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Effects of electron irradiation, sodium hydroxide and poly ethylene glycol on the utilization of pistachio by-products by Zandi male lambs

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ABSTRACT

The current study evaluated the effects of treating pistachio by-products (PBP) with electron irradiation (ER; 30 kGy), sodium hydroxide (NaOH; 4%) or polyethylene glycol (PEG) on nutrient digestion, growth performance and blood metabolites of Zandi lambs. Twenty male Zandi lambs (21 ± 1.52 kg BW) were randomly assigned to a control diet (containing 22% untreated PBP), ER-PBP (containing 22% electron irradiated PBP), NaOH-PBP (containing 22% NaOH treated PBP) or PEG-PBP (containing 22% PEG treated PBP) for 70 d. Data were analyzed using the GLM procedure of SAS for a completely randomized design and significance level was set at 0.05. Treating PBP with ER decreased (−5.21%) neutral detergent fiber (NDF), whereas treating with NaOH increased (+32.24%) NDF content compared to control PBP. The concentrations of phenolic compounds were lower in NaOH-PBP than in control PBP or ER-PBP. Potential degradability ($a+b$) and effective ruminal disappearance of dry and organic matters were lower in NaOH-PBP compared to control or irradiated PBP. Feeding ER-PBP improved feed intake, weight gain and average daily gain compared to other experimental diets ($P<0.05$). Feeding ER-PBP, PEG-PBP or NaOH-PBP similarly increased ($P<0.01$) dry matter and crude protein digestibility compared to control group. Among different serum metabolites only total protein was affected by experimental diets, which was increased ($P<0.01$) in lambs fed PEG-PBP compared to other experimental diets. Alanine aminotransferase (ALT) was decreased ($P<0.01$) in the lambs received dietary treatments compared to those received control diet.

1. Introduction

Iran is the most important pistachio producer in the world followed by USA and Turkey (FAO, 2011). This results in a large amount of pistachio by-products (PBP) with the potential to be used as a feed ingredient for livestock. It has been estimated that PBP production based of fresh weight in Iran is over 400,000 MT annually. Pistachio by-products consist of 53.50% external hull (epicarp) with the remaining composed of leaves, mesocarp and kernel (Bohluli et al., 2008a).

During the last decade many studies reported successful inclusion of PBP in the diets of sheep, dairy cows and steers (Norouzian and Ghiasi, 2012; Rezaeenia et al., 2012; Shakeri et al., 2013). However, the utilization of PBP and the level of its inclusion in the diets of ruminants can be limited by its content of phenolic compounds (Bohluli et al., 2008b). It has been reported that the level of total phenols in the dried PBP varies between 7.5-14.2% depending on

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the variety and growth conditions (Bohluli et al., 2008b; Bagheripour et al., 2008).

Shakeri et al. (2013) reported that feeding PBP silage up to 18% of dietary DM did not have any negative effects on growth performance of Holstein steers, however hemoglobin and white blood cell levels decreased in steers fed diet containing 18% (DM basis) PBP silage. The authors related this observation to the high content of phenolic compounds in PBP. Therefore, removing phenolic compounds from PBP could improve its nutritive value for feeding animals. Bagheripour et al. (2008) showed that adding poly ethylene glycol (PEG) to freeze-dried, sun-dried and ensiled PBP increased *in vitro* fermentation and estimated organic matter digestibility. Conversely, ensiling for 60 d had no effect on the content of phenolic compounds in PBP (Bagheripour et al., 2008). Valizadeh et al. (2009) showed the addition of urea (0.15%) prior the ensiling decreased total phenol and tannin contents of PBP; however treatment with urea also decreased PBP digestibly in rumen, intestine and total tract.

Alkalies have been used for tannin reduction in feedstuff for many years. Sodium hydroxide (NaOH) has been suggested to be the most effective treatment for detannification of tree leaves including oak leaves (Canbolat et al., 2007; Makkar and Singh, 1992). Makkar and Singh (1992) reported that alkali treatment of oak leaves decreased the tannin content by 70–90%. More recently ionizing radiations have also been used in detannification of agricultural by-products (El-Niely, 2007). The gamma radiation (at 10 kGy) showed 33% reduction in the tannin content of PBP (Behgar et al., 2011).

