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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

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Abstract

Twenty-one Awassi male lambs were used to evaluate the effect of replacing barely grains by *Prosopis juliflora* pods (PJP) on growth performance, digestibility, and carcass and meat characteristics. Lambs were fed finishing diets and assigned randomly to one of three dietary treatments. Treatment diets were no PJP (CON; $n = 7$), 100 g/kg PJP (PJP100; $n = 7$), and 200 g/kg PJP (PJP200; $n = 7$). Dry matter (DM) intake tended to be greater (P=0.08) for the PJP200 group than the CON group while the PJP100 group was intermediate. Organic matter (OM) intake was the highest (P<0.05) for the PJP200 group compared to the CON and the PJP100 groups. Crude protein (CP) intake was greater (P<0.05) for the PJP200 group than the CON group with no differences between the CON and the PJP100 groups. Neutral detergent fibre (aNDF) tended to be greater (P=0.07) while acid detergent fibre (ADF) was greater (P<0.05) for the PJP200 than the CON and the PJP100 groups. Digestibility of DM, OM, CP, aNDF, and ADF along with rumen fluid pH and the N retained were similar among all treatment diets. No differences were noticed in final weight, total gain, and average daily gain (ADG) among all treatment diets. Lambs receiving the CON diet had lower (P<0.05) feed conversion

Abbreviations: ADF, acid detergent fibre; ADG, average daily gain; CON, control (no PJP); CP, crude protein; DM, dry matter; *G*, gigot width; aNDF, neutral detergent fibre; OM, organic matter; PJP, *Prosopis juliflora* pods; Wf, maximum shoulder width; WHC, water holding capacity; Wth, width behind shoulders.

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ratio than the PJP100 and the PJP200 diets. Cost of gain was lower ($P<0.05$) for the PJP200 when compared to the PJP100 and the CON groups, with no differences between the CON and the PJP100 diets. No differences were observed between treatment diets in dressing percentage, hot and cold carcass weights, non-carcass components, carcass cut weights, and loin cut tissue percentages and the carcass and longissimus muscle linear measurements among treatment groups except for gigot width (*G*), maximum shoulder width (Wf), width behind shoulders (Wth) and eye muscle area. Gigot width, maximum shoulder width, width behind shoulders, and eye muscle area were greater ($P<0.05$) for the PJP200 than the CON group with no differences between the CON and the PJP100 treatment diets. Meat quality parameters measured were all comparable among the treatment diets with the exception of water holding capacity which was greater in the PJP200 group. Meat of all the treatments had similar tenderness results and within the acceptable tenderness range. These data indicate that feeding fattening Awassi lambs diets containing up to PJP200 did not affect growth performance, nutrient digestibility, and carcass and meat characteristics while being cost effective.

Keywords: Awassi lambs; *Prosopis juliflora* pods; Growth; Digestibility; Carcass characteristics

1. Introduction

In Jordan, grains are the most common feeds used for growing and finishing lambs. However, based on availability and market price, grains frequently account for 60–70% of the production cost (Harb, 1994). Finding alternative feeds, such as olive cakes, tomato pomace, and mesquite (*Prosopis juliflora* species), that can replace part of the grains may be economically advantageous to reduce the feeding costs (Al Jassim et al., 1998). The availability, low cost, and good nutrient content of these feeds in the semi-arid areas such as Jordan increase the profitability of their use.

