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Growth Performance, Carcass and Meat Characteristics of Black Goat Kids Fed Sesame Hulls and *Prosopis juliflora* Pods

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ABSTRACT : Finding alternative feeds, such as sesame hulls and *Prosopis juliflora* species can attenuate difficulties of feed shortage and reduce the cost of animal feed in arid and semi-arid countries. Thirty-two Black male kids with similar initial weights (BW = 16.7±0.80 kg) and 120±5 d of age, were used to evaluate the effect of replacing barley grains and soybean meal with *Prosopis juliflora* pods (PJP) and sesame hulls (SH) on growth performance, digestibility and carcass and meat characteristics. Kids were equally divided into four dietary treatment groups for an 84-d fattening period. Treatment diets had similar crude protein (CP) and metabolizable energy (ME). The treatment groups were: (T1) no PJP nor SH, (T2) 10% PJP and 20% SH, (T3) 15% PJP and 15% SH, and (T4) 20% PJP and 10% SH. A tendency was detected ($p<0.08$) for dry matter (DM), crude protein (CP), organic matter (OM) and neutral detergent fiber (NDF) intakes that were greater for T2 than T3 and T4 while T1 was not different from all other treatment groups. Ether extract (EE) intake was the greatest ($p<0.05$) for T2 and the lowest for T1. Acid detergent fiber (ADF) intake was greater ($p<0.05$) for T2 than T1 while T3 and T4 were intermediate. Final live weight, average daily gain (ADG) and feed conversion ratio (FCR) were comparable among different treatment groups. Digestibility of DM, OM, CP, NDF and ADF were similar among all treatment groups, however, EE digestibility was the lowest ($p<0.05$) for T1 when compared to other treatments. In addition, nitrogen intake, nitrogen in urine and retained and retention percentages were similar among all treatment groups. However, N loss in feces was higher ($p<0.05$) for T2 than T3 and T4 while T1 was intermediate. No differences were observed among treatment groups with respect to fasting live weight, hot and cold carcass weights, dressing-out percentages, mesenteric fat, visceral organs, carcass cuts percentages and carcass linear dimensions. No differences were also observed for dissected loin, leg, rack and shoulder tissues except in the total bone % for loin cuts and in the meat to bone ratio for rack cuts. T3 has the greatest total bone % and the lowest meat to bone ratio when compared to all other treatment groups. No differences were observed between treatment groups in all quality characteristics of the *longissimus* muscle. The present study demonstrates the potential of using PJP and SH for growing kids without adverse effects on growth performance, carcass characteristics and meat quality. (**Key Words :** Black Goat Kids, Sesame Hulls, *Prosopis juliflora* Pods, Growth Performance, Digestibility, Carcass Characteristics)

INTRODUCTION

Goats are raised under a wide variety of ecological zones and are able to survive and produce under harsh environmental conditions (El Khidir et al., 1998). Jordan is a semi-arid country with a rainfall average of 200 mm/year (El-Shatnawi et al., 1999); as a result, it suffers continuously from shortage and an increase in the cost of forage and feedstuff. Based on availability and market price, grains represent approximately 60-70% of the total production cost (MOA, 2007). Therefore, arid and semi-arid countries should be concerned with promoting the use of the readily available natural range grazing, in addition to supplementing animals with agro-industrial by-products. *Prosopis juliflora* and sesame hulls are good examples of low cost alternative feedstuff for animals. *Prosopis juliflora*, present in North America, Africa and Asia, has a green-brown twisted stem, flexible branches and flattened multi-seeded curved pods (Habit and Saavedra, 1988). According to Abdullah and Abdel Hafes (2004), the crude protein and energy contents of *Prosopis juliflora* pods (PJP) are comparable to those in barley grain (12.6% CP and 3.20 kcal/kg ME). Sesame hulls are the by-product of oil

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extraction in the sesame seed industry. After being cleaned from impurities, the sesame seeds are pushed into a peeling machine where mist and pressure are applied to separate the hulls from the seeds. The very small and light seeds escape this process and remain with the hulls. This resulting by-product of sesame hull is sold at a very inexpensive price as livestock feedstuff. In Jordan, a total of 3.250 tons of sesame byproducts are produced annually (MOA, 2007). The crude protein content of sesame hulls is around 25.8%, while ME content is around 3.92 kcal/kg (Farran et al., 2000; Obeidat and Gharaybeh, 2011). Mahgoub et al. (2005) found that replacing Rhodes grass hay with PJP up to 20% in kids diets improved DM intake, ADG, FCR and hot and cold carcass weights; whereas, the performance was reduced when the PJP level was increased to 30% of the diet. Obeidat and Gharaybeh (2011) reported that the replacing barley and soybean meal with sesame hull in Black goat kids finishing diets improved nutrient intake, ADG and cost of gain. Similarly, final body weight, ADG, FCR, and cost of gain improved in growing lambs fed diets containing sesame meal as a substitute of soybean meal at a level of 8% of the diet when compared to lambs fed diets free of sesame meal (Obeidat et al., 2009). No research, however, has been reported on the use of *Prosopis juliflora* pods in combination with sesame hulls in goat diets. Therefore, the objective of the present study was to investigate the effect of feeding diets containing graded levels of sesame hulls in combination with *Prosopis juliflora* pods on nutrient intake, performance, digestibility, carcass characteristics and meat quality of Black goat kids fed these finishing diets.

