

Effects of different dietary crude protein contents on growth performance and visceral organ mass in fattened Awassi lambs

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SUMMARY

This study was conducted to investigate the effects of different crude protein (CP) feeding strategies on the growth performance, food intake and visceral organs weights of Awassi lambs during fattening. Forty eight weaned male Awassi lambs were randomly divided in 4 equal groups according to the diet regimen: whereas the CP content remained constant during the whole 16 week fattening period in diets distributed to the first 3 groups, 12%, 16% and 18% respectively, it was gradually and monthly decreased from 20% to 14% in the diet distributed to the 4th lamb group. The body weight gains and the food intakes in lambs fed with the decreasing CP content diet compared to the other groups were markedly and significantly increased since the 8th week and the 5th week respectively, although these 2 parameters were moderately delayed around the 12th week until the end of the experimental fattening period in all lambs. In addition, the food efficiency was significantly enhanced in animals receiving diets with the decreasing CP content or high protein content (18%). The hot and chilled carcass weights as well as the visceral organ (lungs, kidneys and liver) relative weights were also more elevated in these 2 groups while the kidney fat proportions were significantly decreased. These results show that a gradual decrease in the dietary protein content (from 20% to 14%) during fattening markedly improves the growth performance and the visceral organ mass in lambs, leading to an important reduction in the meat production cost.

Keywords: Awassi lambs, dietary protein content, weight gain, food intake, food efficiency, visceral organs, economic cost.

RÉSUMÉ

Effets de différents teneurs en protéines brutes dans la ration sur la croissance et la masse des organes viscéraux chez les agneaux Awassi à l'engraissement

Cette étude a eu pour objectif d'étudier les effets de différentes teneurs de protéines brutes (PB) dans la ration sur les paramètres de croissance, l'ingéré alimentaire et le poids des organes viscéraux chez des agneaux de race Awassi à l'engraissement. Au total, 48 agneaux Awassi mâles sevrés ont été aléatoirement répartis en 4 groupes égaux en fonction du régime alimentaire : alors que la teneur en PB est restée constante pendant la période d'engraissement de 16 semaines dans les rations distribuées aux animaux des groupes 1, 2 et 3, soit respectivement 12 %, 16 % et 18 %, elle a été progressivement et mensuellement diminuée de 20 % à 14 % dans la ration destinée aux agneaux du groupe 4. Les gains de poids et les ingérés alimentaires, respectivement dès les 8^{ème} et 5^{ème} semaines, ont été significativement et nettement augmentés dans ce dernier groupe par rapport aux valeurs observées dans les 3 autres groupes, malgré le fléchissement de ces 2 paramètres aux alentours de la 12^{ème} semaine et jusqu'à la fin de la période expérimentale chez tous les agneaux. De plus, l'efficacité alimentaire a été significativement augmentée chez les animaux recevant la ration de teneur décroissante en protéines et celle à 18 % de protéines. Les poids des carcasses chaudes et réfrigérées ainsi que les poids relatifs des organes consommables (poumons, reins et foie) ont aussi été plus élevés dans ces 2 groupes alors que la proportion de graisse rénale a significativement diminué. Ces résultats montrent qu'une diminution progressive de la teneur en protéines de la ration (de 20 % à 14 %) durant l'engraissement conduit à une amélioration des performances de croissance et de la masse des organes viscéraux permettant une réduction importante des coûts de production de la viande chez les agneaux.

Mots clés : Agneaux Awassi, protéines brutes alimentaires, gain de poids, ingéré alimentaire, efficacité alimentaire, viscères, coût économique.

Introduction

The cost of feed in sheep fattening programs is estimated to be as much as 80% [4, 15]. Protein supplements are the most expensive fraction in livestock rations. The major source of protein is soybean meal (SBM), and in countries of West Asia and North Africa (WANA), millions of tons of SBM are annually used for the different livestock rations [27]. The cost of SBM as a protein source is 320% more than energy feeds [13]. Recent legislations in some countries restrict the use of protein from animal sources causing an increasing demand for protein from plant sources.