P. juliflora is a leguminous tree that is native to arid and semi-arid regions of the world (Pasieczink, 2001; Harris et al., 2003). It is present in North America, Africa and Asia, having green-brown twisted stem, flexible branches, and produce's flattened, multi-seeded curved pods with hardened pericarp (Habit and Saavedra, 1988). The crude protein and energy contents of *P. juliflora* pods (PJP) are comparable to those in barley grain (Abdullah and Abddel hafes, 2004). Previous studies have shown that replacing wheat bran or barley grains and corn by varying levels of PJP improved DM intake, average daily gain, and feed efficiency (Habit and Saavedra, 1988; Ravikala et al., 1995; Abdullah and Abddel hafes, 2004). Also, Nagpal et al. (1995) indicated that lambs (3 months old) fed PJP had higher live weight, hot carcass weight, and dressing percentage than diets free of PJP. In a study conducted to evaluate the effect of inclusion of PJP in fattening Awassi lambs on growth performance and carcass characteristics, Abdullah and Abddel hafes (2004) found that nutrient intakes; digestibility, growth rate, and feed efficiency improved when PJP was included at 150–250 g/kg of the diets, whereas the performance was reduced when PJP level was increased to 350 and 450 g/kg of the diets. In previous study, Abdullah and Abddel hafes (2004) replaced barley and corn grains partly with PJP. However, due to the high cost of corn grains, recently production systems in fattening Awassi lambs in Jordan has been focused on increasing the level of barley grains over the corn grains in livestock diets.

Therefore, the objective of this experiment was to study the effect of partial replacement of barley grains by *P. juliflora* pods on growth performance, nutrient intake, digestibility, and carcass and meat characteristics of Awassi lambs fed finishing diet.

2. Materials and methods

2.1. Experimental design, animals, and diets

Experimentation was conducted at the Agriculture Centre for Research and Production at Jordan University of Science and Technology. The study area was classified as semi-arid at latitude 32°30′N and elevation of 510 m above sea level. Twenty-one Awassi male lambs on average 70 ± 1.1 days of age and 17.1 ± 0.99 kg body weight were randomly chosen from the university flock born in the winter of 2005 and assigned randomly to one of three treatment diets (7 lambs/treatment diet). These diets were no PJP (CON; $n = 7$), 100 g/kg PJP (PJP100; $n = 7$), and 200 g/kg PJP (PJP200; $n = 7$) and used to replace barley grain in the diets (Table 1). All diets were isonitrogenous/isocaloric; formulated to have 17% CP (DM basis) and to meet the animal's requirements for fattening male lambs according to NRC (1985). The experiment lasted for 86 days. Animals were housed in individual shaded

Table 1
Ingredients and chemical composition of the diet

Item	Diets[a]		
	CON	PJP100	PJP200
Ingredients (g/kg DM)			
Barley grain	500	400	300
Prosopis juliflora pods	0	100	200
Soybean meal	140	140	140
Wheat bran	130	130	130
Wheat hay	190	190	190
Salt	10	10	10
Limestone	15	15	15
Sodium bicarbonate	14	14	14
Mineral and vitamins[b]	1	1	1
Feed cost/tonnes (US$)	201	185	168
Nutrient			
Dry matter (g/kg)	898	894	891
Organic matter (g/kg)	882	866	918
Crude protein (g/kg)	173	174	172
Neutral detergent fibre (g/kg)	361	367	360
Acid detergent fibre (g/kg)	161	179	180
ME (Mcal/kg)[c]	2.60	2.61	2.62

[a] Diets were: (1) no PJP (CON; $n = 7$), (2) 100 g/kg PJP (PJP100; $n = 7$), and 200 g/kg PJP (PJP200; $n = 7$) of the total mixed diet.
[b] Composition per 1 kg contained (vitamin A, 450,000 IU; vitamin D3, 1,100,0000 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).
[c] ME: metabolizable energy; calculated using NRC (1985).