MATERIALS AND METHODS

Animals and experimental design

The study was conducted at the Agriculture Centre for Research and Production at Jordan University of Science and Technology. Thirty-two male Black goat kids with initial body weights of 16.7±0.80 kg and 120±5 d of age were assigned in a completely randomized design to a feeding trial consisting of four dietary treatments. Each treatment was replicated in eight pens (1.5 m×0.75 m), one kid per pen. Kids in each pen were fed one of the four dietary treatments for an 84-d finishing period: (T1) with no *Prosopis juliflora* pods (PJP) or sesame hulls (SH), (T2) 10% PJP and 20% SH, (T3) 15% PJP and 15% SH and (T4) 20% PJP and 10% SH and were used to partially replaced barley grains and soybean meals (Table 1). A one week adaptation period to the pen was allowed before receiving the experimental diets. All diets were formulated to have 17.1% of CP and to meet the animal's requirements for fattening male kids according to NRC (1981). A total mixed

Table 1. Ingredients and chemical composition of the diets (% of DM)

Item	Diet[1]			
	1	2	3	4
Ingredient (% of DM)				
Barley	59	36	34	33
Prosopis juliflora pods	0	10	15	20
Soybean meal	13	6	8	9
Sesame hulls	0	20	15	10
Wheat bran	15	15	15	15
Wheat hay	10	10	10	10
Salt	1.5	1.5	1.5	1.5
Limestone	1.4	1.4	1.4	1.4
Premix[2]	0.1	0.1	0.1	0.1
Feed cost/ton ($)	380	254	259	261
Nutrient				
ME (Mcal/kg)[3]	2.77	2.94	2.91	2.87
DM	93.9	94.3	94.5	94.1
OM (% of DM)	88.6	87.9	88.0	89.7
CP (% of DM)	17.4	17.2	16.8	17.1
EE (% of DM)	2.8	9.9	9.4	6.6
NDF (% of DM)	31.4	32.6	31.9	33.4
ADF (% of DM)	10.7	13.9	14.4	14.7

[1] Diets were: (1) no PJP or SH, (2) 10% PJP and 20% SH, (3) 15% PJP and 15% SH, (4) 20% PJP and 10% SH.

[2] Composition per 1 kg contained (vitamin A, 450,000 IU; vitamin D_3, 11,000,000 IU; vitamin E, 3.18 g, Mn, 10.9 g; I, 1.09 g; Zn, 22.73 g; Fe, 22.73 g; Cu, 2.73 g; Co, 0.635; Mg, 100 g; Se, 0.1 g).

[3] ME = Metabolizable energy; calculated using NRC (1981).

ration was provided twice a day (two equal meals at 09:00 and 15:00) of *ad libitum* allowing a refusal of 10%. Clean water was available all the time in plastic buckets. Refusals were weighed, before the distribution of the morning meal on the following day, to evaluate the daily dry matter intake and other nutrient intakes. Kids were weighed at the beginning of the study and weekly before the morning meal.

Diet preparation

Prosopis juliflora pods were collected near the Jordan Valley during the fruit production season and stored in a cool dry shed. Upon use, pods were allowed to air dry and pass through a rotating forage chopper to reduce their size to 2-4 cm in length, before mixing the diets, to ensure thoroughness during the mixing process. Sesame hulls were purchased from a local seed industry company for oil extraction. Before mixing the diets, sesame hulls were sun dried for approximately 2 days to ease the mixing process. Experimental diets were mixed biweekly and were sampled upon mixing to ensure consistency in their chemical composition.

Digestibility and N balance trial

On the 72^{th} day of the fattening study, a metabolism trial was conducted on 16 randomly selected kids (4 kids from each group) to evaluate nutrient digestibility and N balance. Kids were placed individually in metabolism cages that allowed the separation of feces and urine. Animals were allowed an adaptation period of 7 days to the metabolism cages followed by a collection period of 4 days. During the collection period, feed intake and refusals were recorded. Feed samples and refusals were sampled for further analysis. Daily fecal output was collected, weighed and recorded, then 10% was stored for subsequent analysis. Urine was collected in a plastic container, weighed and recorded, then 5% was kept to evaluate the N retention. Fifty ml of 6 N HCl was added to the urine collecting containers to prevent NH_3 loss from the urine.

