Open Journal of Animal Sciences, 2016, 6, 16-23
Published Online January 2016 in SciRes. http://www.scirp.org/journal/ojas
http://dx.doi.org/10.4236/ojas.2016.61003

Growth Performance and Digestibility in Karadi Lambs Receiving Different Levels of Pomegranate Peels

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Received 22 October 2015; accepted 9 January 2016; published 12 January 2016

Abstract

The objective of current study was to determine the effect of different ratios of pomegranate peel in diets of Karadi lambs (0%, 1%, 2% or 4% as control, T1, T2 and T3, respectively) on body weight, total body gain, average daily gain, daily feed intake and apparent digestibility of nutrients. Sixteen Karadi male lambs weighing 23.29 ± 0.42 kg and 4.5-5 months old randomly divided into equally four treatment groups and individually penned for the period of 63 days. Results indicated that final body weight was significantly (P < 0.05) higher in lambs fed 1% or 2% pomegranate peel (PP) as compared to lambs fed 4% PP. The best improvements in total feed intake, total gain, average daily gain and feed conversion ratio (FCR) in lambs fed 1% PP. The total dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), ash, nitrogen free extract (NFE) and metabolizable energy (ME) intake per (body weight$^{0.75}$) increased (P < 0.05) significantly in lambs fed 1% pomegranate peel (PP); however, the crude fiber (CF) intake decreased in lambs fed 1% PP as compared to other treatments. While, the dry matter digestibility (DMD), crude protein digestibility (CPD), crude fiber digestibility (CFD) and nitrogen free extract digestibility (NFED) were significantly (P < 0.05) higher in lambs fed 1% PP as compared to T2, T3 and control groups. In addition, EED increased significantly in T3 compared to other treatments. In conclusion, it was indicated that addition of pomegranate peel in diet at the rate of 1% or 2% had significant effect on Karadi lambs performance and digestibility.

Keywords

Pomegranate Peel, Growth Performance, Digestibility, Karadi Lambs

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How to cite this paper: Sadq, S.M., Ramzi, D.O.M., Hamasalim, H.J. and Ahmed, K.A. (2016) Growth Performance and Digestibility in Karadi Lambs Receiving Different Levels of Pomegranate Peels. *Open Journal of Animal Sciences*, **5**, 16-23.
http://dx.doi.org/10.4236/ojas.2016.61003

1. Introduction

Pomegranate (*Punica granatum* L.) family Punicaceae has been cultivated around the world in subtropical and tropical regions such as in Iraq, Iran, California, Turkey, Egypt, Italy, India, Chile and Spain. Pomegranate peels contain a substantial amount of polyphenols such as sugar-bound flavoniods quercetin and kaempferol, flavond, diglycoside, ellagic acid tannin and organic acids. Although polyphenolic compounds may improve animal health, they can also decrease proteolytic activity, therefore, compromise protein digestion [1]. Pomegranate components have attracted attention for their apparent wound-healing properties [2], immunomodulatory activity [3] [4], antibacterial activity [5], and antiatherosclerotic and antioxidative capacities [6].

However, fresh pomegranate biomass contains high levels of moisture and soluble sugars [4], rendering its disposal, drying, or preservation problematic. In a previous study, Shabtay *et al*. [4] demonstrated that dietary supplementation with fresh pomegranate peels promoted a significant increase in feed intake, with a positive tendency toward increased body weight gain in bull calves. They suggested that the antioxidant and immunomodulatory properties of pomegranate peels might improve immune function, which could benefit calf health. Recent studies also have shown that effect of antioxidant levels in pomegranate peel in lambs fed helps to improve their health and animal performance [7] [8]. The peel packs some of the weight boosting and health enhancing effects of antibiotics and hormones without the detrimental effects and it may yield meat with higher level of beneficial antioxidants [4]. Pomegranate ellagitannin has been identified as the active antioxidant compound and anticancer activities responsible for protecting low density lipoprotein, cholesterol from oxidation *in vivo* a key step in the pathogenesis of atherosclerosis. Pomegranate peel and its extracts are also being investigated for their potential uses as food biopreservatives, formulation of products in nutraceutical industry and cattle feed [9]. From the above points, it is possible to say that there is no published research which indicates the effects of using pomegranate peels on growth performance and digestibility in Karadi lambs.

