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The Nutritional Effect of Incorporating Different Percentages of Pistachio By-products Silages into the Diet of Sheep on the Quantitative and Qualitative Characteristics of Meat

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ABSTRACT: The effect of incorporation of ensiled pistachio residues (EPR) into the diet of sheep on the quality of mutton was investigated. Twelve male lambs at 6 months of age and average weight of 35.9±1.21 Kg, were divided into four groups (0, 33, 66 and 100 % EPR) and fed for 90 days in a completely randomized design. After fattening period, the lambs were slaughtered and dry matter, protein, fat, ash, NPN and minerals (Ca, P, Mg, K, Mn, Cu, Zn and Fe) of meat were measured. The functional properties of mutton (pH, WBC, texture, cooking loss and OD) and sensory attributes were determined. The results showed that feeding lambs with EPR, there was no significant difference in the meat traits, however meat fats in the treatments were lower in comparison to the control and the lowest amount of fat was obtained in group of the lambs fed with EPR at 66 %. The Zn and Fe of mutton was increased by addition of EPR and the highest amount was obtained in 100 % diet. The results indicated that addition of ensiled pistachio by-products to the diet of lambs improved the quality and nutritional value of mutton compared to the control samples received a standard diet. Therefore, it may be suggested that the use of EPR in sheep diet.

Keywords: Characteristics, Chemical, Ensiled Pistachio Residues, Lamb Meat, Physical.

Introduction

A large portion of people live in food poverty, while a large portion of food production goes out of the consumption cycle in the form of waste, which, in addition to causing financial losses, contributes significantly to environmental pollution. There are high levels of organic waste in agriculture and conversion industries, amounting to about 25-30%. The processing and reuse of these wastes can increase the added value in the agricultural sector. Today, due to the limited food supply that fails to meet the basic needs of livestock, the nutritional needs and deficiencies of animals are partly met by the use of waste products, thus contributing to reduced price of livestock feed, increasing livestock production and also preventing environmental pollution.

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Considering the volume and nutritional value of waste from pistachio production in Iran, this subject is worthy of special attention. The annual production of pistachios in Iran is estimated at 300,000 tons. Iran is a leading producer of pistachios in the world. Since the area under cultivation of this crop in Iran continues to expand, the volume of pistachio waste in the country is also increasing annually. Considering the annual production rate, about 500 thousand tons of pistachio waste is produced (64.5% soft outer skin, 25% clusters, 10% leaves, and 0.5% kernel and shell) (Sayed Momen *et al.*, 2005) and it can be used as a convenient source of feed for ruminants (Frutos, *et al.*, 2004 and Mokhtarpour, *et al.*, 2012). The shelf life of fresh pistachio skin is limited due to its high perishability. The skin must be processed and dried and stored in silos. The by-products of pistachio have numerous phenolic compounds such as tannins. Tannins are commonly classified into two main groups: the hydrolysable and the condensed tannins. The valuable phenolic compounds consumed by ruminants, depends on the type of tannin consumed, its chemical structure and molecular weight, the amount ingested, the type of animal involved and also the geographical location and weather conditions (Frutos, *et al.*, 2004 and Noorolahi, *et al.*, 2020).

Due to the increasing consumption of waste materials in livestock feed, sufficient attention should be paid to the impact of such substances on food products and processed foods. There are few studies on the composition and effects of pistachio by-products incorporation into livestock feed (Sayed Momen *et al.*, 2005; Piasentier, 2003; Tavendale *et al.*, 2005, and Young *et al.*, 1994). The effect of replacing wheat bran by pistachio skin in the diet of dairy goats was investigated by Naserian *et al*. (2016). They concluded that pistachio skin can successfully replace wheat bran in the diet of dairy goats without negative effects on feed intake, nutrient digestibility and milk production. In another study, Forough Ameri *et al.* (2004) used pistachio waste stored in silos to feed dairy cows. They concluded that replacing corn stored in silos with pistachio waste up to 100% had no significant effect on milk production and other factors.

No significant reports have been published on the effect of pistachio residues consumption on the characteristics and quality of meat in Iran or the world. It seems that the amount of tannin in the feed has affected the meat composition such as protein (Waghorn *et al.*, 1987, 1987a, 1994; McNabb *et al.*, 1993; Barry & McNabb, 1999; Iqbal *et al*., 2002; Tavandale *et al*., 2005). The positive effects of tannins in ruminants' feed increase animal performance (Iqbal *et al*., 2002). According to Waghorn *et al.* (1987, 1987a, 1994), the amount of essential amino acids increased after eating tannin-containing feeds. Due to their reactivity with plant proteins as they are being chewed by ruminant animals, condensed tannins partially protect animals against rumen degradation, and therefore increase the flow of amino acids to the small intestine and increase their absorption from the small intestine of sheep. Condensed tannins decrease the degradation of forage protein and 'S' amino acids to mineral sulphide in the rumen and increase the concentration and absorption of Methionine and Cysteine in sheep (McNabb *et al.*, 1993). Barry & McNabb (1999) investigated the positive effects of tannins in ruminants' feed and reported amino acid uptake and non-ammonia nitrogen uptake in the intestine