Slaughtering procedures, carcass composition and meat quality

At the end of fattening trail all kids were slaughtered for the evaluation of carcass traits and meat quality after a 14 h period of fasting with free access to water. All animals were slaughtered on the same day by trained personnel using standard slaughter procedures (Abdullah et al., 1998). The fasting live weight was recorded immediately before slaughter. Hot carcass weight and weights of non-carcass components and some visceral organs (including the mesenteric, lungs and trachea, heart, liver, kidney and kidney fat, spleen and testes) were recorded directly after slaughter. After chilling the carcasses for 24 h at 4°C, cold carcass weights were recorded to calculate the dressing percentage as a ratio of cold carcass weight/fast live weight. *Longissimus* muscle pH and temperature were measured after 24 h of post-mortem through an incision in the *longissimus* (at the 12/13 rib site) using a portable pH meter (pH spear, large screen, waterproof pH/temperature tester, double injection, model 35634-40, Eurotech instruments, Malaysia) and a digital thermometer (Electro-term, model TM99A, cooper instrument corporation, CT, USA). According to Abdullah et al. (1998), tissue depth (GR), rib fat depth (J), eye muscle width (A), eye muscle depth (B), eye muscle area, fat depth (C) and shoulder fat depth (S2) were performed on chilled carcasses and *longissimus* muscles. Carcasses were then cut into four parts (shoulder, rack, loin and leg cuts) (Abdullah and Musallam, 2007). Upon cutting, loin cuts were dissected and *the longissimus* muscles were excised from the loin cuts, separately vacuum packaged and frozen at -20°C for 2 weeks, prior to the meat quality assessment.

The shoulders were separated from the racks first by cutting with a knife along a line against the caudal edges of the 7^{th} rib on each side and the vertebra was sawn through. Racks were separated from loins by cutting against the caudal edges of the 12^{th} rib, the ventral edge of the costal cartilages and through the cartilage disc, separating the 12^{th} and 13^{th} thoracic vertebrate. Legs were separated by cutting between the last and second to last vertebrate. Each major cut was separated into the right and left sides using an electrical saw. All cuts were separated into dissectible bones, muscles and fat (fat was further separated into subcutaneous and intramuscular fat depots).

Measurements of meat quality made on *Longissimus* muscles included Warner-Bratzler shear force values on cooked meat samples, water holding capacity, cooking loss and color coordinates (L^*, a^*, and b^*). Frozen muscles were thawed overnight in a chiller at 4°C prior to the meat quality analyses. Each muscle was divided into slices of specific thicknesses and each slice was used for a specified meat quality measurement. A colorimeter device (12MM Aperture U 59730-30, Cole-Parameter International, Accuracy Microsensors Inc., Pittsford, New York, USA) was used to objectively measure CIELAB (Commission International I' E Clairage) lightness (L*), redness (a*) and yellowness (b*). Color was measured on slices of 15 mm thick; all slices were placed on a polystyrene tray covered with permeable film (to avoid surface drying) and were allowed to bloom for 2 h at 4°C. Three measurements were taken from each slice. The average of the three measurements was recorded as a color coordinate value of the slice. The hue angle was calculated as $\tan^{-1}(b^*/a^*)$; whereas, chroma was calculated as $(a^{*2}+b^{*2})^{1/2}$ (Hunter and Harold, 1987). The water holding capacity was measured by using a procedure described by Grau and Hamm (1953), using samples of approximately 5 g of raw meat (initial weight). Each sample was cut into small pieces, then covered with two filter papers and two thin plates of quartz material and pressed with a weight of 2,500 g for 5 min. The meat samples were then removed from the filter paper and their weights recorded (final weight). The water holding capacity was reported as the weight lost during sample pressing divided by the initial sample weight and was expressed as a percentage. Cooking loss was measured on slices of 25 mm thick, where the slices were placed in plastic bags and cooked in a thermostatically controlled water bath at 75°C for 90 min. Samples were cooled and weighed to calculate the percentage of water lost in cooking. The cooked slices were stored at 4°C over night, then 6 cubes (with sizes of 1×1×1 cm) were cut parallel to the long axis of the muscle fiber. The shear force value was taken for the cubes using a Warner-Bratzler shear blade with the triangular slot cutting edge mounted on a Salter model 235 (Warner-Bratzler meat shear, G-R manufacturing co. 1317 Collins LN, Manhattan, Kansas, 66502, USA) to determine the peak force (kg) when shearing the samples.

Chemical analysis

All samples were dried at 55°C in a forced air oven to reach a constant weight (air equilibrated) then ground to pass a 1 mm screen (Brabender OHG Duisdurg, Kulturstrase 51-55, type 880845, Nr 958084, Germany). Feed, refusals and feces were analyzed for DM, ash, CP and ether extracts (EE). Following the AOAC (1990) procedures, samples were analyzed for DM (100°C in an air-forced oven for 24 h; method 967.3), ash (550°C in an ashing furnace for 6 h; method 942), CP (Kjeldahl procedure) and EE (Soxtec procedure, SXTEC SYSTEM HT 1043 Extraction unit, TECATOR, Box 70, Hoganas, Sweden). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to procedures described by Van Soest et al. (1991) with a modification of use in the ANKOM^{2000} fiber analyzer apparatus (ANKOM Technology Cooperation, Fairport, NY). Neutral detergent fiber analysis was conducted with the use of sodium sulfite and alpha amylase (heat stable) and expressed with a residual ash content. Urine samples were analyzed for N (Kjeldahl procedure; AOAC, 1990) to evaluate the N balance.

Statistical analysis

Data were subjected to an analysis of variance in a completely randomized design using a MIXED procedure of SAS (2000). Animal was used as the experimental unit in the model. The initial BW of the kids was used as a covariate for the performance data. Cold carcass weight was used as a covariate in the analyses of carcass and non-carcass components and carcass cut weights. For shoulder, leg, loin and rack characteristics, their weights were used as a covariate, respectively. Least square means were calculated for all measured variables using the LSMEANS statement and the protected LSD test was used to determine significant differences.