In lamb fattening practice, rations with 200 g/kg dry matter (DM) crude protein are common. Many researches on fattening Awassi lambs dealt with the effects of different crude protein levels (120 to 200 g/kg) [2, 3, 5, 8, 20, 23, 28], showed that crude protein levels up to 170 g/kg DM had the same effect on the average daily gain. These findings indicate that feeding Awassi lambs with high protein rations is under suspicion, taking in consideration the lower level of 145 g/kg CP recommended by the NRC [22]. On the other hand, the NRC tables [22] indicated that the protein level in rations of growing lambs decreases with increasing the body weight.

The objective of this study is to compare the effects of different strategies of protein feedings on growth weight development, average daily gain, feed conversion ratio and visceral organ mass of Awassi lambs.

Materials and Methods

FEEDING TRIAL

Forty eight weaned male Awassi lambs (mean weight: 29.5 ± 2.1 kg) were used in the experiment, conducted in the Najah National University farm after the approval by the Animal Care and Use Committee. Lambs were treated against both internal and external parasites (IVOMEC, Merial, USA and Cogla Vac, France, respectively) and were injected with enterotoxaemia vaccine.

Lambs were divided into four equal feeding groups (n = 12 in each group) in a completely randomized design. In each feeding group, the animals were fed individually with total mixed rations (TMR) (Table I).

Animals in the experimental groups 1, 2 and 3 were fed with corn-SBM based rations with protein contents of 120, 160 and 180g/kg respectively, during the whole experimental period (4 months). Animals in the group 4 were fed with a ration which the protein content was decreased according to the experimental period duration: a starting content of 200g/kg CP was used for one month then rations with decreased CP contents (18%, 16% and 14% respectively) were given to the lambs for the next three months of the feeding trial (Table II). Dietary rations were formulated to meet NRC [21] standards.

Experimental group	Dietary CP content (g/kg)	Feeding duration (month)
Group 1	120	4 months
Group 2	160	4 months
Group 3	180	4 months
Group 4	200	1 st month
	180	2 nd month
	160	3 rd month
	140	4 th month

CP: crude protein.

TABLE II: Feeding trial design according to the crude protein (CP) contents in the rations distributed to the weaned Awassi lambs.

Feed samples were taken for chemical analysis. The feeds were sampled every 10 days throughout the trial. Dry matter was determined at 105°C [7] and nitrogen was determined according to the Kjeldahl procedure [7]. The Neutral detergent fibre (NDF) and the acid detergent fibre (ADF) contents were determined as described by Goering and Van Soest [12].

GROWTH PERFORMANCE AND CARCASS TRAITS

For analyzing growth performance, lambs were biweekly weighted and food intake was daily recorded.

The lambs were slaughtered by stunning with a captive bolt pistol and bleeding, skinning and eviscerating as routinely

	12% CP	14% CP	16% CP	18% CP	20% CP
Ingredients (%)					
Soybean meal	11.8	17.5	23.5	28.9	34.6
Corn	74.4	68.8	63.0	57.3	51.6
Wheat bran	9.65	9.70	9.80	9.80	9.90
Soap stock oil	1.05	0.90	0.90	0.90	0.80
Limestone	2.6	2.6	2.6	2.6	2.6
Salt	0.4	0.4	0.4	0.4	0.4
VMP ¹	0.1	0.1	0.1	0.1	0.1
Chemical composition					
Dry matter (%)	90	90	90	90	90
Crude protein (%)	12.0	14.0	16.0	18.0	20.0
NDF (%)	24.8	25.0	26.0	24.9	25.2
ADF (%)	14.9	15.0	15.5	15.0	15.3
Calcium (%)	0.90	0.91	0.89	0.93	1.00
Phosphorus (%)	0.40	0.42	0.38	0.40	0.50
ME ² (Mcal/kg)	2.57	2.57	2.57	2.58	2.58

CP: crude protein; VMP¹: vitamin and mineral premix which contains per kg: vitamin A, 2000000 IU; vitamin D₃, 40000 IU; vitamin E, 400 mg; Mn, 12.8 mg; Zn, 9.0 mg; I, 1.56 g; Fe, 6.42 mg; Co, 50 mg; Se, 32 mg plus antioxidant; NDF: neutral detergent fibre; ADF: acid detergent fibre; ME²: metabolisable energy on tabular values (NRC [21, 22]).