pens (1.5 m × 0.75 m), and fed twice a day (two equal meals at 09:00 and 15:00 h). *P. juliflora* pods were collected near the Jordan Valley, allowed to air dry, and passed through a rotating blade forage chopper to reduce the size into 2–4 cm in length before mixing the diets to ensure thorough during the mixing process and to avoid sorting. Diets were mixed biweekly during the study and were sampled upon mixing to ensure consistency in their chemical composition (Table 1). A total mixed ration diet was offered *ad libitum* to all animals with free access to fresh water for the duration of the study. All refusals were collected, weighed, and recorded before the next day feeding to evaluate daily DM intake and other nutrient intakes, and representative samples were taken to be chemically analyzed. Feeders were managed to allow no more than 10% of feed per animal to remain 1 h prior to feeding and if the feeders found empty, 10% of feed was added to the previous amount offered on the day before the next feeding. Animals were given a 1-week adaptation period to the pens before receiving the experimental diets. Lambs were weighed at the beginning of the study and weekly, thereafter, before the morning feeding throughout the study. According to procedures of AOAC (1990) feed samples were analyzed for DM (100 °C in air-forced oven for 24 h; method 967.03), OM (550 °C in ashing furnace for 6 h; method 942), and CP (Kjeldahl procedure). Neutral detergent fibre (aNDF) and acid detergent fibre (ADF) were analyzed according to procedures described by Van Soest et al. (1991) with modifications for use in the ANKOM^{200} fibre analyzer apparatus (ANKOM Technology Cooperation, Fairport, NY). Neutral detergent fibre analyses were conducted with using sodium sulfite and alpha amylase (heat stable) and expressed with residual ash content.

2.2. Digestion and N balance experiment

On day 74 of the fattening period, three animals from each treatment diet were selected randomly and housed individually in metabolism crates that allowed separation of urine and faeces to evaluate nutrient digestibilities and N balance. Animals were given 7 days as an adaptation period for the metabolism crates followed by a 4-day collection period. During the 4-day collection period, feed intake and refusals were recorded. Feed samples and refusals were sampled for further analysis. Daily faecal output was collected, weighed, and recorded, and then 10% was kept for subsequent analyses. Using plastic containers, urine was collected, weighed, and recorded, and then 5% was kept to evaluate N retention. Each bottle had 50 mL of 6N HCl to prevent ammonia losses. All samples were dried at 55 °C in a forced-air oven to reach a constant weight, air equilibrated, and then ground to pass 1 mm screen (Brabender OHG Duisdurg, Kulturstrase 51–55, type 880845, Nr 958084, Germany) and kept for further analysis. During the digestibility and N balance experiment, feed, refusals, and feces were analyzed for DM, OM, CP, aNDF, and ADF. According to procedures of AOAC (1990) feed samples were analyzed for DM (100 °C in air-forced oven for 24 h; method 967.03), OM (550 °C in ashing furnace for 6 h; method 942), and CP (Kjeldahl procedure). Neutral detergent fibre and acid detergent fibre were analyzed according to procedures described by Van Soest et al. (1991) with modifications for use in the ANKOM^{200} fibre analyzer apparatus (ANKOM Technology Cooperation, Fairport, NY). Neutral detergent fibre analyses were conducted with using sodium sulfite and alpha amylase (heat stable) and expressed with residual ash content. Urine samples were analyzed for N (Kjeldahl procedure; AOAC, 1990) to evaluate N balance.

2.3. Slaughtering procedures

At the end of the experiment all animals were slaughtered to evaluate carcass characteristics and meat quality. All animals were processed by trained personnel using standard slaughter procedures (Abdullah et al., 1998) after being fasted for around 18 h. Final live weight, fasted live weight and hot carcass weight were recorded afterwhat carcasses were chilled at 4 °C for 24 h and reweighed in order to calculate dressing percentage as cold carcass weight/fasting live weight ratio. Non-carcass edible components were removed and weighed directly after slaughter. Non-carcass components included lungs and trachea, heart, liver, spleen, kidneys, kidney fat, and testes. Immediately after slaughtering the animals, rumen fluid samples were collected from each animal. Samples were filtered using 4 layer of cheese cloth and pH was measured (pH Spear, Eutech Instrument, USA). On the next day, the following measurements were taken on the hanging chilled carcasses: carcass length, leg length, gigot width, width behind shoulders, maximum shoulder width, and tissue depth following the procedure described by Abdullah et al. (1998). Carcasses were then cut into four parts (shoulder, rack, loin and leg cuts). Upon cutting, loin cut was dissected and longissimus muscle excised from the loin cut and vacuum-packed immediately and stored at −20 °C for 2 weeks until the time of meat quality assessment.