RESULTS AND DISCUSSION

Diets, nutrient intake and growth performance

Nutrient composition (Table 1) of the four diets fed to the kids in the current study were almost similar except for the EE content due to the high level of EE in sesame hulls compared to barley grains and soybean meals. The substitution of soybean meal and barley grain with SH and PJP reduced the cost of diets. This reduction in cost is due to the fact that the expense of PJP is only based on the cost of laborers to collect them and to the low cost of sesame hulls when compared to the current price of soybean meal and barley grains. Also, the fact that all kids made it through the study without the costs associated with health problems supports the possibility of using sesame hulls and *Prosopis juliflora* pods as an alternative feed in diets of finishing black goat kids.

Least-squares means of nutrient intake, growth performance and feed conversion ratio for kids fed various levels of *Prosopis juliflora* pods and sesame hulls are presented in Table 2. A tendency was detected ($p<0.08$) for DM, OM, CP and NDF intakes that were greater for T2 than T3 and T4, while T1 was intermediate. Ether extract intake was significantly different between all treatment groups with the highest value ($p<0.05$) for T2 and the lowest for T1. Acid detergent fibre intake was higher ($p<0.05$) for T2 than T1 while T3 and T4 were not different from the other two treatments. Obeidat and Gharaybeh (2011) studied the effect of replacing soybean meal with sesame hulls and found that nutrient intakes were improved for kids fed a diet containing 10% sesame hulls when compared to control while kids on a 20% sesame hulls diet displayed no differences compared to the control group. Obeidat and Aloqaily (2010) also studied the effect of using SH in Awassi lamb diets as a substitute for barley grains and soybean meal and found that nutrient intakes were improved in lambs fed a diet containing up to 25% SH. Previous studies show that using sesame meal in feeding calves and lambs increases their nutrient intake (Khan et al., 1998; Obeidat et al., 2009). Similar results were obtained by Obeidat et al. (2008) and Mahgoub et al. (2005) where nutrient intakes were increased in lambs and Omani goat offered a diet containing up 20% PJP. However, Abdullah and Abdel Hafes (2004) reported that the inclusion of more than 25% of PJP in finishing Awassi diets depressed feed intake. Obeidat et al. (2009) concluded that nutrient intake improved when lambs were fed two different protein sources (i.e., soybean meal and sesame meal or sesame

Table 2. Least-squares means of nutrient intake and growth performance traits in Black goat kids fed control and finishing diets containing *Prosopis juliflora* pods and sesame hulls

Variable	Treatment[1]				SEM
	1	2	3	4	
Intake (g/d)					
DM	759.6	853.3	632.8	652.4	78.62
OM	694.2	757.5	562.2	592.6	70.15
CP	111.2	119.4	76.7	86.6	13.59
EE	21.6^{d}	84.1^{a}	59.4^{b}	42.8^{c}	5.85
NDF	245.1	293.1	216.3	229.9	26.23
ADF	82.5^{b}	126.5^{a}	99.5^{ab}	101.8^{ab}	11.19
Growth performance					
Initial weight (kg)	17.0	16.9	16.0	16.9	0.80
Final weight (kg)	26.6	26.2	23.7	23.2	1.45
ADG (g)[2]	114.3	113.3	84.1	77.6	17.58
FCR[3]	6.9	7.8	7.9	8.6	1.34

[1] Diets were: (1) no PJP or SH, (2) 10% PJP and 20% SH, (3) 15% PJP and 15% SH, (4) 20% PJP and 10% SH.
[abcd] Means within the same row with different superscripts differ ($p<0.05$).
[2] ADG = Average daily gain ((final weight-initial weight)/80 days). [3] FCR (g DM intake/g ADG) = Feed conversion ratio.

hulls). This could be related to the fact that feeding two protein sources could change the amino acid profile in the diet and thus the proteins would complement each other.

Results related to initial and final body weights, ADG and FCR are shown in Table 2. At the beginning and throughout the study, they were all comparable among the different treatment groups. Consistent with the current study, Obeidat et al. (2008) reported that final body weight, ADG and FCR were not affected when PJP was included at rates of 0, 10 and 20% in lamb diets. Similarly, Abdullah and Abdel Hafes (2004) studied the effect of the inclusion of different levels of PJP in Awassi lambs diets and found that final weight, ADG and feed efficiency were not affected by the inclusion of PJP at 0%, 15% and 25%. However, Mahgoub et al. (2005) found an improvement in weight gain and FCR for kids fed a diet containing 20% PJP. Obeidat and Gharaybeh (2011) also observed no differences in the FCR when SH substituted soybean meal and barley grains. However, an improvement in final body weight and ADG was found for kids fed a 10% SH diet when compared to control and 20% diets. Obeidat and Aloqaily (2010) reported that using SH in Awassi lambs diets at 0%, 12.5% and 25% did not affect final body weight, feed efficiency and ADG. The maximum values of ADG and FCR obtained in the present study from T1 and T2 (114.3, 113.3 g/d and 6.9, 7.8 DM intake (g)/gain (g) for ADG and FCR for T1 and T2, respectively) were comparable with values recorded for Black goat kids obtained by Obeidat and Gharaybeh (2011) and Abdullah and Musallam (2007).