TABLE I: Ingredients and chemical compositions of the rations distributed to the Awassi lambs during the feeding trial.

practiced at the slaughter plant. The liver and gall bladder were removed from the viscera. The heart was removed from the body immediately adjacent to the base. Lungs, without trachea, were removed and weighed, and the total weights of kidneys were recorded. Abdominal fat was also weighed. The hot carcass weight was recorded for all carcasses. All carcasses were chilled at -3°C for 24 hours and the corresponding weight was also recorded.

STATISTICAL ANALYSIS

Data were analyzed using SAS [26]. When significant treatment difference was detected, comparisons between means were made using Fisher's least significant difference (LSD) procedures. Differences were considered as significant when P values were less than 0.05.

Results

GROWTH PERFORMANCE

The Table III summarizes the weight gains of lambs under different strategies of protein feeding according to the time. Lambs exhibited similar cumulative gains whatever the dietary regimen for the first six weeks of the feeding trial. Since the 8th week of fattening until the end of the experimental period (on week 16), the cumulative weight gains were significantly higher in lambs fed with the ration in which the protein content was gradually decreased from 20% to 14% (group 4) than in lambs fed with a ration in which the CP content was constant (groups 1, 2 and 3) ($P < 0.05$). Although the daily weight gains declined since the 12th week of fattening in all groups (the percentages of decrease in the daily gain were 25%, 21.0%, 22% and 18% in the groups 1, 2, 3 and 4

respectively), the mean daily weight gains calculated for the 12 week period, the 14 week period and for the whole period were markedly increased in the group 4 compared to the other 3 groups ($P < 0.05$), although lambs fed with a 18% CP constant ration exhibited also high mean daily weight gains whereas the lowest values were observed in the group 1 (12% CP constant ration).

On over the whole experimental period, the daily food intakes calculated for each week appeared to be greater in the group 4 (fed with a decreased CP content-ration) than in the 3 other groups but differences were statistically significant ($P < 0.05$) from the 5th week to the end of the feeding trial (Table IV). However, the daily food intakes have fluctuated in all the groups according to time: they were remained roughly constant until the 6th – 7th week and thereafter they decreased slowly until the 12th week and more abruptly until the 16th week (Table IV). Consequently, the food conversion ratios calculated for the 12 week period were lower than those calculated for the 14 week period and for the whole period whatever the CP content in the dietary ration. Moreover, this parameter was significantly higher in lambs fed with a 18% CP content and in lambs fed with a decreased CP content-ration ($P < 0.05$) during the 3 considered periods (12 weeks, 14 weeks and 16 weeks).

VISCERAL ORGANS AND CARCASS TRAITS

As shown in Table V, the relative weights of the edible viscera (lungs, kidneys and liver) were significantly increased in lambs fed with a 180 g/kg CP dietary ration (group 3) or with the ration in which the CP content was gradually decreased (group 4) compared to the 2 other groups (CP content: 12 and 16% respectively) ($P < 0.05$). In addition, the visceral organ fat such as the kidney fat was also significantly reduced in these 2 groups ($P < 0.05$). By contrast, no significant effect of the dietary CP content was evidenced for the spleen,