2.4. Meat quality measurements

Meat quality parameters measured were pH, colour (CIE $L^* a^* b^*$ coordinates), cooking loss, water holding capacity (WHC), and shear force values. Frozen longissimus muscles were thawed in a chiller at 4 °C over night while still in plastic bags. Each muscle was divided into slices of specific thickness and each slice was used for specified meat quality measurement as described by Abdullah and Musallam (2007) and Qudsieh (2006). Colour was measured on slices of 15 mm thick, all slices were placed on a polystyrene tray and covered with permeable film and allowed to oxygenate for 2 h at 4 °C. Cooking loss was measured on slices of 25 mm thickness, slices were weighed before cooking, placed in plastic bags and cooked in a water bath at 75 °C for 90 min and re-weighed after cooking to calculate the percentage of water lost on cooking. The cooked slices were stored at 4 °C over night, then 6 cores, with the size of 1 mm^3 were cut from the slices to measure shear force values. Meat cores were sheared in a perpendicular direction of the muscle fibre using Warner-Bratzler (WB) shear blade with the triangular slot cutting edge mounted on Salter Model 235 (Warner-Bratzler meat shear, G-R Manufacturing Co. 1317 Collins LN, Manhattan, KS 66502, USA) to determine the peak force (kg) required to shear the samples were evaluated on the cooked slices. pH was measured after thawing by homogenizing 2 g of raw meat in 10 mL of neutralized 5-mM iodoacetate reagent, pH of the homogenate was measured using pH spear (pH Spear, Large screen, waterproof pH/Temperature Tester, double injection, model 35634-40, Eurotech instruments, Malaysia). Water holding capacity was measured using the procedure described by Grau and Hamm (1953), approximately 5 g of raw meat was cut into small pieces and placed between 2 filer paper and two quartz plates, and pressed with a weight of 2500 g for 5 min, then meat was removed and weighed, WHC was calculated as a percent of the initial weight WHC% = (initial weight − final weight) × 100/initial weight.

2.5. Statistical methods

Data were analyzed using MIXED procedure of SAS (1996). For all data, the fixed effects included only treatment. Initial body weight was used as covariant for analysis. Least square means were separated using appropriate pair-wise *t*-tests if the fixed effects were significant (P<0.05).

3. Results

3.1. Live weight gain and feed conversion ratio

Least square means of nutrient intakes of lambs fed finishing diets containing PJP are presented in Table 2. A tendency was detected (P=0.08) for DM intake to be higher for the PJP200 group than the CON group while the PJP100 group was intermediate. Organic matter intake was the highest (P<0.05) for the PJP200 group when compared to the CON and the PJP100 groups. Also, crude protein intake was higher (P<0.05) for the PJP200 group than the CON group while the PJP100 group was similar to the CON and the PJP200 groups. Intake of aNDF tended (P=0.07) to be higher for the PJP200 than the CON and

Table 2
Least squares means for nutrient intake and performance of Awassi lambs fed finishing diets containing *Prosopis juliflora* pods

Item	Diets[a]			
	CON	PJP100	PJP200	SE
Nutrients intake (g/day)				
Dry matter	1070c	1098cd	1216d	53.8
Organic matter	960a	954a	1127b	48.8
Crude protein	183a	197ab	210b	9.0
Neutral detergent fibre	382c	379c	437d	20.5
Acid detergent fibre	170a	180a	217b	10.2
Initial body weight (kg)	16.9	17.0	17.5	0.99
Final body weight (kg)	40.1	38.4	41.1	1.81
Total gain (kg)	23.2	21.4	23.7	1.07
ADG (g)[b]	271.2	249.9	272.7	0.01
FCR[c]	3.97a	4.44b	4.42b	0.12
Cost/kg gain (US$)	0.80ac	0.82a	0.74bd	2.14

Within a row, means without a common transcript letters (a and b) differ (P<0.05). Within a row, means without a common transcript letters (c and d) differ (P<0.1).