Results of the current study and previous studies show the inclusion of SH and PJP in the diets of Black goat kids produces an improvement or at least no negative effect with inclusion levels up to 20% in nutrient intake and growth performance. However, our result indicated that the inclusion of 10% PJP with 20% SH in the kids diet (Table 2, T2) numerically improved nutrient intake and growth performance compared with T3 (15% PJP and 15% SH) and T4 (20% PJP and 10% SH) diets which contain greater levels of PJP. The decline in kids growth performance in T3 and T4 diets could have been due to the depression in feed intake that was also noticed in previous studies which examined diets containing high levels of PJP (Abdullah and Abdel Hafes, 2004; Mahgoub et al., 2005). Obeidat et al. (2008) reported that the reduction in feed intake was the main reason for not showing an improvement in growth performance when diets had high levels of PJP. The presence of trypsin inhibitor, tannins and other phenolic compounds found in the pods was the reason behind appetite suppression of animals to the diet (Zolfaghari and Harden, 1982; Ravikala et al., 1995; Mahgoub et al., 2004).

Digestibility and N balance

Nutrient digestibility and N balance results are presented in Table 3. Digestibility of DM, OM, CP, NDF and ADF was similar among all treatment diets. However, EE digestibility was the lowest ($p<0.05$) for T1 when compared to other treatments. In addition, N intake, N in urine and N retained and retention percentages are similar among all treatment diets with the exception of the N loss in feces which was higher ($p<0.05$) for T2 than T3 and T4 while T1 was intermediate. Results in this study are consistent with results reported by Obeidat and Gharaybeh (2011) and Obeidat and Aloqaily (2010) that the inclusion of sesame hulls in kids and lambs diets did not affect DM, OM, NDF and CP digestibilities. However, EE digestibility was found to be greater for kids and lambs fed diets

Table 3. Nutrient digestibility's coefficient and N balance in Black goat kids fed control and finishing diets containing *Prosopis juliflora* pods and sesame hulls

Digestibility coefficients	Treatment[1]				SEM
	1	2	3	4	
DM	80.8	72.5	76.5	77.8	3.62
OM	83.0	75.7	78.7	80.7	3.25
CP	72.8	70.7	68.6	73.0	7.02
EE	83.3[b]	94.0[a]	94.0[a]	92.9[a]	0.97
NDF	69.5	56.9	64.2	66.7	5.57
ADF	61.2	50.2	60.4	63.8	6.70
N-Balance					
N-Intake (g/d)	22.3	26.3	21.0	18.9	4.27
N-feces (g/d)	6.0[ab]	7.2[a]	4.7[b]	4.2[b]	0.82
N-urine (g/d)	6.7	7.1	7.7	5.3	1.09
Retained (g/d)	9.5	12.0	8.5	9.4	4.03
Retention (%)	43.6	39.9	40.6	41.0	17.5

[1] Diets were: (1) no PJP or SH, (2) 10% PJP and 20% SH, (3) 15% PJP and 15% SH, (4) 20% PJP and 10% SH.
[ab] Means within the same row with different superscripts differ ($p<0.05$).

containing SH. compared to control diets. Obeidat et al. (2008) also observed no differences in the digestibility coefficient and N balance when PJP partially substituted barley grains with a rate of 10, 15 and 20% in lamb diets. The results of the nutrients digestibility's in the present study revealed that the inclusion of SH and PJP in the diet brings no adverse effects on feed intake, N balance and nutrient digestibility's and therefore, SH and PJP can be used as an alternative applicable in feeding Black goat kids.

Slaughter data, carcass cuts and linear measurements

Fasting live weight, hot and cold carcass weights, dressing-out percentages, mesenteric fat and visceral organs are shown in Table 4. No differences were observed among treatment diets with respect to parameters measured. Carcass cuts percentages and carcass linear dimensions are presented in Table 5. No differences in carcass cuts percentages (shoulder, rack, loin and leg cuts) were observed between treatment diets. In addition, no differences were observed in shoulder fat depth (S2), leg fat depth (L3), fat depth (C), tissue depth (GR), rib fat depth (J), eye muscle width (A) and depth (B), eye muscle area and A:B ratio among treatment diets.

Obeidat and Gharaybeh (2011) studied the effect of feeding Black goat kids SH at levels of 0, 10 and 20% replacing soybean meal and barley grains. They found that

Table 4. Least-squares means for fast live weight, hot and cold carcass weight, dressing-out % and non-carcass component weights of Black goat kids fed control and finishing diets containing *Prosopis juliflora* pods and sesame hulls

Variable	Treatment[1]				SEM
	1	2	3	4	
Fast live weight (kg)	26.1	25.4	23.0	22.6	1.60
Hot carcass weight (kg)	12.1	11.5	9.7	10.1	0.96
Cold carcass weight (kg)	11.6	11.1	9.3	9.7	0.93
Dressing-out %	44.3	43.3	42.2	42.7	1.24
Mesenteric fat (g)	634	526	407	417	85.0
Lungs and trachea (g)	361	366	325	348	17.0
Heart (g)	104	123	204	214	71.0
Liver (g)	497	467	399	448	42.0
Spleen (g)	48	53	43	50	6.0
Kidney (g)	79	78	72	82	9.0
Kidney fat (g)	385	355	282	310	54.0
Testes (g)	232	253	204	217	30.0
Total offal[2] (kg)	2.38	2.26	1.98	2.14	0.21

[1] Diets were: (1) no PJP or SH, (2) 10% PJP and 20% SH, (3) 15% PJP and 15% SH, (4) 20% PJP and 10% SH.
[2] Total offal include heart, spleen, liver, lungs and trachea, mesenteric fat, kidney fat, kidneys and testes weights.