The main objectives of this study were to determine the effect of supplementation pomegranate peel to the diet on Karadi lambs performance and apparent digestibility of nutrients.

2. Materials and Methods

2.1. Location of Experiment

This study was carried out at the Animal Farm, Dept. of Animal Production, Faculty of Agric. Sci. Univ. of Sulaimani, Bakrajo, Sulaimani, Kurdistan, Iraq.

2.2. Pomegranate Peels Preparation

Mature pomegranate fruits were washed and chopped manually to separate the seeds and peel. The rind (peels) obtained, chopped into small pieces using a sharp knife and dried in air circulatory tray drier at 60˚C ± 5˚C for 6 h till its moisture content reached 12% - 14%. Dried pieces were cooled, powdered in a laboratory disc mill to pass through 20 mesh sieve, packed in high density polyethylene bags and stored at ambient temperature (25˚C ± 5˚C) until use [10] [11]. The chemical composition namely moisture, crude protein, crude fat, ash, crude fibres and carbohydrates content of pomegranate peels powder are shown in **Table 1**.

Table 1. Chemical composition of pomegranate peels powder and barley straw.

Item %	Pomegranate peels	Barley straw
Organic matter (OM)	96.2	91.6
Crude protein (CP)	5.1	4.1
Ether extract (EE)	4.9	1.2
Total Ash	3.7	8.4
Crude fiber (CF)	11.22	41.0
Nitrogen free extract (NFE)	80.5	45.3
Metabolizable energy ME (MJ/Kg)*	27.92	6.6**

*ME was calculated according to Mirzaei-Aghsaghali [17]. **ME of barley straw was calculated according to Hassan *et al*. [18].

2.3. Experiment Diets and Animals

A total of 16 Karadi male lambs were used. They were weighing 23.29 ± 0.42 kg and 4.5 - 5 months old. All lambs were individually housed and treated against ecto- and endo-parasites. After an adaptation periods of 14 days, lambs were randomly divided equally in to four treatments for a period of 63 days. Four rations were used in this experiment which contained one of the four levels of pomegranate peels (PP) (0%, 1%, 2%, or 4%). Chemical composition and formulation ingredients' diets are presented in **Table 2**.

Table 2. Formulation and chemical composition of experimental diets.

Ingredients (%)	Control 0% PP	T1 1% PP	T2 2% PP	T3 4% PP
Barley grain	40	40	40	40
Wheat barn	28	27	26	24
Yellow corn	20	20	20	20
Soybean meal	10	10	10	10
Pomegranate peels	0	1	2	4
Salt (NaCl)	1	1	1	1
Minerals and vitamins	0.5	0.5	0.5	0.5
Dicalcium phosphate	0.5	0.5	0.5	0.5
Chemical composition%				
Organic matter (OM)	93.7	93.77	93.81	93.87
Crude protein (CP)	15.7	15.6	15.5	15.3
Ether extract (EE)	3.12	3.12	3.13	3.14
Total ash	6.3	6.23	6.19	6.13
Crude fiber (CF)	7.8	7.7	7.6	7.5
Nitrogen free extract (NFE)	67.08	67.35	67.58	67.93
Metabolizable energy ME (MJ/Kg)*	12.63	12.65	12.67	12.69

Means followed by the same letter within a row are not significant ($P < 0.01$). *ME (MJ/kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE [19].

Lambs of the control group received basal diet with 0% PP, whereas lambs in T1, T2 and T3 received PP at a rate of 1%, 2% or 4% **Table 2**. All lambs were fed concentrate at a rate of 3% of their body weight. The refusal of the diet was collected and weighed daily before offering the feed in the next morning. Barley straw was given *ad libitum*. Clean water was available constantly. Lambs were weighed at weekly intervals.