[a] Diets were: (1) no PJP (CON; $n = 7$), (2) 100 g/kg PJP (PJP100; $n = 7$), and 200 g/kg PJP (PJP200; $n = 7$) of the total mixed diet.

[b] ADG = average daily gain ((final weight − initial weight)/86 days).

[c] FCR (g DM intake/g ADG) = feed conversion ratio.

Table 3
Nutrient digestibility, N balance, and rumen fluid pH of Awassi lambs fed finishing diets containing *Prosopis juliflora* pods

Item	Diets[a]			
	CON	PJP100	PJP200	SE
Digestibility coefficients				
Dry matter	0.71	0.73	0.71	0.02
Organic matter	0.74	0.74	0.74	0.02
Crude protein	0.75	0.72	0.75	0.02
Neutral detergent fibre	0.52	0.53	0.53	0.04
Acid detergent fibre	0.50	0.49	0.50	0.05
N balance (g/day)				
Intake	38.93	37.58	40.64	1.66
Fecal	9.91	10.47	10.10	0.53
Urinary	14.55	15.13	17.28	0.83
Retained	14.47	11.98	13.26	1.98
Rumen fluid pH	6.76	6.69	6.70	0.11

[a] Diets were: (1) no PJP (CON; $n = 7$), (2) 100 g/kg PJP (PJP100; $n = 7$), and 200 g/kg PJP (PJP200; $n = 7$) of the total mixed diet.

PJP100 treatment diets. Also, ADF intake was the highest (P<0.05) for the PJP200 than the CON and the PJP100 treatment diets.

Initial and final body weights, total gain, ADG, feed conversion ratio, and gain cost are shown in Table 2. At the beginning of the study, average initial body weight was similar among treatment groups. No differences were noticed in final weight, total gain, and ADG between treatment groups throughout the study. In Table 2, feed conversion ratio in CON diet was significantly lower than both PJP treatments. Cost of gain was lower (P<0.05) for the PJP200 group than the PJP100 group while tending to be lower (P=0.08) than the CON group.

3.2. Digestion and N balance

Nutrient digestibilities and N balance results are presented in Table 3. Digestibility of DM, OM, CP, aNDF, and ADF were similar among all treatment diets. All animals in all experimental diets had similar N intake. In addition, no differences were observed in N loss in the faeces and N loss in the urine. Therefore, all animals were in positive N balance. Rumen pH was similar for all animals.

3.3. Carcass and non-carcass characteristics

Fasting live weight, hot and cold carcass weights, dressing percentages, non-carcass components and carcass cuts weights and loin cut tissues percentages are shown in Table 4. No differences were observed among treatment diets with respect to the parameters. Loin tissues percentages and ratios were comparable among the treatment diets.

Carcass linear dimensions are presented in Table 5. No differences in carcass length, leg length, leg fat depth (L3), tissue depth (GR), rib fat depth (*J*), eye muscle width (*A*) and

Table 4
Least square means of carcass and non-carcass components of Awassi lambs fed finishing diets containing *Prosopis juliflora* pods