Table 5. Least-squares means for carcass cuts percentages and carcass linear dimensions of Black goat kids fed control and finishing diets containing *Prosopis juliflora* pods and sesame hulls

Variable	Treatment[1]				SEM
	1	2	3	4	
Shoulders (%)[2]	47.4	47.5	46.7	46.6	1.38
Legs (%)[2]	31.8	31.6	34.6	31.4	1.51
Racks (%)[2]	9.7	9.4	9.4	9.9	0.34
Loins (%)[2]	9.4	9.5	9.4	9.7	0.59
Shoulder fat depth (S2) (mm)	6.8	7.0	5.4	8.0	0. 80
Leg fat depth (L3) (mm)	9.0	9.0	8.0	10.0	1.00
Fat depth (C) (mm)	2.6	2.7	2.6	2.6	0.19
Tissue depth (GR) (mm)	15.0	15.0	13.0	16.0	1.40
Rib fat depth (J) (mm)	7.0	7.0	7.0	8.0	0.93
Eye muscle width (A) (mm)	50.3	49.0	50.7	49.3	1.80
Eye muscle depth (B) (mm)	20.3	21.3	18.6	17.6	2.50
Eye muscle area (cm^2)	7.12	7.04	7.12	6.57	0.710
A:B ratio	2.5	2.4	2.8	2.7	0.25

[1] Diets were: (1) no PJP or SH, (2) 10% PJP and 20% SH, (3) 15% PJP and 15% SH, (4) 20% PJP and 10% SH.
[2] Calculated as percentages of cold carcass weight.

hot and cold carcass weights, dressing-out %, non-carcass components, carcass cuts and linear dimensions were all similar between treatments. Similarly, Obeidat and Aloqaily (2010) reported that the inclusion of SH in Awassi lambs diet did not affect slaughter data, non-carcass components, carcass cuts percentages and linear measurements, but had higher heart and kidney fat and mesenteric fat weights in lambs fed diets containing SH. Obeidat et al. (2009) demonstrated that the inclusion of sesame meal at levels of 0, 8 and 16% did not have an impact on hot and cold carcass weight, carcass cuts and carcass linear measurements of Awassi lambs. Abdullah and Abdel Hafes (2004) also found that the inclusion of up to 25% of PJP in lamb diets did not have an impact on carcass characteristics. These results indicate that SH and PJP can partially replace up to 30% of the soybean and barley in the finishing diets without affecting carcass characteristics, non-carcass components and carcass cuts proportions.

Dissected cuts and meat quality characteristics

No differences were observed among treatments in dissected legs, loin tissues (Table 6), dissected racks, shoulder tissues (Table 7), muscle weight, pH, cooking loss, water holding capacity, Warner-Bratzler shear force and all color measurements (lightness (L*), redness (a*), yellowness (b*), chroma and hue angle) (Table 8). The only exceptions were the total bone % in loins and meat to bone ratio in racks, where T3 had the greatest % and the lowest ratio ($p<0.05$), respectively. In the current study, results obtained for all dissected cuts and meat qualities were comparable with results reported by Abdullah and Musallam (2007) for Black goat kids. However, the purpose of using alternative feedstuff in livestock diets is to reduce the cost while improving (or at least not affecting) carcass characteristics and meat quality. The present results clearly indicate that replacing up to 30% of the fattening diets with alternative feeds did not have any impact on carcass characteristics, cuts proportions or meat quality. Similarly, Obeidat et al. (2008) studied the effect of feeding PJP to lambs and found that loin dissection and meat quality parameters were similar among diet treatments. Abdullah and Abdel Hafes (2004) also found that the inclusion of up to 25% of PJP in lamb diets did not have an impact on carcass characteristics. Obeidat and Gharaybeh (2011) studied the effect of feeding Black goat kids SH at levels of 0, 10 and 20% replacing soybean meal and barley grains. They found that carcass cuts dissections and meat quality was all similar between treatments. Similarly, Obeidat and Aloqaily (2010) reported that inclusion of SH in Awassi lambs diet did not affect meat quality parameters or dissectible cuts. Obeidat et al. (2009) demonstrated that the inclusion of sesame meal at levels of 0, 8 and 16% did not have an impact on cuts dissection. Obeidat et al. (2009) also found that pH, color, cooking loss, water holding capacity and shear force values were all comparable between treatments. Previous studies and this current study have shown the possibility of using PJP or SH or a combination in animal diets without causing problems to carcass characteristics and meat quality.

