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Effect of salt, kinnow and pomegranate fruit by-product powders on color and oxidative stability of raw ground goat meat during refrigerated storage

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ABSTRACT

Effects of salt, kinnow and pomegranate fruit by-product powders on color and oxidative stability of raw ground goat meat stored at 4 ± 1 °C was evaluated. Five treatments evaluated include: control (only meat), MS (meat + 2% salt), KRP (meat + 2% salt + 2% kinnow rind powder), PRP (meat + 2% salt + 2% pomegranate rind powder) and PSP (meat + 2% salt + 2% pomegranate seed powder). Addition of salt resulted in reduction of redness scores. Lightness increased in control and unchanged in others during storage. Redness scores declined and yellowness showed inconsistent changes during storage. Thiobarbituric acid reactive substances (TBARS) values were higher ($P < 0.05$) in MS followed by control and KRP samples compared to PRP and PSP samples throughout storage. The PSP treated samples showed lowest TBARS values than others. Percent reduction of TBARS values was highest in PSP (443%) followed by PRP (227%) and KRP (123%). Salt accelerated the TBARS formation and by-products of kinnow and pomegranate fruits counteracted this effect. The overall antioxidant effect was in the order of PSP > PRP > KRP > control > MS. Therefore, these powders have potential to be used as natural antioxidants to minimize the auto-oxidation and salt induced lipid oxidation in raw ground goat meat.

1. Introduction

Modern trend towards convenience foods has resulted in increased production and consumption of ground meat products. Grinding of meat disrupts the integrity of muscle membranes and exposes lipid membranes to metal ions and facilitates the interaction of pro-oxidants with unsaturated fatty acids resulting in generation of free radicals and propagation of oxidative reaction (Asghar, Gray, Buckley, Pearson, & Booren, 1988). Salt (NaCl) is added to muscle foods for a variety of purposes, including flavoring and inhibition of microbial growth. However, salt has been demonstrated to accelerate lipid oxidation in various meat products (Lee, Mei, & Decker, 1997; O'Neill, Galvin, Morrissey, & Buckley, 1999; Shimizu, Kiriake, Ohtubo, & Sakai, 2009; Torress, Pearson, Gray, & Shimokomki, 1988). Lipid oxidation is further responsible for changes in color, flavor, texture and nutritive value of meat (Fernandez, Perej-Alverez, & Fernandez-Lopez, 1997).

Reduction of lipid oxidation during storage of meat and meat products can be accomplished with antioxidants. These antioxidants delay the onset of lipid oxidation by reacting with free radicals and quenching the metal ions. Synthetic antioxidants like butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), etc. have been successfully used to reduce the lipid oxidation induced changes in meat products. However, reports of adverse health effects of these synthetic chemicals have increased the resistance to use synthetic antioxidants. Therefore, there is a growing interest in natural sources of antioxidants for applications in meat products. Few widely investigated natural antioxidants include vitamin E (α-tocopherol acetate), ascorbic acid, tea catechins and rosemary extract (Arnold, Schaefer, & Scheller, 1991; McCarthy, Kerry, Kerry, & Buckley, 2001). It is now well established that dietary supplementation of vitamin E in meat animals significantly improves the oxidative stability in postmortem muscles (Faustman et al., 1989; Liu, Lanari, & Schaefer, 1995; Philips et al., 2001). Aksu and Kaya (2005) reported that α-tocopherol was as effective as BHA in retarding lipid oxidation when used as a processing ingredient in cooked and sliced beef kavurma. Potential use of powders and extracts of different fruits as natural antioxidants in meat and meat products have been studied in recent years. Antioxidant effect of cherry fruits (Britt, Gomma, Gray, & Booren, 1998) apple (Osada, Hoshina, Nakamura, & Sugano, 2000), citrus fruit by-products (Fernandez-Lopez et al., 2004) and green tea leaves (Bozkurt, 2006) have been investigated for their use in meat products. Antioxidant effects of grape seed, oregano extract and rosemary in frozen vacuum packaged beef and pork was evaluated by Rojas and Brewer (2008). In a most recent study, Hernández-Hernández, Ponce-Alquicira, Jaramillo-Flores,

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and Guerrero (2009) evaluated the antioxidant effect of rosemary and oregano extracts on TBARS and color of model raw pork batters.

Pomegranate (*Punica granatum*) rind is an inedible part/by-product obtained during processing of pomegranate juice. Rind and seeds of pomegranate fruits have been demonstrated to be high in antioxidant activity (Devatkal, Narsaiah, & Borah, 2010). Pomegranate peel or rind extract had scavenging activity against super oxide anions and inhibitory action on low density lipoprotein oxidation (Li et al., 2006). Use of pomegranate juice and rind powder as a source of natural antioxidant in chicken patties had been investigated (Naveena, Sen, Vaithiyanathan, Babji, & Kondaiah, 2008a). Further antioxidant effect of pomegranate rind extract in cooked goat meat patties had been demonstrated by Devatkal et al. (2010).

Kinnow or Tangerine (*Citrus reticulata*) is a citrus fruit variety grown in north Indian states, mainly Punjab and Rajasthan. In the process of juice extraction, 30–34% of kinnow peel is obtained as a major by-product. Kinnow peel is a rich source of Vitamin C, carotenoids, limonene, and polyphenolic antioxidants (Anwar et al., 2008).

Keeping in view the economic and nutritional significance of pomegranate and kinnow by-products, an investigation was carried out to evaluate the effect of kinnow rind powder (KRP), pomegranate rind powder (PRP) and pomegranate seed powder (PSP) on salt induced lipid oxidation and color changes in ground goat meat stored aerobically at 4 ± 1 °C.