The objective of the current experiment was to study the effects of feeding PBP treated with electron irradiation (ER), NaOH or PEG on the growth performance, digestibility and blood metabolites in Zandi sheep.

2. Material and methods

2.1. Feed description and preparation

Pistachio by-products were gathered from a local pistachio processing factory, located 5 km Saveh city, in Iran and were sun dried before used in the present study. Approximately 190 kg of PBP were packed in 120 polyethylene bags ($15 \times 20\,cm^2$; 1.6 kg per bag) and exposed to 30 kGy of ER with a fixed beam energy of 10 MeV and dose rate of 180 kGy min^{-1} at room temperature by a Rhodotron accelerator model TT200. Another portion of PBP (200 kg) was treated with 200 L of NaOH solution (40 g/L of water). The NaOH treated PBP were stored in silos at ambient temperature for 3 days and dried before use.

2.2. Chemical analysis

Samples of treated PBP were ground through 1 mm screen and were analyzed in duplicate for crude protein (CP; #955.04), organic matter (OM; #942.05) and ether extract (EE; #920.39) according to AOAC (1999). Neutral detergent fiber (NDF), acid detergent fiber (NDF) and acid detergent lignin (ADL) were determined according to Van soest et al. (1991). Total phenolics (TP), tannin (T) and condensed tannin (CT) contents were determined according to Makkar (2003).

Table 1
Ingredients and chemical composition of diet fed to sheep.

Items	
Ingredients (% as fed basis)	
Pistachio by-products	22.00
Wheat straw	12.20
Wheat bran	10.00
Barley grain	45.00
Soybean meal	9.00
Limestone	1.00
Mineral and vitamin premix	0.40
Common salt	0.40
Total	100.00
Chemical composition (g/100 g DM)	
Dry matter (%)	92.35
Crude protein	14.90
Ether extract	5.26
Neutral detergent fiber	23.20
Acid detergent fiber	19.80
Calcium*	0.58
Phosphorus*	0.47
ME (kcal/kg DM)*	2.80

* Estimated based on NRC (2001).

2.3. Animals, experimental diets and feeding trial

Twenty male Zandi lambs with the initial average body weight of 21 ± 1.52 kg were housed in individual pens and were allocated to four dietary treatments in a completely randomized design for 70 days. The basal diet consisted of 220 g/kg DM PBP, 130 g/kg DM wheat straw and 650 g/kg DM barley based concentrate. The four dietary treatments included of control diet (Treatment 1; basal diet containing 22% PB), ER-PBP (Treatment 2; containing 22% electron irradiated PBP), NaOH-PBP (Treatment 3; containing 22% NaOH treated PBP) and PEG-PBP (Treatment 4; PEG added to basal diet as 15 g/kg of diets DM). The ingredients and chemical composition of the basal diet are presented in Table 1.

Throughout the 70 d experiment, body weight was measured weekly. Feed intake and ort of lambs were recorded and sampled daily for determination of nutrient intake of DM, CP ($N \times 6.25$), EE and NDF as describes before.

2.4. Nutrient digestibility

All lambs were fitted with fecal collection bags for 5 d at the end of the trial. Fecal materials were dried at 55 °C. Diet and ort were sampled daily at each feeding, weighed, and dried at 55 °C. Dried samples were composited by sheep and were analyzed in duplicate for DM, ash, CP, EE and NDF as described before. Apparent total digestibility of nutrients was estimated by the marker ratio technique using acid insoluble ash (AIA) as an internal marker (Van Keulen and Young, 1977).

2.5. In situ ruminal degradability

Nylon bags which ($18.5 \times 9\,cm^2$) with a pore size of 48 μm containing 5 g ground (2 mm screen) of PBP, ER-PBP and NaOH-PBP were incubated in the rumen of three