CONCLUSION

The present study demonstrates the potential of using *Prosopis juliflora* pods and sesame hulls in diets for growing lambs without adverse effects on growth performance, carcass characteristics and meat quality. The

Table 6. Least-squares means for dissected leg and loin tissue of Black goat kids fed control and finishing diets containing *Prosopis juliflora* pods and sesame hulls

Variable	Treatment[1]				SEM
	1	2	3	4	
Leg weight (g)	2,117	1,974	1,736	1,795	198
Subcutaneous fat (%)	4.4	4.7	4.1	5.0	0.53
Intermuscular fat (%)	4.63	4.64	4.28	4.8	0.33
Total lean (%)	61.0	61.1	58.6	59.6	1.41
Total bone (%)	24.1	23.8	27. 5	24.6	1.52
Total fat (%)	9.0	9.6	8.4	9.8	0.75
Meat to bone ratio	2.6	2.6	2.2	2.5	0.18
Meat to fat ratio	6.9	6.6	7.2	6.2	0.60
Loin Weight (g)	609	544	515	552	66.4
Subcutaneous fat (%)	8.3	7.9	6.8	9.6	0.78
Intermuscular fat (%)	9.7	9.5	7.3	9.5	0.93
Total lean (%)	51.7	53.7	48.6	49.8	1.81
Total bone (%)	21.8[b]	23.0[b]	31.2[a]	22.5[b]	3.03
Total fat (%)	17.8	17.3	13.9	18.9	1.62
Meat to bone ratio	1.4	1.3	0.9	1.3	0.17
Meat to fat ratio	1.9	1.9	2.5	1.6	0.30

[1] Diets were: (1) no PJP or SH, (2) 10% PJP and 20% SH, (3) 15% PJP and 15% SH, (4) 20% PJP and 10% SH.
[ab] Means within the same row with different superscripts differ ($p<0.05$).

Table 7. Least-squares means for dissected rack and shoulder tissue of Black goat kids fed control and finishing diets containing *Prosopis juliflora* pods and sesame hulls

Variable	Treatment[1]				SEM
	1	2	3	4	
Rack weight (g)	644	584	522	556	65.3
Subcutaneous fat (%)	11.5	10.1	9.8	12.0	1.69
Intermuscular fat (%)	8.8	9.3	6.6	8.4	1.08
Total lean (%)	52.1	51.6	47.5	50.9	1.66
Total bone (%)	20.1	20.8	32.6	19.0	4.71
Total fat (%)	20.6	19.6	16.6	20.7	2.5
Meat to bone ratio	2.9[a]	2.7[a]	2.1[b]	3.1[a]	0.28
Meat to fat ratio	2.4	2.8	3.5	2.8	0.73
Shoulder weight (g)	3,043	2,991	2,535	2,693	277
Subcutaneous fat (%)	4.9	4.3	4.6	5.1	0.46
Intermuscular fat (%)	9.8	9.5	8.2	7.7	0.76
Total lean (%)	52.1	49.2	49.5	48.3	1.14
Total bone (%)	24.6	26.9	27.4	28.5	2.05
Total fat (%)	14.1	13.3	12.2	12.1	0.72
Meat to bone ratio	2.2	1.8	1.9	1.7	0.15
Meat to fat ratio	3.7	3.7	4.2	4.1	0.23

[1] Diets were: (1) no PJP or SH, (2) 10% PJP and 20% SH, (3) 15% PJP and 15% SH, (4) 20% PJP and 10% SH.
[ab] Means within the same row with different superscripts differ ($p<0.05$).

Table 8. Least-squares means for a range of meat quality characteristics of longissimus muscle for Black goat kids fed control and finishing diets containing *Prosopis juliflora* pods and sesame hulls

Variable	Treatment[1]				SEM
	1	2	3	4	
Muscle weight (g)	114.0	103.5	89.9	104.2	13.3
pH	6.0	5.9	6.0	5.9	0.13
Cooking loss %	37.5	35.5	35.5	37.7	2.05
Expressed juiciness %	27.8	26.7	29.1	27.2	1.89
Warner-Bratzler shear force (kg)	3.90	3.50	4.30	4.30	0.50
Color					
L*	38.7	36.5	40.2	41.6	1.48
a*	2.5	2.3	1.8	2.3	0.36
b*	16.1	18.8	19.4	19.0	1.60
Chroma	17.89	19.0	19.5	19.2	1.56
Hue	81.28	82.9	84.7	83.0	1.65

[1] Diets were: (1) no PJP or SH, (2) 10% PJP and 20% SH, (3) 15% PJP and 15% SH, (4) 20% PJP and 10% SH.

substitution of soybean meal and barley grain with sesame hulls and *Prosopis juliflora* pods reduced the cost of diets. However, our result indicated that the inclusion of 10% *Prosopis juliflora* pods with 20% sesame hulls combination in the kid's diet numerically improved nutrient intake and growth performance compared with the combination of 15% *Prosopis juliflora* pods and 15% sesame hulls or with 20% *Prosopis juliflora* pods and 10% sesame hulls diets which both contains greater levels of *Prosopis juliflora* pods.