Item	Diets[a]			
	CON	PJP100	PJP200	SE
Fasting live weight (kg)	38.8	37.2	40.4	1.74
Hot carcass weight (kg)	19.3	18.7	20.0	0.92
Cold carcass weight (kg)	18.4	18.1	19.5	0.83
Dressing percentage	47.5	48.7	48.3	0.72
Non-carcass components				
Heart weight (g)	149.1	139.4	157.1	6.48
Liver weight (g)	622.0	558.9	618.9	24.48
Spleen weight (g)	69.71	69.43	68.29	6.11
Kidney weight (g)	110.6	104.0	114.0	4.31
Kidney fat weight (g)	149.4	134.3	128.3	21.5
Testes weight (g)	164.6	139.4	229.7	29.61
Lungs and trachea (g)	507.1	494.0	530.0	26.11
Carcass cuts weights and loin cut tissues percentages				
Fat tail weight (kg)	1.60	1.82	1.92	0.19
Legs weight (kg)	6.20	5.94	6.33	0.29
Shoulders weight (kg)	6.82	6.54	7.16	0.32
Racks weight (kg)	1.71	1.63	1.73	0.09
Loins weight (kg)	1.85	1.83	2.03	0.15
Intermuscular fat (%)	19.0	21.2	17.1	2.3
Subcutaneous fat (%)	4.0	3.8	3.5	0.7
Total fat (%)	23.1	25.1	20.6	2.0
Total lean (%)	45.3	47.3	46.8	1.9
Total bone (%)	18.4	16.7	20.2	1.3
Loin meat to bone ratio	2.5	2.9	2.4	0.2
Loin meat to fat ratio	2.1	2.0	2.4	0.3

[a] Diets were: (1) no PJP (CON; $n=7$), (2) 100 g/kg PJP (PJP100; $n=7$), and 200 g/kg PJP (PJP200; $n=7$) of the total mixed diet.

depth (*B*), fat depth (*C*), and shoulder fat depth (S2) were observed among treatment diets except for gigot width, maximum shoulder width, and width behind shoulder. Gigot width, maximum shoulder width and eye muscle area were the highest ($P<0.05$) for the PJP200 than the PJP100 and the CON groups, with no differences between the CON and the PJP100 treatment diets. Width behind shoulders was greater ($P<0.05$) for the PJP200 than the CON group while the PJP100 group was intermediate. Eye muscle area is measured as the ratio between the width and depth of longissimus muscle. According to the results, muscles of lambs fed PJP200 were not as deep as muscles of lambs fed PJP100 and CON diets, thus muscularity was better in PJP100 and CON groups.

3.4. Meat quality

Least square means of longissimus muscle quality are presented in Table 6. No differences were observed between treatment diets in pH, cooking loss, and shear force values. However,

Table 5
Least square means for carcass linear dimensions of Awassi lambs fed finishing diets containing *Prosopis juliflora* pods

Item	Diets[a]			
	CON	PJP100	PJP200	SE
Carcass length (LB) (cm)	106	105	106	1.7
Leg length (*T*) (cm)	21	21	21	0.3
Width behind shoulder (Wth) (cm)	14a	15ab	15b	0.4
Maximum shoulder width (Wf) (cm)	16a	16a	18b	0.4
Gigot width (*G*) (cm)	16a	16a	17b	0.4
Leg fat depth (L3) (mm)	13	14	12	1.4
Tissue depth (GR) (mm)	15	16	15	1.1
Rib fat depth (*J*) (mm)	7	7	7	0.7
Eye muscle width (*A*) (mm)	64	63	66	1.3
Eye muscle depth (*B*) (mm)	27	26	27	0.9
Eye muscle area (cm^2)	14a	14a	16b	1.4
Fat depth (*C*) (mm)	3.8	5.1	4	0.5
Shoulder fat depth (S2) (mm)	5	5	5	0.6

Within a row, means without a common transcript letters (a and b) differ (P<0.05).
[a] Diets were: (1) no PJP (CON; $n=7$), (2) 100 g/kg PJP (PJP100; $n=7$), and 200 g/kg PJP (PJP200; $n=7$) of the total mixed diet.

water holding capacity was lower (P<0.05) for the PJP200 group than the CON group. No differences were observed in brightness (L^*), redness (a^*), yellowness (b^*), and hue angle between all treatment diets. However, croma tended (P=0.07) to be greater in the PJP100 than the CON and PJP200 diets.