2.4. Digestibility Trial and Feces Collection

In the last week of the experiment, total feces were collected from each lamb for 7 days. Feces from the individual lambs were collected and weighed every morning by fitting lambs collection bags [12]. The feces were mixed thoroughly by hand and 10% sub-sample was retained and stored at −15˚C. At the end of the collection period, the sample of feed and refusal were dried at 65˚C for 48 h and feces were dried at 65˚C until constant weight. The dried samples were ground through 1 mm mash. Aliquots of the samples from each day were pooled and analyzed chemically. The apparent digestibility coefficient of feed nutrients was determined according to McDonald *et al*. [13].

2.5. Chemical Analysis of Experimental Diet

In this experiment, concentrate diets were used which contained: barely, yellow corn, soy bean meal, vitamins

and minerals mixture. Barley straw was used as a source of roughage. Samples of feedstuff, offered feed and refusals were dried at 50˚C until constant weight before chemical analyses. Samples then ground through a 1 mm screen for chemical analysis. Dry matters (DM), organic matter (OM), ether extract (EE), crude fibre (CF) and nitrogen free extract (NFE) were determined according to FAO [14].

2.6. Statistical Analysis

Data were analyzed according to XLSTAT [15] program for one way analysis of variance. Differences among means were carried out by using Duncan's [16] multiple range tests.

Data from experiment were analyzed according to the following model:

$$Yij = \mu + t_i + eij$$

where: Yij = the dependent variable, μ = overall mean, T_i = effect of the treatment (i = control, 1% PP, 2% PP or 4% PP), eij = random residual error.

3. Results

3.1. Final Body Weight, Total Body Gain, Feed Intake and Feed Conversion Ratio

Final body weight, total body gain, average daily gain, total feed intake, concentrate and barley straw and feed conversion ratio are given in **Table 3**. Total body gain and average daily gain of lambs were the same for all treatment groups. The final body weight was significantly ($P < 0.05$) higher in lambs fed 1% or 2% pomegranate peel (PP) being 34.9 kg and 34.2 kg for T1 and T2, respectively as compared to lambs fed 4% PP (31.7 kg). The difference between T1 and T2 in final body weight was not significant. Total DM intake and feed conversion ratio (FCR) of lambs fed 1% PP showed better performance compared to other treatment groups. In spite of, all treatment differences were significant ($P < 0.05$) in barley straw intake and FCR. The best improvement in total gain, average daily gain and FCR in lambs fed 1% PP (**Table 3**). However, marginally higher total gain and average daily gain were observed in the T1 (11.5 kg and 182.5 g/day) followed by T2, control and T3 groups.

Table 3. Effect of different levels of pomegranate peels on animal performance of Karadi lambs.

Parameter	Control 0% PP	T1 1% PP	T2 2% PP	T3 4% PP
Initial body weight (kg)	23.6 ± 0.66^{a}	23.4 ± 1.29^{a}	23.5 ± 1.61^{a}	23.3 ± 1.55^{a}
Final body weight (kg)	33.3 ± 0.38^{ab}	34.9 ± 0.58^{a}	34.2 ± 0.62^{a}	31.7 ± 0.48^{b}
Total body gain (kg)	9.7 ± 0.75^{a}	11.5 ± 1.56^{a}	10.7 ± 1.57^{a}	8.4 ± 1.80^{a}
Average daily gain (g/day)	153.97 ± 11.8^{a}	182.54 ± 24.8^{a}	169.84 ± 24.9^{a}	133.33 ± 28.6^{a}
Total feed intake (DM g/day)	1110 ± 41.4^{b}	1146 ± 25.7^{a}	1115 ± 59.6^{b}	1118 ± 37.5^{b}
Concentrate intake (DM g/day)	789 ± 17.7^{a}	797 ± 13.3^{a}	792 ± 13.3^{a}	799 ± 17.8^{a}
Straw intake (DM g/day)	321 ± 8.6^{b}	349 ± 22.6^{a}	323 ± 13.5^{b}	319 ± 6.4^{b}
FCR (g DM intake /g LWG)	7.21 ± 0.38^{b}	6.27 ± 0.41^{c}	6.57 ± 0.25^{bc}	8.39 ± 0.11^{a}

$^{a\text{-}c}$Means followed by different superscripts within a row are significant ($P < 0.05$). FCR: Feed conversion ratio; DM: Dry matter; LWG: Live Weight Gain; PP: Pomegranate Peels.