as appropriate indicators of the positive effect of tannins on protein metabolism. Condensed tannins with a high molecular weight has band more strongly with enzyme and other proteins than those with a low molecular weight (Beart *et al.*, 1985; Horigome *et al.*, 1998; Kawamoto *et al.*, 1996; Frutos, *et al.*, 2004).

Mahdavi (2009a) and Mahdavi *et al.* (2009b) examined the efficacy and performance of pistachio waste by applying different physical and chemical methods on the waste from pistachio peeling workshops and its use in the diet of fattened lambs. Their results showed no negative effect on the fattening performance, conversion ratio, and other carcass parameters as well as liver and kidney function and health.

Ebadi *et al.* (2009) evaluated the characteristics of meat from sheep fed on dried pistachio skin. Their results indicated that the addition of dried pistachios to sheep's diet increased the amount of calcium, phosphorus, and beneficial micronutrients in their meat, such as iron and zinc, as compared to the controls.

Mutton has special properties and are affected by many factors such as production factors (biological & production system) and technical aspects (slaughter & post slaughter) (Beriain *et al.*, 2000). One of the main factors, that is affecting the quality of mutton is the type and quality of livestock feed (Agriculture Victoria, 2018; Suttie *et al.*, 1991; Bigham,1986). In order to investigate the nutritional effects of dietary content on the quality of meat produced, this and most previous studies on the subject have examined important characteristics such as WBC, texture, cooking loss, and pH of meat (Sen *et al.*, 2011; Beriain *et al.*, 2000; Rost Akrim *et al.*, 1997; Young *et al.*, 1994; Boylen *et al.*, 1976). The customer is concerned with meat quality that includes desirable taste and nutritious values. The organoleptic quality and its marketability of meat is evaluated by sensory characteristics. The sensory attributes namely color, taste, smell, flavor and juiciness is determined by taste panels (Beriain *et al.*, 2000).

The present study examined the effect of using pistachio residues stored in silos (Figure 1) in the diet of *Afshari* sheep. *Afshari* sheep is considered as a tall sheep and is able to walk in the mountains and rocky areas (Figure 2). The largest population and the main distribution area of Afshari sheep is located in Zanjan province, that includes 65% of the population of sheep in this province and was estimated about 1,500,000 heads.

Different parts of pistachio residues *(shell, endocarp, cluster and leaves)*

Fig. 1. Pistachio residues stored in silos

Fig. 2. *Afshari* sheep

Materials and Methods

In a completely randomized design, 12 six-month-old *Afshari* lambs with an average weight of 35.9±1.21 kg were fattened for 90 days with a diet containing waste from pistachio peeling units, that had been stored in silos, at the Animal Science Research Institute of Iran (ASRI). The effect of diet containing pistachio by-products on meat characteristics up to 25 % of dry matter and at four percentages (0, 33, 66, and 100 percent of dry matter of the diet) was studied in three replicates livestock. After slaughter and the stage of rigor mortis and cold storage (5°C), the leg cut of carcasses was sampled.

The percentage of dry matter, protein, fat, ash, NPN and minerals (Ca, P, Mg, K, Mn, Cu, Zn and Fe) in the meat samples were determined using standard methods of AOAC (2000).

The functional properties of mutton (pH, WBC, texture, cooking loss and color) and sensory attributes were determined.

pH ultimate: Minced meat samples were homogenized with distilled water at a ratio of 1:5 for few minutes. The pH of the meat slurry was measured using a pH meter (Schott-Gerate, CG 804, German).

Water binding capacity (WBC): Meat sample was centrifuged to assess its WBC. The percentage of WBC of mutton was determined by the following formula (Shults *et al*., 1972).

$$WBC = 300 - (11.43 \times S)$$

Where S is the supernatant.

Texture: The firmness and hardness of the meat tissue (raw and cooked) were measured by a texture analyzer, QTS-25 model (CNS Farnell, UK). Muscle samples trimmed of external fat; the rectangular samples (1×3 and 7 cm long) were used for shear force determination. Maximum peak force was measured and taken as meat hardness.

Cooking loss %: Meat samples (1×2×5 cm) were cooked at 85 °C, to a core temperature of 75 °C. Cooked meat was drained, cooled, and dried with filter paper and the percentage of cooking loss were measured using the following equation (Pena *et al*. 2009).

$$\text{Cooking loss \%} = \frac{Wf - Wi}{Wi} \times 100$$

Where W_f and W_i are the final and initial weights (g) of the samples, respectively.