Table 6
Least square means for a range of meat quality characteristics of Awassi lambs fed finishing diets containing *Prosopis juliflora* pods

Item	Diets[a]			
	CON	PJP100	PJP200	SE
pH[b]	6.04	6.14	6.17	0.05
Cooking loss (%)	36.6	33.1	35.1	3.8
Water holding capacity (%)	23.2a	22.0ab	20.4b	0.7
Shear force (kg/cm^2)	2.6	2.6	2.4	0.2
Colour coordinates				
L^* (brightness)	36.40	35.80	35.00	2.2
a^* (redness)	5.04	4.91	4.37	0.8
b^* (yellowness)	10.18	11.09	8.75	2.7
Croma	11.74	12.51	10.07	2.3
Hue angle	65.55	67.44	66.49	5.7

Within a row, means without a common transcript letters (a and b) differ (P<0.05).
[a] Diets were: (1) no PJP (CON; $n=7$), (2) 100 g/kg PJP (PJP100; $n=7$), and 200 g/kg PJP (PJP200; $n=7$) of the total mixed diet.
[b] pH measured after thawing.

4. Discussion

4.1. Live weight gain and feed conversion ratio

In the present study higher DM, OM, CP, aNDF, and ADF intakes were observed in the PJP200 group. However, no differences in intakes were recorded in the other two groups. These results are consistent with Mahgoub et al. (2005b) who found that inclusion of PJP in Omani goat diets up to 200 g/kg of the diet improved feed intake. Also, these results agree with results of Abdullah and Abddel hafes (2004), where the DM intake increased in the lambs offered the diet that contained 150 g/kg PJP. However, Mahgoub et al. (2005b) and Abdullah and Abddel hafes (2004) reported that nutrient intakes were depressed in animals that consumed diets containing more than 200 g/kg PJP (*i.e.*, 250, 300, 350, and 450 g/kg). According to Zolfaghari and Harden (1982), Ravikala et al. (1995), and Mahgoub et al. (2004) the reduction in feed intake when diets contained large proportions of PJP may be due to the presence of trypsin inhibitor, large amounts of the tannins, and other phenolic compounds found in the pods which suppressed the appetite of the animals to the diet, or may be due to the high content of aNDF in the PJP that limits nutrient intakes.

Replacement of part of the barley grains with PJP had no effect on final body weight, total gain, or ADG in lambs. Similarly, no effect of diets that contained PJP at the levels of 0, 150, and 250 g/kg *P. juliflora* pods on rate or efficiency of growth was detected by Abdullah and Abddel hafes (2004). In contrast, same author reported that the rate and efficiency of growth decreased at higher levels of PJP (350 or 450 g/kg). Similarly, Mahgoub et al. (2004) reported a reduction in ADG with higher levels of *Prosopis cineraria* at levels of 300 and 450 g/kg, when compared to 0 and 150 g/kg of the diets. Cumulatively, these studies suggest that growth rate may be adversely affected as the level of PJP increased. The decline in growth rate could have been due to the depression in feed intake that was noticed in previous studies which examined diets containing high levels of PJP.

In the current study, Awassi lambs receiving the CON diet had lower FCR than the PJP100 and the PJP200 treatment groups. Consistent with the current study, Mahgoub et al. (2004) found a reduction in FCR when feeding animals *P. cineraria* pods at 0 and 150 g/kg while the ratio increased as *P. cineraria* increased. Cost of feeding was lower for lambs fed the PJP200 diet when compared to other two groups. This reduction in cost is due to the fact that PJP cost nothing except for the cost of labour to collect them. This explains the lower feeding cost when diets included PJP. Similar results were observed by Abdullah and Abddel hafes (2004) and Ravikala et al. (1995). Similar results were also obtained when animals were fed non-conventional feeds (Al Jassim et al., 1998; Abo Omar, 2002). Cost of feeding represents the major component of the production systems. Therefore, feeding animals non-conventional feeds would improve the profitability.

