues, and selected muscles were weighed individually. The femur and tibia of each hind leg were both weighed and their lengths were measured with digital calipers.

Statistical analysis

Data, except average feed intake, were analyzed by using the general-least-squares procedures (SAS, 1985) to evaluate the effect of feeding three sources of protein with or without formaldehyde treatment (T, NT). Repeated measures were used to analyze the effect of time on lambs performance. The model contained effects due to protein source, formaldehyde level and the interaction between the source of protein and the treatment after being adjusted by covariance analysis for differences in the appropriate covariate. The interaction term was removed from the model if it was statistically non-significant (p>0.05). Average feed consumption data were analyzed using the general least square repeated measures procedures following the same model mentioned above.

RESULTS

Final live weight and ADG over the 107 day period were affected by both source of protein and formaldehyde treatment (Table 2 and Figure 1). Lambs fed SBM gained significantly (p<0.05) more weight than those fed CSM (26.5 and 19.6 kg for SBM and CSM groups, respectively). Lambs fed untreated diets had better (p<0.01) daily gain compared to those fed formaldehyde-treated diets. For instance, lambs fed untreated soybean gained 248 g/d while lambs fed formaldehyde-treated soybean gained 182 g/d.

Similarly total feed intake per animal was significantly

Table 3. Least-squares means of final live weight, hot and cold carcass weights, dressing-out percentages, and non-carcass component weights for Awassi lambs

Item	SBM		SSM		CSM		Significance				Cov[1]
	NT*	T	NT	T	NT	T	R^2 %	RSD	R	T	
No. of lambs used	4	4	4	4	4	4					
Final live wt. (kg)	47.7[a]	41.2[bd]	43[ab]	40.6[bd]	41.3[bd]	37.6[cd]	81.7	3.5	*	**	***
Hot carcass wt. (kg)	23.4[a]	19.9[bc]	21.4[ab]	19.3[bc]	20.0[bc]	17.8[c]	82	1.9	*	**	***
Cold carcass wt. (kg)	22.6[a]	19.0[bc]	21.0[ab]	18.6[bc]	19.3[bc]	16.9[c]	80	1.95	*	**	***
Dressing-out %	50.2[ab]	49.7[ab]	51.3[a]	50.0[ab]	50.7[a]	47.7[b]	44	1.8	NS	*	NS
Head & leg wt. (kg)	3.2	3.2	3.0	3.0	3.1	3.2	76	0.2	NS	NS	***
Dig. Tract empty wt. (kg)	1.4[a]	1.2[ab]	1.1[b]	1.2[b]	1.2[ab]	1.2[ab]	86	0.1	*	NS	***
Small intestine wt. (g)	903	783	735	811	819	738	70	0.1	NS	NS	***
Large intestine wt. (g)	925	834	852	984	924	894	75	0.1	NS	NS	***
Heart wt. (g)	164	147	147	147	156	152	78	0.01	NS	NS	***
Kidney wt. (g)	114	102	98	108	112	110	57	13.5	NS	NS	**
Spleen wt. (g)	70	54	58	66	68	48	57	0.01	NS	0.07	NS
Liver wt. (g)	641[a]	614[ab]	549[bc]	570[abc]	579[abc]	529[c]	78	0.1	*	NS	***
Lungs and trachea wt. (g)	568	434	537	440	492	466	41	0.1	NS	0.06	NS
Kidney fat wt. (g)	219	178	160	205	199	185	34	112	NS	NS	*
Mesenteric fat wt. (g)	462	319	332	328	505	457	34	0.20	NS	NS	0.07
Testes wt. (g)	278	258	257	215	229	248	53	62.6	NS	NS	**

* NT: non-formaldehyde treatment, T: formaldehyde treatment, R^2: coefficient of determination, RSD: residual standard deviation, R: ration.
NS: p>0.05, * p<0.05, ** p<0.01, *** p<0.001.
[1] The covariate was initial live weight for final weight, hot and cold carcass weight and dressing-out percentage, and final live weight for all other variables.