Color: The optical density (OD) of meat pigments was determined using spectrophotometer. Muscle samples were trimmed of external fat and the absorbance of the extract are measured at 555, 540-580, and 505 nm for myoglobin, oxymyoglobin and metmyoglobin, respectively (Pearson & Gillett, 1997 and Elbe, 1996).

Sensory evaluation: The sensory attributes as color, texture, aroma, flavor and taste were determined by taste panels.

The experimental groups were statistically analyzed in SAS software (1995) using the ANOVA. The comparison of the means was carried out using Duncan's method at a 5% confidence level.

Results and Discussion

The results showed that the meat of livestock fed with different percentages of pistachio skin stored in silos and the controls were not significantly different in terms of physical and chemical characteristics. Although the amounts of meat protein in the treatment groups were less than the control group. The amount increased as the percentage of pistachio skin in the diet increased. Table 1 presents the protein content of sheep meat in the experimental groups receiving the 33%, 66%, and 100% treatments and the control group. The increase in meat protein content as the percentage of pistachio skin increases in the diet might indicate its dependence on the amount of tannin in the feed. Tannins containing in pistachio residues has affected protein metabolism (Waghorn *et al.*, 1987, 1987a, 1994; McNabb *et al.*, 1993; Barry & McNabb, 1999; Iqbal *et al*., 2002; Tavandale *et al*., 2005). Iqbal *et al*. (2002) reported that tannins containing plants increase animal performance. Waghorn *et al.* (1987, 1987a, 1994), reported that the amount of essential amino acids increased after eating tannin-containing feeds. Reaction of tannin with plant proteins during chewing of ruminant animals, slightly protect it against rumen degradation and therefore increase the flow of amino acids to the small intestine of sheep and improve their absorption. On the other hand, condensed tannins decrease the degradation of forage protein and 'S' amino acids to mineral sulphide in the rumen and increase the concentration and absorption of Methionine and Cysteine in sheep (McNabb *et al.*, 1993). Barry & McNabb (1999) mentioned the positive effects of tannins in ruminants' feed and reported amino acid uptake and non-ammonia nitrogen uptake in the intestine are appropriate indicators of the positive effect of tannins on protein metabolism.

The fat percentage of the meat in the experimental groups was lower than the control group and the lowest fat content obtained was in the 66% group (30.40±6.70% of dry matter) (Table 1). The results indicated that tannin-containing feed improved the protein and energy metabolism in the animal's body, therefore it was affected on the amount of energy stored in muscle tissue and finally decreased the percentage of meat fat in comparison with control sample.

No significant differences were observed in ash, NPN, and mineral concentrations between the experimental and control groups.

The quality assessment and functional properties of the meat in the experimental groups showed no statistically significant differences ($P>0.05$) with the control group, which had been fed a standard diet (Table 2).

The results show that the shear force of cooked meat in the treatment containing 66% pistachio residues had the lowest value (9.27 Kg), that indicates the softer texture in this treatment ($P<0.05$). It seems that the low amount of meat fat had affected on the softy texture in the treatments containing pistachio residues, especially at 66% level (Tables 1and 2).

The concentration of meat OD in the treatments containing 66% and 100% pistachio by-products was higher than the control samples. It appears that the color of the waste used has an impact on this item, but as mentioned before, no statistically significant differences were observed in the OD between the experimental groups ($P>0.05$).

Table 3 presents the correlation of the quantitative and qualitative characteristics of the meat extracted from the ensiled treatment group. As suggested by the

results, there is a significant correlation between dry matter properties and protein and meat ash (P≤0.05). The percentage of dry matter had a negative correlation with protein (-0.88, 0.01) and ash (-0.63, 0.05). Based on these results, the percentage of protein had a positive and significant correlation with meat ash (+0.67, 0.01). The pH and shrinkage after cooking had a negative correlation with the non-protein nitrogen (NPN) of the meat (P≤0.05). It appears that the use of pistachio by-products stored in silos in livestock feed has affected the obtained coefficients. Pistachio skin contains anthraquinones, tannins, and flavonoids (Ahangi, 1993). The tannins in plants are water-soluble polyphenolic compounds and are capable of making strong bonds with other tissue compounds (proteins, polysaccharides, etc.) (Müller-Harvey & McLaughlin, 1992).