	12% CP (group 1)	16% CP (group 2)	18% CP (group 3)	20-14% CP (group 4)	LSD
Cumulative weight gains (kg)					
At 2 weeks	4.1	4.7	3.7	5.1	-
At 4 weeks	7.0	7.6	7.1	9.5	-
At 6 weeks	9.6	9.9	10.2	13.5	-
At 8 weeks	12.1 ^b	10.7 ^b	13.0 ^b	16.5 ^a	4.7
At 10 weeks	13.2 ^b	11.8 ^b	15.5 ^b	19.3 ^a	5.0
At 12 weeks	13.5 ^b	13.6 ^b	16.6 ^b	21.1 ^a	6.9
At 14 weeks	13.3 ^b	14.2 ^b	16.6 ^b	21.6 ^a	4.0
At 16 weeks	13.6 ^b	14.3 ^b	17.4 ^b	22.9 ^a	4.2
Mean daily weight gain (g/d)					
For 12 week period	161.0 ^b	162.0 ^b	198.0 ^b	251.0 ^a	39.0
For 14 week period	136.0 ^b	145.0 ^b	148.0 ^b	220.0 ^a	30.0
For 16 week perio	121.4 ^b	128.0 ^b	155.0 ^b	205.0 ^a	31.1

CP: crude protein; LSD: least significant difference.

Different superscripts ^{a,b} in the same row indicate significant difference ($P < 0.05$).

TABLE III: Cumulative and mean weight gains in weaned Awassi lambs according to the dietary crude protein content.

	12% CP (group 1)	16% CP (group 2)	18% CP (group 3)	20-14% CP (group 4)	LSD
Daily food intake (kg/d)					
Week 1	1.194	1.202	1.159	1.302	-
Week 2	1.216	1.232	1.143	1.385	-
Week 3	1.162	1.284	1.198	1.377	-
Week 4	1.142	1.248	1.230	1.417	-
Week 5	1.199 ^b	1.105 ^b	1.206 ^b	1.482 ^a	0.367
Week 6	1.109 ^b	1.146 ^b	1.275 ^b	1.463 ^a	0.394
Week 7	1.151 ^b	1.021 ^b	1.316 ^b	1.395 ^a	0.406
Week 8	1.072 ^b	0.912 ^b	1.175 ^b	1.393 ^a	0.320
Week 9	1.145 ^b	0.952 ^b	1.271 ^b	1.350 ^a	0.345
Week 10	1.108 ^b	0.983 ^b	1.332 ^b	1.362 ^a	0.320
Week 11	0.984 ^b	1.006 ^b	1.271 ^b	1.397 ^a	0.308
Week 12	0.970 ^b	1.028 ^b	1.146 ^b	1.360 ^a	0.347
Week 13	0.896 ^b	0.947 ^b	1.086 ^b	1.184 ^a	0.399
Week 14	0.908 ^b	1.014 ^b	1.088 ^b	1.230 ^a	0.366
Week 15	0.821 ^b	0.822 ^b	0.974 ^b	1.220 ^a	0.322
Week 16	0.943 ^b	0.952 ^b	1.053 ^b	1.245 ^a	0.351
Mean food intake (kg)					
For 12 week period	112.6 ^b	110.0 ^b	123.5 ^b	140.3 ^a	15.7
For 14 week period	149.0 ^b	147.0 ^b	165.6 ^b	186.2 ^a	16.9
For 16 week period	190.4 ^b	188.2 ^b	211.7 ^b	240.8 ^a	16.8
FCR (kg food / kg WG)					
For 12 week period	8.3 ^a	8.1 ^a	7.4 ^b	6.6 ^b	0.8
For 14 week period	11.2 ^a	10.4 ^a	9.9 ^b	8.6 ^b	0.3
For 16 week period	14.0 ^a	13.2 ^a	12.1 ^b	10.5 ^b	0.2

CP: crude protein; LSD: least significant difference; FCR: food conversion ratio; WG: weight gain.
Different superscripts ^{a,b} in the same row indicate significant difference ($P < 0.05$).

TABLE IV: Variations of the food intake (kg) and of the food efficiency (kg of food / kg of weight gain) in weaned Awassi lambs according to the dietary crude protein content.