Table 4. Least-squares means for carcass linear dimensions of Awassi lambs

Item	SBM		SSM		CSM		Significance				Cov[1]
	NT*	T	NT	T	NT	T	R^2 %	RSD	R	T	
No. of lambs used	4	4	4	4	4	4					
Body length (LB) (cm)	101	102	102	101	103	103	79	2.33	NS	NS	***
Eye muscle width (A) (mm)	62	63	62	63	61	62	53	3.60	NS	NS	**
Eye muscle depth (B) (mm)	26	26	28	25	24	25	45	2.42	NS	NS	NS
Fat depth (C) (mm)	5.4	5.2	5.7	5.5	5.8	5.8	38	1.43	NS	NS	**
Tissue depth (GR) (mm)	17.3	16.4	17.8	15.9	17.1	17.2	72	1.93	NS	NS	***
Rib fat depth (J) (mm)	9.4	7.7	8.1	7.5	9.2	7.8	47	1.99	NS	NS	*
Leg fat depth (L3) (mm)	13.7	10.3	12.6	13.4	17.2	13.6	65	3.70	NS	NS	***
Shoulder fat depth (S2) (mm)	6.3	5.5	6.6	6.7	6.6	5.8	35	1.92	NS	NS	*

* NT: non-formaldehyde treatment, T: formaldehyde treatment, R^2: coefficient of determination, RSD: residual standard deviation, R: ration.
NS: p>0.05, * p<0.05, ** p<0.01, *** p<0.001.
[1] The covariate was cold carcass weight for all variables.

affected by protein source and formaldehyde treatment (Table 2 and Figure 2). Lambs fed untreated SSM consumed more feed (1.3 kg/head per day) than lambs fed untreated SBM or CSM, while lambs fed CSM consumed the least (1.1 kg/head per day). Formaldehyde treatment caused a significant decrease (p<0.01) in feed intake (Table 2). Lambs fed treated SSM consumed a higher amount of feed (1.2 kg/head per day) compared to lambs fed treated soybean and cottonseed meals (1.0 kg and 1.0 kg/head per day, respectively). Feed requirement per unit of gain was not affected by formaldehyde treatment (Table 2) except for the second period, where groups receiving untreated SBM, SSM and CSM had better FCR than the treated groups. Source of protein had an effect (p<0.10) on FCR during period 3 and during the whole period, but not at the first and the second period (Table 2). However, lambs fed untreated SBM had the lowest FCR for the whole period compared to other treatments group.

Final live weight, cold and hot carcass weights, dressing-out percentages and non-carcass component weights are presented in Table 3. Source of protein had a significant effect (p<0.05) on final live weight, hot and cold carcass weight, digestive tract empty weight and liver weight when adjusted to either initial or final live weights. Lambs fed SBM diets had constantly higher values than lambs fed SSM and CSM diets. Supplementation with undegradable protein had a significant effect (p<0.05) on dressing-out percentage and a highly significant effect (p<0.01) on final live weight and hot and cold carcass weights. The lower values pertain to lambs fed treated diets compared to lambs fed untreated diets for the three treatment types (SBM, SSM and CSM). Formaldehyde treatment also had a moderate effect (p<0.10) on spleen, lung and trachea weights (Table 3).

Table 5. Least-squares means for all cut weights of Awassi lambs

Item	SBM		SSM		CSM		Significance				Cov[1]
	NT*	T	NT	T	NT	T	R^2 %	RSD	R	T	
No. of lambs used	4	4	4	4	4	4					
Tail fat wt. (kg)	2.97	2.54	2.91	2.83	2.63	2.51	72	0.53	NS	NS	***
R&L[2] leg wt. (kg)	5.97	6.28	6.12	6.04	5.83	6.26	93	0.32	NS	NS	***
R&L loin wt. (kg)	1.97	1.74	1.86	1.94	2.09	1.91	81	0.23	NS	NS	***
R&L rack wt. (kg)	1.69	1.73	1.62	1.72	1.72	2.08	61	0.31	NS	NS	***
R&L shoulder wt. (kg)	6.64	6.97	6.81	6.72	6.96	6.91	94	0.33	NS	NS	***

* NT: non-formaldehyde treatment, T: formaldehyde treatment, R^2: coefficient of determination, RSD: residual standard deviation, R: ration.
NS: p>0.05, * p<0.05, ** p<0.01, *** p<0.001.
[1] The covariate was cold carcass weight for all variables. [3] R&L: right and left sides of each cut.