2. Materials and methods

2.1. Material

Thigh meat of goats (slaughtered at an age of 12–18 months and weighing 15–18 kg) was obtained from a local retail meat plant and stored at 4 °C for 24 h before use. Fresh meat samples were obtained for each replication. Fresh pomegranate (*P. granatum*) and kinnow (*Citrus reticulate*) fruits were obtained from retail fruit market. Thiobarbituric acid (MP Biomedicals Pvt. Ltd., Mumbai, India), 1,1,3,3-tetraethoxypropane (Sigma–Aldrich, New Delhi, India), standard tannic acid (SD Fine Chemicals, Mumbai, India), and 1,1-diphenyl 2-picrylhydrazyl (Sigma–Aldrich, New Delhi, India) used in the study were of analytical grade.

2.2. Preparation of kinnow rind powder (KRP), pomegranate rind powder (PRP) and pomegranate seed powder (PSP)

Mature and healthy kinnow and pomegranate fruits were washed, cut manually and peeled off. The rind (peel) thus obtained was cut into small pieces using a sharp knife and dried in an air circulatory tray drier (Narang Scientific Works, New Delhi, India) at 60 °C for 48 h. Dried pieces were cooled and powdered in a heavy duty kitchen grinder. The powder was sieved using a sieve (1.651 mm, ASTM No. 10) and packed into 100 g units and stored at room temperature in high density polyethylene bags for further use. Similarly powder from pomegranate seeds was prepared by drying the pomegranate fruit seeds in a tray drier and grinding in a heavy duty kitchen grinder and sieving.

2.3. Treatment of ground goat meat samples

About 3 kg goat meat was minced twice (10 mm plate followed by 8 mm plates) using a meat mincer (Sirman, Italy). Ground meat samples (500 g each) were assigned to five different treatments: (I) Control (meat without salt and natural antioxidant); (II) MS (meat with 2% added salt); (III) KRP (meat with 2% salt and 2% kinnow rind powder); (IV) PRP (meat with 2% salt and 2% pomegranate rind powder) and (V) PSP (meat with 2% salt and 2% pomegranate seed powder). Immediately after adding all ingredients, samples were thoroughly mixed, made into patties, aerobically packaged in low density polyethylene bags and stored at 4 ± 1 °C for 6 days. During storage instrumental color and lipid oxidation was evaluated at 2 days interval.

2.4. Estimation of total phenolics and DPPH radical scavenging activity

About 10 g of KRP, PRP and PSP were individually mixed with 100 ml boiled distilled water and left for an hour. The extracts obtained by filtration were analyzed for total phenolic content using Folin–Ciocalteus (F–C) assay (Escarpa & Gonzalez, 2001). Suitable aliquots of extracts were taken in a test tube and the volume was made to 0.5 ml with distilled water followed by the addition of 0.25 ml F–C (1 N) reagent and 1.25 ml sodium carbonate solution (20%). The tubes were vortexed and the absorbance recorded at 725 nm after 40 min. The amount of total phenolics was calculated as tannic acid equivalent from the calibration curve using standard tannic acid solution (0.1 mg/ml).

The ability to scavenge 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical by KRP, PRP and PSP was estimated by the method of Singh, Murthy, and Jayaprakasha (2002). Each extract of KRP, PRP and PSP (100 μg) diluted with 0.1 M Tris–HCl buffer (pH 7.4) was mixed with 1 ml of DPPH (250 μM) with vigorous shaking. The reaction mixture was stored in the dark at room temperature for 20 min and then absorbance was measured at 517 nm using a UV–VIS spectrophotometer (Model: Spectroscan 80 DV, Biotech Eng. Management Company Ltd., UK). The scavenging activity was calculated by the following equation:

$$\text{Scavenging activity}\% = \frac{(\text{Absorbance}_{\text{Blank}} - \text{Absorbance}_{\text{Sample}})}{\text{Absorbance}_{\text{Blank}}} \times 100$$

2.5. Instrumental color evaluation

Color changes in control and treated goat meat samples during storage were monitored by evaluating Hunter Lab *L* (*lightness*), *a* (*redness*), and *b* (*yellowness*) values at an interval of 2 days. Colorimetric analysis on ground goat meat was performed using a Hunter Lab Miniscan XE Plus colorimeter (Hunter Associates Laboratory Inc., Reston, VA, USA) with 25 mm aperture set for illumination D65, 10° standard observer angle. Color readings were measured on four randomly chosen spots of ground goat meat patties.

2.6. Thiobarbituric acid reactive substances (TBARS) value

Lipid oxidization was monitored by measuring thiobarbituric acid reactive substances during storage. TBARS were determined using extraction method described by Witte, Krauze, and Bailey (1970). TBARS were extracted in chilled 20% trichloroacetic acid (TCA). Two milliliters of TCA extract was mixed with 2 ml, 0.1% thiobarbituric acid and heated for 30 min, cooled and the absorbance was measured at 532 nm. 1,1,3,3, tetraethoxypropane was used as standard for TBARS assay. TBARS numbers were calculated as mg of malonaldehyde per kg of meat sample. Change in TBARS values during each storage interval was calculated arithmetically and expressed as percent change. Similarly percent reduction of TBARS in different treatments was also calculated.

2.7. Statistical analysis

The experiment was replicated thrice and all parameters were measured in duplicate. Mean values for various parameters were