4.2. Digestion and N balance

Digestibility of DM and nutrients and N balance could be affected by feeding different levels of PJP due to the presence of anti-nutritional factors such as tannins and phenolic compounds (Horton et al., 1993; Mahgoub et al., 2004). However, in the current study, digestibility of DM, OM, CP, aNDF, and ADF and N balance were similar between all treatment diets. These results are inconsistent with the study of Abdullah and Abddel hafes (2004), who reported an increase in DM and OM digestibility in Awassi lambs fed diet containing 150 g/kg PJP when compared to the control and other treatment diets that contained PJP at 250, 350, and 450 g/kg in the diets. However, in their study, the digestibility coefficient was decreased as the proportion of PJP in the animal's diet increased Abdullah and Abddel hafes (2004). Mahgoub et al. (2005a) reported that the digestibility coefficient was decreased as the proportion of non-conventional feeds in the animals diet increased. This could be explained by the fact that these feeds have high fibre content when compared to the commercial diets. Bunting et al. (1988) also found that digestibility of all organic matters was reduced when animals consumed diets containing different and increasing levels of *Prosopis glandulosa*. Our study and previous studies (Bunting et al., 1988; Abdullah and Abddel hafes, 2004) have indicated that lamb's rations containing 200 g/kg or less PJP lead to no adverse effects on feed intake, N balance, and nutrient digestibilities.

4.3. Carcass and non-carcass characteristics

Diets and nutrient contents may affect carcass characteristics and meat quality. Nagpal et al. (1995) indicated that growing lambs fed PJP had higher live weight, increased hot carcass weight, and dressing out percentages than diets free of PJP. However, in the current study, dressing percentages, non-carcass components, carcass cuts weights and loin cut tissues percentages were similar for all treatment diets. These differences may have resulted from different ingredients or different energy or protein percentages in the diets. Results of the current study are consistent with those are reported by Abdullah and Abddel hafes (2004) and Mahgoub et al. (2004).

In the current study, all carcass linear measurements did not differ among treatment diets except for gigot width (*G*), maximum shoulder width (Wf) and width behind shoulders (Wth). Gigot width, width behind shoulders, and maximum shoulder width were the highest for the PJP200 group. Similar results were observed by Mahgoub et al. (2005a) who found that the width behind shoulders was greater when using PJP and date palm by-products when compared to the control diet. These results are also consistent with those reported by Abdullah and Abddel hafes (2004) and Ravikala et al. (1995) when feeding PJP to growing lambs. It is possible that feeding such feed sources results in changing the portioning and distribution of available nutrients in a way that provides more nutrients to the upper part of the body.

4.4. Meat quality

Meat quality parameters measured were comparable among all the treatment diets except for the water holding capacity which resulted more favourable in PJP200 compared to other groups. Water holding capacity was better in lambs fed PJP200 possibly because of having more bound water to their muscle fibres thus their ability will be better for retaining more water within its muscle fibres. The pH values for all treatments were within the acceptable range at which meat is considered to be tender (Qudsieh, 2006). Tenderness values obtained are considered to be within the acceptable range as well. Field et al. (1971) stated in his review that shear force values around 3.6 kg/cm^2 or less are considered to have acceptable tenderness for goat and sheep meat. These results are comparable with the findings of Qudsieh (2006) for male lambs slaughtered at different live weights.

5. Conclusion

This experiment was conducted to study the effect of partial replacement of barley grains by *P. juliflora* pods on growth performance and carcass and meat characteristics on Awassi lambs fed finishing diet. The present study demonstrated the potential for using *P. juliflora* pods for growing lambs without causing any health problems nor affecting growth performance. Thus, including *P. juliflora* pods in diets of Awassi lambs seems to be beneficial for livestock producers.

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