Table 6. Least-squares means for all dissected leg tissue weights

Item	SBM		SSM		CSM		Significance				Cov[1]
	NT*	T	NT	T	NT	T	R^2 %	RSD	R	T	
No. of lambs used	4	4	4	4	4	4					
Leg wt. (g)	2,958	3,120	3,020	2,980	2,906	3,115	95	136	NS	NS	***
Total muscle wt. (g)	1,688	1,790	1,740	1,486	1,602	1,745	64	245	NS	NS	***
Total bone wt. (g)	451^{a}	543^{bc}	524^{bc}	525^{bc}	493^{ac}	534^{bc}	74	38.0	NS	*	***
Total fat wt. (g)	738	686	725	639	824	714	81	109	NS	NS	***
Intermuscular fat wt. (g)	248	256	317	231	314	263	56	60.1	NS	NS	**
Subcutaneous fat wt. (g)	484	431	405	410	415	456	85	68.5	NS	NS	***
Femur wt. (g)	139^{a}	159^{bc}	146^{ac}	155^{ac}	147^{ac}	157^{ac}	78	11.4	NS	*	***
Femur Length (cm)	17.1^{a}	18.2^{bc}	17.6^{ac}	18.1^{bc}	17.7^{ac}	18.3^{bc}	84	0.44	NS	**	***
Femur diameter (cm)	6.1	6.1	6.1	6.2	6.1	6.0	30	0.4	NS	NS	0.06
Tibia wt. (g)	126^{a}	223^{b}	151^{a}	164^{ab}	158^{a}	181^{ab}	55	43	NS	*	***
Tibia Length (cm)	19.4	20.4	20.5	19.7	20.3	20.6	58	0.72	NS	NS	***
Tibia diameter (cm)	5.4	5.5	5.4	5.2	5.3	5.5	56	0.24	NS	NS	**
Five large muscle[3] wt. (g)	905	997	922	961	905	968	85	72.9	NS	0.08	***
Leg muscle/bone ratio	3.67	3.29	3.28	2.86	3.26	3.27	37	0.46	NS	NS	NS

* NT: non-formaldehyde treatment, T: formaldehyde treatment, R^2: coefficient of determination, RSD: residual standard deviation, R: ration.
NS: p>0.05, * p<0.05, ** p<0.01, *** p<0.001.
[1] The covariate was cold carcass weight for all variables.
[2] Five large muscle= *M. semitendinosus, M. semimembranosus, M. biceps femoris, M. quadriceps femoris, M. adductor.*

Data in Tables 4 to 7 shows the least-squares means for carcass linear dimensions, carcass cut weights and all dissected leg and loin tissue weights when adjusted the same carcass weight. In general, there were no significant differences among all carcass linear dimensions, carcass cut weights and dissected loin tissue weights for both treatments (protein source and formaldehyde treatment).

Supplementation with treated protein but not source of protein resulted in significantly higher dissected leg total bone weight (p<0.05), tibia and femur weight (p<0.05), femur length (p<0.01) and five large leg dissected muscle weights (p<0.10).

DISCUSSION

Lambs supplemented with soybean meal gained more compared to those supplemented with sunflower or cottonseed meal. These results are in agreement with Maner (1973) who reported that sunflower meal produced less daily gain compared to that produced by soybean meal fed to steers. While Abdullah et al. (1999) and Balsi et al. (1995) both reported that source of protein, soybean or sunflower, had no effect on daily gain of lambs and steers. Cottonseed meal had the adverse effect on daily gain. Treating the protein supplement with formaldehyde, in this study, depressed the growth performance. This disagrees with the results of Kanjanapruthipong et al. (2002) and Spears et al. (1980) on non-lactating dairy cows and sheep, respectively. Kanjanapruthipong et al. (2002) found a significant increase in ADG in the animals fed TMR containing rumen undegradable protein from formaldehyde treated SBM compared with those fed TMR containing only SBM (p<0.05). Spears et al. (1980) also found that sheep fed soybean treated with formaldehyde had significantly better daily gain compared to those fed untreated soybean. The difference may be due to the type of animal and the percentage of CP used. Crude protein percentage in this study was 16% while Spears et al. (1980) used 12% protein diets. Klopfenstein (1985) indicated that responses to low degradable protein are more evident when ruminants are fed diets with feed stuffs of low protein contents. According to NRC (1985), the CP requirement of fattening lambs, based on their mean body weight and daily gain observed is 187±4 g/d. The actual CP intake was 164-229 g, which is

