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Effects of dietary pomegranate seed pulp on oxidative stability of kid meat

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ABSTRACT

This study was conducted to evaluate the effects of dietary pomegranate seed pulp (PSP) on meat color and lipid stability of kids. Thirty-two Mahabadi male kids were randomly assigned to one of four diets with different levels of PSP: 1 — diet without PSP (Control), 2 — diet containing 5% PSP (PSP5), 3 — diet containing 10% PSP (PSP10), and 4 — diet containing 15% PSP (PSP15). The kids were slaughtered at the end of the study and *m. longissimus lumborum* (LL) was sampled. The TBARS values of both raw and cooked meat were decreased ($P < 0.0001$) by increasing levels of PSP in the diet. The meat of kids fed PSP15 showed higher a* and C* values ($P < 0.01$) and lower H* and b* values ($P < 0.001$), than kids fed with Control diet. The results of this experiment indicated that replacing barley and corn grains with PSP in the diet may improve the color and lipid stability of kid meat.

1. Introduction

Meat quality is important in animal production in order to meet consumer demands, with color and flavor being among the most relevant attributes (Liu, Lanari, & Schaefer, 1995(. Lipid oxidation of meat during post-mortem aging has been related to its deterioration of flavor, color, odor, quality, and nutritive value (Luciano et al., 2009; Morrissey, Sheehy, Galvin, Kerry, & Buckley, 1998), and it can be reduced by dietary supplementation of antioxidants (Coronado, Trout, Dunshea, & Shah, 2002). Recently, the interest in using natural antioxidants in livestock production has increased because they are viewed to be safer than synthetic antioxidants and have greater application potential for consumer's acceptability, palatability, stability, and shelf-life of meat products (Kang et al., 2008; Naveena, Sen, Vaithiyanathan, Babji, & Kondaiah, 2008; Park & Kim, 2008). As a result, the search for natural antioxidants, especially of plant origin, has notably increased in recent years. Waste products from the processing of fruit and vegetables offer a practical and economic source of antioxidants that could be included in ruminant's diet instead of synthetic antioxidants. Pomegranate (*Punica granatum* L.) is an important commercial fruit crop that is extensively cultivated in parts of Asia, North Africa, the Mediterranean, and the Middle East (Sarkhosh, Zamani, Fatahi, & Ebadi, 2006). Iran is one of the most important pomegranate producers and exporters in the world, and its total production in 2005 was 670,000 t (Anonymous, 2005). Increasing agro-industrial units for producing pomegranate juice has led to increased amounts of byproducts including peels and seeds (Shabtay et al., 2008). Annual production of pomegranate by-products (peels and seeds) exceeds 120,000 t in Iran (Mirzaei-Aghsaghali et al., 2011) and the cost of dried seeds is less than half of the barely and corn grains. Pomegranate is known to contain considerable amounts of phenolic compounds, including anthocyanins (3-glucosides and 3, 5-diglucosides of delphinidin, cyanidin, and pelargonidin), ellagic acid, punicalin, punicalagin, pedunculagin, and different flavonols (Gonzalez-Molina, Moreno, & Garcia-Viguera, 2009). These compounds are known for scavenging free radicals and inhibiting lipid oxidation in vitro (Gil, Tomas-Barberan, Hess-Pierce, Holcroft, & Kader, 2000). Recent studies have found that pomegranate by-products may have the potential to be a good source of nutrients and antioxidants for livestock nutrition. Shabtay et al. (2008) suggested that the antioxidant and immunomodulatory properties of pomegranate peels might improve immune function, which could benefit calf health. Recently, Kotsampasi et al. (2014) found that feeding pomegranate byproduct silage to growing lambs increased the total phenolic content and antioxidant activity of meat. Also, it has shown that dietary supplementation of concentrated pomegranate extract increased milk antioxidant activity of dairy cows (Shabtay et al., 2012). Although in a few studies the effect of the inclusion of pomegranate by-products as extract additives or mixture of peel and seed silage in ruminant's diet on their performance is evaluated, according to our knowledge, no other studies have examined the effects of inclusion of dried pomegranate seed pulp (PSP) as a replacement feed for cereal grains of diet on

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meat stability of kid. Therefore, the aim of this study was to determine the effects of replacing barley and corn grains of kid's diet with 5%, 10%, and 15% (DM basis) of PSP on meat lipid and color stability.

2. Materials and methods

2.1. Animals, diets, and experimental design

Thirty-two *Mahabadi* male kids, 4–5 months of age and 16.5 ± 2.8 kg body weight (BW), were used in a completely randomized design experiment. Pomegranate seed pulp used for this study originated from the Yazd variety of pomegranate, and was obtained from the "*Anariyan*" factory in Ferdows, Iran (Table 1). Fresh seed pulp (containing 47.5% dry matter, DM) was dried for 48 h at 65 °C. At the beginning of the experiment, kids were randomly allotted to one of four dietary treatments (n = 8 per group). The dietary treatments included different levels of PSP: 1 — diet without PSP (Control), 2 — diet containing 5% PSP (PSP5), 3 — diet containing 10% PSP (PSP10), and 4 — diet containing 15% PSP (PSP15) (DM basis). Diets were formulated to be isocaloric and isonitrogenous, and to meet NRC (2007) requirements (Table 2). In PSP containing diets, the PSP was included instead of barley and corn grains. The PSP had higher oil content than grains but its NDF content was higher and its non-fiber carbohydrate (NFC) content was less than that of grains and this caused its metabolizable energy (ME) to be less than that of grains (Table 1). As a result, although PSP containing diets had a higher EE content than Control diet, their ME content was the same as that of Control diet or even slightly less than it (Table 2). Kids were housed in individual pens (1.3 m × 1.0 m) with constant illumination. Feed was offered ad libitum as TMR, but there were two feeding times daily at 0700 and 1700 h. Amounts of diet fed and refused were weighed daily for each kid to determine dry matter intake (DMI). The quantity of feed offered was adjusted daily with 20% excess of the daily intakes to ensure ad libitum consumption. Animals were weighed after a 14 h fasting on days 0, 21, 42, 63 and 84 of the experiment to determine the average daily gain (ADG) and feed conversion ratio [FCR; DMI, (g/day)/ADG, (g/day)]. Clean drinking water was always available in plastic buckets and pens were cleaned weekly. Before the beginning of the experimental period, kids were gradually adapted to the experimental diets for 14 days.