3.2. Daily Nutrient Intake during Digestibility Trial in Karadi Male Lambs

Table 4 presented the mean value of metabolic body weight, DM, OM,CP,EE, Ash, CF, NFE and ME intake during digestibility trial in Karadi lambs. The result indicated that total DM, OM, CP, EE, Ash, NFE and ME intake expressed as (g/day and $BW^{0.75}$) increased ($P < 0.05$) significantly in lambs fed 1% pomegranate peel (PP). Except crude fiber (CF) intake decreased in lambs fed 1% PP as compared to other treatment groups. However, some parameters in the current work (DMI, OMI, CPI and ash intake (g/day)) were almost similar across all treatment groups. But all other parameters expressed as ($BW^{0.75}$) was significantly different among treatment groups.

Table 4. Effect of different levels of pomegranate peels on daily nutrient intake of Karadi lambs during the digestibility trial.

Parameter	Control 0% PP	T1 1% PP	T2 2% PP	T3 4% PP
Metabolic weight ($W^{0.75}$)	13.49 ± 0.15^{ab}	13.89 ± 0.33^{a}	13.80 ± 0.051^{a}	13.01 ± 0.021^{b}
Total DMI (g/day)	1008 ± 8.69^{a}	1024 ± 5.87^{a}	1021 ± 5.76^{a}	1005 ± 2.48^{a}
DMI (g/kg $W^{0.75}$)	74.72 ± 0.66^{b}	78.71 ± 0.34^{a}	73.99 ± 0.51^{b}	72.35 ± 1.67^{b}
OMI (g/day)	944.5 ± 8.1^{a}	961.2 ± 5.5^{a}	957.8 ± 5.4^{a}	942.4 ± 2.3^{a}
OMI (g/kg $W^{0.75}$)	70.03 ± 0.62^{b}	73.88 ± 0.32^{a}	69.41 ± 0.48^{b}	67.99 ± 1.56^{b}
CP (g/day)	158.3 ± 1.4^{a}	156.7 ± 0.9^{a}	158.3 ± 0.9^{a}	156.8 ± 0.4^{a}
CP (g/kg $W^{0.75}$)	11.73 ± 0.10^{ab}	12.04 ± 0.05^{a}	11.47 ± 0.08^{b}	11.31 ± 0.26^{b}
EE (g/day)	31.45 ± 0.27^{b}	32.15 ± 0.18^{a}	31.96 ± 0.18^{ab}	31.36 ± 0.08^{b}
EE (g/kg $W^{0.75}$)	2.33 ± 0.02^{b}	2.47 ± 0.01^{a}	2.32 ± 0.02^{b}	2.26 ± 0.05^{b}
Ash (g/day)	63.5 ± 0.55^{a}	62.8 ± 0.36^{a}	63.2 ± 0.36^{a}	62.6 ± 0.16^{a}
Ash (g/kg $W^{0.75}$)	4.71 ± 0.04^{ab}	4.83 ± 0.02^{a}	4.58 ± 0.03^{bc}	4.52 ± 0.10^{c}
CF (g/day)	78.6 ± 0.68^{a}	76.8 ± 0.44^{b}	77.6 ± 0.44^{ab}	77.4 ± 0.19^{ab}
CF (g/kg $W^{0.75}$)	5.83 ± 0.05^{ab}	5.90 ± 0.03^{a}	5.62 ± 0.04^{bc}	5.58 ± 0.13^{c}
NFE (g/day)	676.2 ± 5.8^{b}	696.6 ± 3.9^{a}	689.9 ± 3.9^{a}	676.9 ± 1.7^{b}
NFE (g/kg $W^{0.75}$)	50.13 ± 0.44^{b}	53.47 ± 0.23^{a}	50.00 ± 0.35^{b}	48.84 ± 1.12^{b}
ME MJ/kg DM	12.73 ± 0.11^{b}	12.99 ± 0.08^{a}	12.94 ± 0.07^{ab}	12.71 ± 0.03^{b}
ME (g/kg $W^{0.75}$)	0.944 ± 0.008^{b}	0.999 ± 0.004^{a}	0.937 ± 0.006^{b}	0.917 ± 0.021^{b}

$^{a\text{-}c}$Means followed by different superscripts within a row are significant ($P < 0.05$).