Table 1. Mean and standard errors of the composition of mutton fed with different percentages of pistachio by-products silages

Meat composition (% DM)	pistachio by-products silages (%)			Control
	33	66	100	
Dry matter	34.29±3.38	31.40±3.38	31.28±3.38	33.75±3.38
Protein	55.98±7.46	56.72±7.46	60.15±7.46	61.50±7.46
Ash	3.13±0.34	3.04±0.34	3.15±0.34	3.36±0.34
Fat	35.98±6.70	30.40±6.70	36.01±6.70	45.49±6.70
NPN	0.25±0.015	0.22±0.015	0.24±0.015	0.23±0.015
Ca	0.18±0.03	0.21±0.03	0.25±0.03	0.24±0.03
P	0.01±0.003	0.007±0.003	0.01±0.003	0.01±0.003
Mg	0.17±0.02	0.16±0.02	0.18±0.02	0.16±0.02
K	1.76±0.17	1.79±0.17	1.71±0.17	1.78±0.17
Mn (ppm)	0.20±0.15	0.25±0.15	0.20±0.15	0.28±0.15
Cu (ppm)	8.16±1.12	7.64±1.12	8.38±2.12	7.13±1.12
Zn (ppm)	80.48±19.48	103.28±19.48	129.50±19.48	125.32±19.48
Fe (ppm)	44.84±9.89	47.21±9.89	60.14±9.89	57.82±9.89

Table 2. The characteristics of mutton fed with different percentages of pistachio by-products silages as compared to control

Characteristics		Control (0%)	33%	66%	100%	Standard error
pH		5.76^{a}	5.65^{a}	5.75^{a}	5.87^{a}	0.07
Water-Binding Capacity (WBC)		37.11^{a}	21.87^{a}	29.49^{a}	18.06^{a}	5.71
Texture-raw meat (Kg)		18.79^{a}	16.29^{a}	16.56^{a}	17.58^{a}	1.86
Texture-cooked meat (Kg)		14.32^{a}	11.88^{ab}	9.27^{b}	14.41^{a}	0.85
Cooking loss (%)		49.42^{a}	47.59^{a}	45.91^{a}	46.88^{a}	3.17
Color (OD)	505	0.241^{a}	0.218^{a}	0.351^{a}	0.349^{a}	0.14
	540	0.320^{a}	0.295^{a}	0.402^{a}	0.436^{a}	0.13
	555	0.274^{a}	0.247^{a}	0.356^{a}	0.389^{a}	10.3
	580	0.301^{a}	0.275^{a}	0.390^{a}	0.401^{a}	0.13

In each row, the numbers marked with different letters showed a significant difference (P<0.05).

Table 3. The correlation between the characteristics of mutton fed with pistachio by-products silages

Characteristics	Pr	NPN	ASH	PH	FAT	WBC	Cooking loss	Raw texture	Cooked texture	OD_{505}	OD_{540}	OD_{555}	OD_{580}
DM	-0.88**	0.45	-0.63*	-0.48	0.43	0.24	-0.18	-0.26	-0.04	-0.49	-0.49	-0.48	-0.51
Pr		-0.37	0.67**	0.41	-0.33	-0.12	0.36	0.28	0.33	0.25	0.27	0.26	0.3
NPN			-0.26	-0.57*	-0.07	-0.06	-0.73**	-0.1	0.23	-0.5	-0.5	-0.48	-0.53
ASH				0.27	-0.35	0.39	0.21	0.06	0.44	0.2	0.25	0.23	0.22
PH					0.08	-0.23	0.51	0.41	0.32	0.49	0.53	0.51	0.5
FAT						-0.13	-0.02	0.11	0.28	0.07	0.03	0.05	0.03
WBC							0.07	-0.05	0.08	-0.35	-0.33	-0.34	-0.35
Cooking loss								0.21	0.14	0.1	0.17	0.13	0.17
Raw texture									0.13	0.34	0.33	0.35	0.33
Cooked texture										-0.13	-0.06	-0.07	-0.11
OD_{505}											0.99***	0.99***	0.99***
OD_{540}												1.00***	1.00***
OD_{555}													0.99***

The results showed that other characteristics of meat from livestock fed with pistachio skin stored in silos did not have a significant correlation, but a full positive correlation (+1, 0.0001) was observed between the ODs of meat (myoglobin, oxymyoglobin, and metmyoglobin).

The meat marketability analysis in terms of sensory and organoleptic evaluation (color, texture, aroma, and taste) showed no significant difference between the experimental groups (P>0.05), that confirms the quality of meat from livestock fed with pistachio by-products silages is comparable and equal to that of livestock fed with a standard diet (NRC, 1984).

Conclusion

The present study indicated that the consumption of ensiled pistachio residues in the diet of Afshari sheep did not show significant effects on the quantitative and qualitative characteristics of meat. The lowest amount of fat and the highest amounts of Zn & Fe in mutton were obtained in group of the lambs fed with EPR at 66 and 100 % respectively. It was concluded that ensiled pistachio by-products might be successfully employed in sheep diets.

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