	12% CP (group 1)	16% CP (group 2)	18% CP (group 3)	20-14% CP (group 4)	LSD
Organ weight (g/kg)					
Lungs	12.2 ^b	15.6 ^b	17.6 ^a	17.5 ^a	3.6
Kidneys	6.4 ^b	6.2 ^b	9.4 ^a	9.2 ^a	4.2
Liver	15.9 ^b	16.0 ^b	19.2 ^a	19.0 ^a	2.1
Spleen	1.9	1.7	1.9	1.8	-
Testicles	7.9	7.1	7.3	7.9	-
Heart	5.8	6.9	7.1	5.9	-
Tail	63	54	45	61	-
Abdominal fat	37 ^a	23 ^v	16 ^b	31 ^a	13.6
Kidney fat	3.4 ^a	3.9 ^a	2.2 ^b	2.6 ^b	0.65
Carcass traits					
Hot carcass weight (kg)	19.8 ^b	20.1 ^b	21.6 ^b	24.1 ^a	2.1
Chilled carcass weight (kg)	18.9 ^b	19.4 ^b	20.8 ^b	23.3 ^a	2.0

CP: crude protein; LSD: least significant difference.
Different superscripts ^{a,b} in the same row indicate significant difference ($P < 0.05$).

TABLE V: Carcass traits and variations of the mean weights of the visceral organs (g/kg of empty body weight) from the Awassi lambs according to the dietary crude protein content.

testicle, heart and tail weights and the abdominal fat proportion appeared predominant in animals receiving diet with a constant low 12% CP content (group 1) and with decreased protein contents (group 4) compared to the 2 other groups ($P < 0.05$). However, the dietary protein content has also exerted significant effects on some carcass parameters: lambs fed with the 120 g/kg CP had more ($P < 0.05$) back fat thickness compared to that of lambs receiving other feeding schedules. Both hot and chilled carcass weights were also affected by dietary protein content: lambs fed with the decreasing level of protein had heavier ($P < 0.05$) weights of hot and chilled carcasses.

ECONOMIC COST EVALUATIONS

According to the prevailing food prices, the production costs (expressed per kg of body weight or per kg of weight gain) were significantly depressed for the 12 week period, the 14 week period and for the whole experimental period when lambs have received a diet containing 18% CP or in which the CP content has varied from 20% to 12% ($P < 0.05$) (Table VI). Lots of savings can be achieved by adopting these two feeding schedules, especially the diet regimen with a decreasing CP content: compared to the lambs receiving a diet with a constant 12% CP content, the production costs for 1 kg of body weight were reduced by 26.4% when the dietary CP was 18% and by 37.7% when this parameter was decreased for 20% to 14%.

Discussion

In the present study, the progressive decline in the dietary crude protein content has significantly improved the growth performance (increase in weight gains and in food intake as well as decrease in the food conversion ratio), the carcass traits and the edible organ relative weights compared to constant 12% to 18% CP contents during the fattening period and consequently can lead to a marked reduction in the meat production costs.

In the first six weeks of feeding period, weight gains in lambs fed with different CP diets were in agreement with previous findings using dietary CP contents comprised between 147 g/kg and 199 g/kg CP [14] and up to 170 g/kg [2, 3, 5, 20]. The higher weight gains observed in lambs fed with the

decreasing CP content diet for the rest of the feeding period can be explained by the fact that Awassi breed has a low growth rates compared to large western lamb breeds and that its requirements for CP at early stages of fattening is low [13]. An average daily gain of 275 g/d was obtained with Awassi lambs fed with a 144 g/kg CP diet [19] whereas the daily gain reached 368 g/kg in Romanov lambs fed with 146 g/kg CP diets [9]. Indeed, the mean daily weight gains in the weaned Awassi lambs observed in the present study whatever the dietary crude protein content and whatever the fattening period considered (12, 14 or 16 week period) were low compared to previous fattening experiments with similar CP contents [2, 3, 20]. The high average initial weight of lambs can explain the low daily gain in Awassi breed that exhibits lower growth rates compared to larger meat breeds. Therefore, this large difference in growth rates between breeds should be reflected on the nutrient requirements. On other hand, ANDREWS and ORSKOV [6] showed that maximum weight gain was observed when diets include 170 g/kg CP compared to lower amounts (14.5%) recommended by NRC [22]. These findings indicate that lamb feeding with crude protein enriched diets for the entire feeding period is not an appropriate practice, taking in consideration the NRC recommendations which support to decrease the dietary protein content according to the weight gain during fattening. The lambs' final body weights were reflected on lambs hot and chilled carcass weights. Heavier body weights resulted in heavier carcasses as indicated in lambs fed with the decreasing content of protein.