3.3. Apparent Digestibility of Nutrients in Karadi Male Lambs

The apparent digestibility of all nutrients is presented in **Table 5**. Result indicated that digestibility crude protein (CPD) was significantly ($P < 0.05$) higher in lambs fed 1% PP or T1 (71.7%), control group (63.5%) as compared to T2, T1 (69.2%, 68.3%) respectively.

Furthermore, the mean value of ether extract digestibility (EED) was significant ($P < 0.05$) different among treatment groups, the highest value was found in group lambs fed 4% PP. But the dry matter digestibility (DMD), crude fiber digestibility (CFD) and nitrogen free extract digestibility (NFED) decreased significantly in lambs fed 4% pomegranate peel compared to other treatment groups. While, the organic matter digestibility (OMD) was not significant ($P > 0.05$) among treatment groups. However, OMD marginally showed higher digestibility in control group (67.7%) followed by T1 (66.8%), T2 (66.3%) and T3 (66.1%). Also, the total digestible nutrient (TDN), digestible energy (DE) and metabolizable energy (ME) are shown in **Table 5**. No significant were found among treatment groups.

Table 5. Effect of different levels of pomegranate peels on apparent digestibility of nutrient (%) of Karadi lambs.

Parameter	Control 0% PP	T1 1% PP	T2 2% PP	T3 4% PP
DMD	68.38 ± 0.43^{a}	67.10 ± 0.62^{a}	66.40 ± 0.69^{b}	65.32 ± 0.37^{c}
OMD	67.70 ± 1.04^{a}	66.80 ± 0.68^{a}	66.30 ± 0.37^{a}	66.10 ± 0.56^{a}
CPD	63.5 ± 0.87^{c}	71.7 ± 0.71^{a}	69.2 ± 0.49^{b}	68.3 ± 0.89^{b}
EED	60.4 ± 0.43^{b}	61.9 ± 0.68^{b}	61.5 ± 0.57^{b}	63.8 ± 0.69^{a}
CFD	59.4 ± 0.59^{a}	59.1 ± 0.17^{a}	56.3 ± 0.37^{b}	54.6 ± 0.31^{c}
NFED	74.7 ± 0.44^{a}	74.8 ± 0.21^{a}	73.7 ± 0.74^{a}	72.3 ± 0.69^{b}
TDN[1]	69.17 ± 0.44^{a}	69.72 ± 0.91^{a}	69.15 ± 0.64^{a}	68.68 ± 0.56^{a}
DE[2]	3.049 ± 0.131^{a}	3.074 ± 0.032^{a}	3.048 ± 0.028^{a}	3.028 ± 0.023^{a}
ME[3]	2.500 ± 0.137^{a}	2.520 ± 0.169^{a}	2.499 ± 0.102^{a}	2.482 ± 0.056^{a}

$^{a\text{-}c}$Means followed by different superscripts within a row are significant ($P < 0.05$). DMD = Dry matter digestibility, OMD = Organic matter digestibility, CPD = crude protein digestibility, EED = Ether extract digestibility, CFD = Crude fiber digestibility, NFED = Nitrogen free extract digestibility, [1]TDN (DM) = DCP + DEE × 2.25 + TDC [20]. [2]DE = %TDN × 0.04409 [21]. [3]ME = DE × 0. 82 [21]. TDC= Total digestible carbohydrate, TDN = Total digestible nutrient, DE = Digestible energy, [3]ME= Metabolizable energy.

4. Discussion

4.1. Effect of Addition of Pomegranate Peel on Lambs Performance

Pomegranate peel (PP) is rich in tannins, which previously shown to have both adverse and beneficial effects in ruminants [7] [22]. Thus, it increased the final body weight, refers by addition of pomegranate peel in the diets. In the present study, 1% to 2% PP supplementation increased final body weight in Karadi lambs. Similar results were also reported by Aerts *et al*., [23] indicated that concentration of tannins (2% to 4%) in the diet of sheep improve production efficiency in ruminants such as increased feed intake, body weight gain, wool production, milk yield and ovulation rate. In contrast, the final body weight did not have any change when lambs fed pomegranate peel at the rate (2%, 4% and 6% PP) reported by [7]. However, numerically increased the total gain and average daily gain in lambs fed (1% to 2% PP), it seems that lambs had a best response to addition of 1%PP (**Table 3**).