Samples of TMR, PSP and refusals were collected three times during the trial and stored at −20 °C for chemical analysis. The animals were cared for according to the guidelines of the Iranian Council of Animal Care (1995).

Table 1
Chemical composition, phenolic compounds and antioxidant activity of PSP.

Chemical composition	% of DM
DM	93.38
CP	11.12
Ether extract	10.10
Ash	2.80
NDF	43.10
ADF	31.10
Calcium	0.008
Phosphorus	0.03
ME (MJ/kg of DM)[a]	10.8
Phenolic compounds	**% of DM**
Total phenols	3.92
Total tannins	2.95
Condensed tannins	0.11
Hydrolysable tannins	2.84
Gallic acid	0.35
Tannic acid	0.24
Ellagic acid	1.60
Punicalin	0.13
Punicalagin A	0.13
Punicalagin B	0.39
Antioxidant activity	
FRAP (μmol Fe^{2+}/L)	782.1

[a] To determine the metabolizable energy (ME) content of PSP, first its gross energy content was measured (16.3 MJ/kg of DM). Then the DM digestibility was measured by in situ and in vitro techniques (the mean value was 81%) and digestible energy (DE) content was calculated (13.5 MJ/kg of DM). Then for calculating the ME content, the equation of McDonald, Edwards, Greenhalgh, and Morgan (1995), ME = 0.80 DE, was used.

Table 2
Ingredient and chemical composition of experimental diets.

	Diets[1]			
	Control	PSP5	PSP10	PSP15
Ingredient (% of DM)				
Alfalfa hay	14.60	14.60	14.60	14.60
Corn silage	15.40	15.40	15.40	15.40
Barley grain, ground	41.26	37.50	35.36	30.52
Corn grain, ground	11.04	9.80	6.94	6.78
Canola meal	3.06	3.06	3.06	3.06
Soybean meal	3.74	3.74	3.74	3.74
Wheat bran	7.67	7.67	7.67	7.67
Pomegranate seed pulp	0	5	10	15
Calcium carbonate	1.02	1.02	1.02	1.02
Mineral and vitamins supplement[2]	0.85	0.85	0.85	0.85
Sodium bicarbonate	0.85	0.85	0.85	0.85
Salt	0.51	0.51	0.51	0.51
Chemical composition (% of DM)				
ME (MJ/kg of DM)	10.96	10.92	10.88	10.88
DM (%)	69.54	69.54	69.54	69.54
CP	14	14	14	13.9
Ether extract	2.8	3.2	3.5	3.9
NDF	28.9	30.2	31.6	32.8
NFC[3]	48.4	46.8	44.9	43.4
Ash	7.7	7.7	7.7	7.7
Calcium	0.73	0.73	0.73	0.72
Phosphorus	0.42	0.41	0.39	0.38

[1] Control, PSP5, PSP10 and PSP15 contained 0, 5, 10 and 15% PSP (DM basis), respectively.
[2] Containing vitamin A (250,000 IU/kg), vitamin D (50,000 IU/kg) and vitamin E (1500 IU/kg), manganese (2.25 g/kg), calcium (120 g/kg), zinc (7.7 g/kg), phosphorus (20 g/kg), magnesium (20.5 g/kg), sodium (186 g/kg), iron (1.25 g/kg), sulfur (3 g/kg), copper (1.25 g/kg), cobalt (14 mg/kg), iodine (56 mg/kg) and selenium (10 mg/kg).
[3] Non-fibrous carbohydrates (NFC) were estimated according to the equation: NFC = 100 − (NDF + CP + EE + Ash).

2.2. Slaughter procedures and muscle sampling

At the end of the trial, kids were weighed after 16 h of feed deprivation and then slaughtered. After the slaughter, non-carcass components were removed, and then carcass was chilled at 4 °C for 24 h. Then *m. longissimus lumborum* (LL, between the 12th thoracic and 5th lumbar vertebrae) of the left half carcass was collected. Fresh LL muscle samples were divided into two portions. One portion was divided randomly into four sub-samples, vacuum-packed, and used to evaluate the lipid and color stability during refrigerated storage in darkness at 4 °C (at 0, 4, 8, and 12 days of storage), using one sub-sample for each day of storage. The remaining portion was cooked at 85 °C for 60 min, then stored under the same conditions as the raw meat and used to measure the lipid stability.

2.3. Chemical analysis

Samples of TMR, PSP and refusals collected during the trial (three times) were pooled and ground in a hammer mill with a 1 mm screen (Arthur Hill Thomas Co., Philadelphia, PA), and analyzed (three replicates) for dry matter (DM, 945.15), ash (967.05), crude protein (CP, Kjeldahl N × 6.25, 990.03), ether extract (EE, 945.16), calcium (927.02), and phosphorus (964.06) according to AOAC (1990). The