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REFERENCES

Abdullah, A. Y. and H. S. Musallam. 2007. Effect of different levels of energy on carcass composition and meat quality of male black goats kids. Livest. Sci. 107:70-80.

Abdullah, A. Y. and B. Y. Abdel Hafes. 2004. Inclusion of *Prosopis juliflora* pods in finishing Awassi lamb diets. Proc. 11th AAAP Animal Science Congress, vol. 2:373-375.

Abdullah, A. Y., R. W. Purchas and A. S. Davies. 1998. Patterns of change with growth for muscularity and other composition characteristics of Southdown rams selected for high and low back depth. NZ. J. Agric. Res. 41:367-376.

AOAC. 1990. Official methods of analysis, 15th ed. Asscc. Anal. Chem., Arlington, VA.

El Khidir, I. A., S. A. Babiker and S. A. Shafie. 1998. Comparative feedlot performance and carcass characteristics of Sudanese desert sheep and goats. Small Rumin. Res. 30:147-151.

El-Shatnawi, M. K. J., H. Z. Ghosheh, H. K. Shannag and K. I. Ereifej. 1999. Defoliation time and intensity of wall barley in the Mediterranean rangeland. J. Range Manage. 52:258-262.

Farran, M. T., M. G. Uwayjan, A. M. A. Miski, N. M. Akhdar and V. M. Ashkarian. 2000. Performance of broilers and layers fed graded levels of sesame hull. J. Appl. Poult. Res. 9:453-459.

Grau, W. R. and R. Hamm. 1953. Muscle as food. In: Food Science and Technology (Ed. P. J. Bechtel). A Series of Monographs (1985). Academic Press, New York.

Habit, M. A. and J. C. Saavedra. 1988. The Current State of Knowledge on *Prosopis juliflora*. FAO, Plant Production Division, Rome.

Hunter, R. S. and R. W. Harold. 1987. Uniform color scales. In: The Measurement of Appearance, 2nd ed. Hunter Association laboratory, VA, pp. 135-148.

Khan, M. J., M. Shahjalal and M. M. Rashid. 1998. Effect of replacing Til oil cake by poultry excreta on growth and nutrient utilization in growing bull calves. Asian-Aust. J. Anim. Sci. 11:385-390.

Mahgoub, O., I. T. Kadim, N. E. Forsberg, D. S. Al-Ajmi, N. M. Al-Saqry, A. S. Al-Abri and K. Annamalai. 2005. Evaluation of Meskit (*Prosopis juliflora*) pods as a feed for goats. Anim. Feed Sci. Technol. 121:319-327.

Mahgoub, O., I. T. Kadim, D. S. Al-Ajmi, N. M. Al-Saqri, A. S. Al-Abri, A. R. Richie, K. Annamalai and N. E. Forsberg. 2004. The effect of replacing Rhodes Grass (*Chloris gayana*) hay with Ghaf (*Prosopis cineraria*) pods on the performance of Omani native sheep. Trop. Anim. Health Prod. 36:281-294.

Ministry of Agriculture. 2007. The Annual Report of the Animal Production Department. Amman, Jordan.

NRC (National Research Council). 1981. Nutrient requirements of goats: Angora, dairy and meat goats in temperate and tropical countries. National Academy of Sciences, Washington, DC, USA.

Obeidat, B. S. and F. F. Gharaybeh. 2011. Effect of feeding sesame hull on growth performance, nutrient digestibility, and carcass characteristics of Black goat kids. Asian-Aust. J. Anim. Sci. 24:206-213.

Obeidat, B. S. and B. H. Aloqaily. 2010. Using sesame hulls in Awassi lambs diets: Its effect on growth performance and carcass characteristics and meat quality. Small Rumin. Res. 91:225-230.

Obeidat, B. S., A. Y. Abdullah, K. Z. Mahmoud, M. S. Awawdeh, N. Z. Al-beitawi and F. A. Al-Lataifeh. 2009. Effects of feeding sesame meal on growth performance, nutrient digestibility, and carcass characteristics of Awassi lambs. Small Rumin. Res. 82:13-17.

Obeidat, B. S., A. Y. Abdullah and F. A. Al-Lataifeh. 2008. The effect of partial replacement of barley grains by *Prosopis juliflora* pods on growth performance, nutrient intake, digestibility, and carcass characteristics of Awassi lambs fed finishing diets. Anim. Feed. Sci. Technol. 146:42-54.

Ravikala, K., A. M. Patel, K. S. Murthy and K. N. Wadhwani. 1995. Growth efficiency in feedlot lambs on *Prosopis juliflora* based diets. Small Rumin. Res. 16:227-231.

SAS Institute Inc. 2000. SAS/STAT User's Guide: Version 8, 1st ed. SAS Institute Inc., Cary, NC.

Van Soest, P. J., J. B. Robertson and B. A. Lewis. 1991. Methods for dietary fibre, neutral detergent fibre, and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:473-481.

Zolfaghari, R. and M. Harden. 1982. Nutritional value of Mesquite beans (*Prosopis glandulosa*). In: Mesquite Utilization. College of Agricultural Sciences (Ed. H. W. Parker), Texas Tech University, Lubbock, TX, USA, pp. 1-9.