Table 7. Least-squares means for dissected loin tissue weights

Item	SBM		SSM		CSM		Significance				Cov[1]
	NT*	T	NT	T	NT	T	R^2 %	RSD	R	T	
No. of lambs used	4	4	4	4	4	4					
Loin wt. (g)	960	808	907	946	1,019	974	77	129	NS	NS	***
Total muscle wt. (g)	533	428	456	491	494	454	79	61.3	NS	NS	***
Total bone wt. (g)	138	133	154	141	123	139	34	24.2	NS	NS	NS
Total fat wt. (g)	329	226	277	297	383	290	50	118	NS	NS	**
Inter muscular fat wt. (g)	166	132	121	138	200	177	54	67.0	NS	NS	**
Subcutaneous fat wt. (g)	137	94	156	158	180	115	46	65.8	NS	NS	*
Longissimus muscle wt. (g)	226	196	216	225	212	218	74	27.7	NS	NS	***

* NT: non-formaldehyde treatment, T: formaldehyde treatment, R^2: coefficient of determination, RSD: residual standard deviation, R: ration.
NS: p>0.05, * p<0.05, ** p<0.01, *** p<0.001.
[1] The covariate was cold carcass weight for all variables.

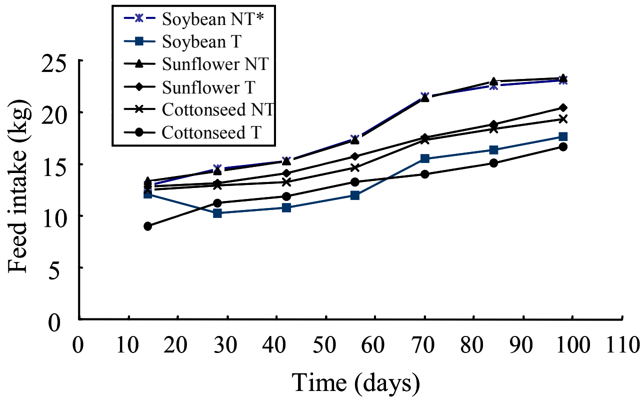

Figure 2. Daily feed intake (kg) of Awassi lambs fed different sources of protein of different degradability. Note: The significant differences (F test) for overall experiment were: 1. Among rations ** p<0.05, 2. Among treatments, *** p<0.004, 3. Among weeks, *** p<0.0001, 4. Ration×treatment, NS: p>0.05, * NT: non-formaldehyde treatment, T: formaldehyde treatment.

over the requirement except for lambs fed the treated SBM and CSM that were lower than requirements by 15 and 19 g/d, respectively.

Lambs supplemented with SBM were more efficient than those supplemented with SSM or CSM during period 3 (Table 2) and during the whole period. These results are in agreement with results obtained by Abdullah et al. (1999). These authors reported that lambs supplemented with SBM had better FCR than those supplemented with SSM or bitter vetch seeds during the first period (14 day) but not at the end of the trial. In the present study, FCR were 5.4 and 6.6 kg of feed/kg gain for Awassi lambs supplemented with SBM and SSM, respectively, whereas in the study by Abdullah et al. (1999), FCR were 6.1 and 8.18 kg of feed/kg gain, respectively. Explanation for the difference might be due to the faster ADG of lambs in this study (248 and 202 g/day for SBM and SSM, respectively) compared to the other study reported by Abdullah et al. (1999) (179 and 173 g/day, respectively), although the CP percentage and lamb initial live weights were almost similar in both studies. This indicated a close relationship between FCR and ADG as reported by Abdullah et al. (1999).