On the other hand, increased feed intake and feed conversion ratio (FCR) in lambs fed 1% pomegranate peel as compared to other treatment groups. This also explains the high total feed intake and FCR in this group, which revealed the highest intake (1146 g·day^{-1} and 6.27 g DM intake/g LWG). This improvement in total feed intake and FCR in lambs fed 1% PP may be it is more palatability compared to 2% or 4% PP because of animal feed selection depends heavily on the palatability of the feed. Tannins are usually associated to a decrease in palatability, and consequently discourage grazing [24]. High tannin levels reduce preference of plants by cattle, sheep and goats [25]. In contrast, Frutos *et al*. [26] reported no effect of chestnut (Hydrolysable Tannin) HT on DMI and FCR in finishing lambs consuming a high-energy ration (14.2 MJ GE/kg DM). In addition, there are exceptions to tannin suppression of DMI and in some cases there is an increase in DMI due to tannin supplementation [27] [28].

4.2. Effect of Supplementation Pomegranate Peel on Daily Nutrient Intake during Digestibility Trials in Karadi Lambs

In our study, the results showed that pomegranate peel (PP) has effect on daily nutrient intake during digestibility trial in Karadi lambs. The mean value of nutrients increased in lambs fed 1% PP compared to other treatment, due to containing a low level of tannin in lambs fed 1% PP. Several studies suggested that contents of condensed tannins higher than 50g/kg dry matter (DM) significantly reduce voluntary feed intake, in most ruminants, while medium or low levels seems to have a minor effect [26]. Similar results was found by Jami *et al*. [29] who showed that using 1% - 4% pomegranate peel extract improved DM, CP, and NDF intake and digestibility in dairy cows. Shabtay *et al*., [4] reported that using pomegranate peel up to 20% in feedlot calves diet, not only does not possess adverse effects on fattening performance but also because of its palatability, feed intake and consequently average daily gain were increased. They are suggested that tannins are considered to have both adverse and beneficial effects in ruminant animals. High concentrations of tannins may reduce feed intake, digestibility of protein and carbohydrates and animal performance via their negative effects on palatability and digestion.

4.3. Effect of Supplementation Pomegranate Peel on Apparent Digestibility of Nutrients in Karadi Male Lambs

The higher digestibility of crude protein (CPD), crude fiber digestibility and nitrogen free extract (NFED) are increased in lambs fed 1% PP in our study, can be related to the low concentration of tannin in this group. High concentrations of tannins may reduce feed intake, digestibility of protein and carbohydrates and animal performance via their negative effects on palatability and digestion. Low and moderate (2% - 4.5%) concentrations of condensed tannins in the diet improved production efficiency in ruminants, by increasing the flow of non-ammonia nitrogen and essential amino acids from the rumen. In ruminants a particularly important positive effect of tannins is dietary protein protection from ruminal microflora attack [30] [31]. Due to the binding of tannins to dietary protein, and also to a reduction in the activity of a large proportion of microflora, there is an increased rate of amino acid absorption in the intestine, which improves the utilization of nitrogen by ruminants [32]. As well as binding to protein, tannins can also bind to carbohydrates, leading also to a reduction in ruminal gas production [32] [33]. Due to a combination of these activities tannins can be associated with improvements in animal growth and productivity and consequentially minimization of effects to the environment. However, the high digestibility of ether extract (EED) was found in lambs fed 4% PP, due to tannin was protected the ether

extract to degrade in the rumen and it is escape and flow rate from rumen in to the small intestine and it is more suitable for absorption [34].

5. Conclusion

Supplementation of 1% or 2% PP had a significant effect on final body weight, total DM intake, FCR and digestibility of nutrient in Karadi lambs.

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