Average food intake values in the first five weeks of the fattening period were similar to the intake previously reported [2, 3, 5, 20]. Although some authors have observed that the CP content in the ration had no significant effect on both organic and dry matter intake [9, 17], the food intake was markedly increased in lambs fed with the decreasing CP content diet compared to animals fed with constant CP content diets since the 5th week of fattening in the present study. In the same way, DROUILLARD *et al.* [10] have reported that the food intake was remarkably increased in lambs receiving a 14.5% CP diet compared to those fed with a lower CP content (8.9%) diet. FLUHARTY and Mc CLURE [11] also observed an increase in food intake when lambs were fed with a protein enriched diet. However, this parameter has declined since the 12th week and until the end of the present experiment in the all feeding treatment groups. This variation was associated with a period of hot weather that prevailed for few weeks.

	12% CP (group 1)	16% CP (group 2)	18% CP (group 3)	20-14% CP (group 4)	LSD
Food cost (NSI/kg of BW)	1.57 ^a	1.72 ^a	1.33 ^b	1.30 ^b	0.16
Growth cost (NSI/kg of WG)					
For 12 week period	13.1 ^a	13.9 ^a	9.9 ^b	8.6 ^b	0.40
For 14 week period	17.7 ^a	17.8 ^a	13.3 ^b	11.2 ^b	2.9
For 16 week period	22.0 ^a	22.6 ^a	16.2 ^b	13.7 ^b	3.9

CP: crude protein; LSD: least significant difference; BW: body weight; WG: weight gain; NSI: new Israeli sheqel (1 US Dollar = 3.75 NIS). Different superscripts ^{a,b} in the same row indicate significant difference ($P < 0.05$).

TABLE VI: Food cost and economic cost for growth in the Awassi lambs according to the dietary crude protein content.

Similarly to the average daily gains, FCR values reported here were not comparable to previous results in Awassi lambs [2, 3, 5, 20]. Again, the lower growth rate at heavier weights of this relatively small breed and the elevated initial body weight at the beginning of the fattening period can explain the low food conversion ratio values.

Weights of edible organs (lungs, kidneys and liver) reported here are in agreement with previous results [1, 2, 20] and greatly depend to the body weight at the slaughtering [18]. The heavier weights of some organs such as livers and lungs observed in lambs receiving diets with 180g/kg or with the decreasing CP content were probably associated with the fermentation end products. Similar findings were reported by ORTIGUES and DOREAU [24] where heavier livers were obtained in goats and in lambs [11] fed with protein enriched diets. Nevertheless, the elevated relative weights of lungs from lambs fed with diets in which the protein content was 18% or decreased from 20% to 14% during the fattening period were in disagreement with previous results: indeed, KAMALZADEH *et al.* [16] and PRUD'HON [25] have suggested that the lung development was poorly affected by the dietary protein content because of its low metabolic activity and its early maturation.

As a conclusion, decreasing the dietary crude protein content during the fattening period in lambs has induced significant improvements in growth performance, food efficiency and in the carcass traits (hot and chilled carcass weights and edible organ weights) leading to a subsequent reduction in the economic costs. In this way, according to the prevailing food prices and the total weight gain in Awassi lambs which around 1 million is under fattening, few hundred millions of New Israeli Sheqel can be saved for the benefit of local farmers. Consequently, this feeding strategy may be recommended during the fattening of the Awassi lambs.

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