Feed required per kg of gain was not affected by formaldehyde treatment except for the second 28 days of the experiment. Lack of treatment effect in most periods and at the entire 107 days may due to the higher protein level in the diet. Lambs fed formaldehyde treated meals consumed significantly (p<0.01) less feed compared to those fed untreated meals (Table 2 and Figure 2). This result is in contrast with those reported by Spears et al. (1980) in steers, Tewatia et al. (1995) in lactating goats and with Santos et al. (1998) on dairy cow who reported that there were no differences in DMI when SBM was replaced by the rumen undegradable protein (RUP) sources. However, the present results are in agreement with those of Schmidt et al. (1973), which suggested no beneficial effect of formaldehyde treatment in soybeans. One explanation for the inconsistency of formaldehyde treatment effects on ADG and/or FCR may be due to the level of formaldehyde. Responses to formaldehyde treatment might be due to a decreased loss of ammonia from the rumen, and increase in quantity of amino acid escaping rumen degradation and reaching the lower gut for absorption (an improvement in the pattern of amino acid available for absorption in the small intestine) or a combination of these factors (Husain and Offer, 1987; Santos et al., 1998). So levels of formaldehyde below the optimum will result in less quantity of protein entering the lower digestive tract of ruminants, while levels above the optimum may greatly alter protein digestibility in the lower gut. As a consequence, in both cases formaldehyde treatment will not cause optimal animal production (Husain and Offer, 1987; Santos et al., 1998). In the present study, one level of formaldehyde was used thus making it difficult to recommend the optimum level of formaldehyde treatment. However, Spears et al. (1980) concluded that 0.3% formaldehyde is optimum, compared to 0.6 or 0.9%, for SBM protection from rumen degradation.

The source of protein had a significant effect on final live weight, hot and cold carcass weight, digestive tract empty weight and liver weight. Lambs fed SBM diets had constantly higher values than lambs fed SSM and CSM diets. These results do not agree with those of Abdullah et al. (1999) and Hassan et al. (1990) who found that source of protein (SBM, SSM) did not affect carcass characteristics.

Supplementation with undegradable protein had a significant effect on final live weight, hot and cold carcass weights and dressing-out percentage when adjusted to initial live weight. The lower values pertains lambs fed treated diets compared to lambs fed untreated diets for the three treatment types (SBM, SSM and CSM) that resulted from differences in ADG. In general, there were no significant differences among all carcass linear dimensions, carcass cut weights and dissected loin tissue weights at the same carcass weight for both treatments (protein source and formaldehyde treatment). Hassan et al. (1991) investigated the response to supplementation with rumen undegradable nitrogen (RUN) given with diets of either 70:30 or 30:70 roughage:concentrate ratio, upon carcass composition of fat-tail Awassi sheep. The physical composition of the main wholesale cuts and dressing-out % were not affected by RUN supplementation or roughage:concentrate ratio. Similar results were obtained by Al-Jassim et al. (1991) with growing Awassi lambs and desert goats receiving diets with low and high levels of RUP using formaldehyde-treated SBM. A trend towards a reduction ($p>0.05$) in dressing-out % was observed for lambs fed the high RUP diets, but diet had no significant effect on the proportions of dissected carcass components in both species. Al-Jassim et al. (1991) concluded that the response to RUP supplementation by both species indicates that the RUP supply from the control diet (low RUP) was insufficient for adequate growth. Carcass traits of lambs fed control or formaldehyde-treated diets were similar, although kidney fat was reduced ($p<0.05$) in lambs fed formaldehyde-treated barley (McAllister et al., 1992).

The differences in bone weights and lengths in favor of formaldehyde-treated diets are hard to explain due to lack of literature regarding these characteristics.

CONCLUSION

Results suggest that the treatment of SBM, SSM and CSM with formaldehyde did not improve efficiency of feed utilization, lamb performance or carcass traits and that the SBM diet resulted in better lamb performance compared to other experimental diets.

ACKNOWLEDGMENTS

The authors would like to acknowledge the assistance of F. S. Al-Barakeh, R. Qudsieh, M. Abu Ishmais, I. Tahat and Z. Batayneh and farm staff for their technical assistance.

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