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ORIGINAL ARTICLE

Tenderizing effect of blade tenderizer and pomegranate fruit products in goat meat

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Abstract Toughness of goat meat is a major problem with regard to consumer acceptance. Keeping this in view a blade tenderizer was developed for tenderization of goat meat. Pomegranate fruit products were also explored for tenderization effect on goat meat. Tenderization of goat meat with pomegranate seed powder improved the textural properties marginally with slight adverse colour change and taste. Samples treated with PRP got lower score for colour in sensory evaluation and there was adverse effect on taste of treated meat. Blade tenderization and 4% PSP proved better for tenderization and were compared with control and 0.2% papain in goat meat chunks. The cooked samples treated with papain and blade incisions got better sensory scores and required lesser shear force compared to 4% PSP and control. Overall the papain treated meat was superior in terms sensory attributes followed by blade incision and PSP. The results suggested that the blade incisions can be used for tenderization of goat meat. Pomegranate seed powder maybe considered for mixing with other spices to marinate goat meat mainly for its beneficial effects.

Keywords Mechanical tenderization · Colour · Tenderness · Pomegranate seed powder · Papain

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Introduction

Goat meat is the most popular red meat in India and enjoys great popularity in many developing countries. Tenderness is the major factor affecting consumer satisfaction and eating quality. In order to improve tenderness, different physical and enzymatic methods are adopted. Davis et al. 1977; Savell et al. 1977; Tyszkiewicz et al. 1997 have shown that blade tenderization yielded greater improvement in tenderness of less tender cuts of meat among physical methods. Kudachikar et al. (2007) also used blade tenderization for buffalo rumen meat. Schilling et al. (2003) combined blade tenderization with another physical method of hydrodynamic shockwave treatment for improvement of tenderness.

Naveena et al. (2004) evaluated many proteolytic substances of plant origin and concluded that cucumis and ginger gave better results to tenderize buffalo meat. Use of papain as a proteolytic enzyme and the mechanism by which it increases the tenderness is well established. Papain is a plant protease which acts against connective tissue. They first break up the mucopolysaccharide of the ground substance matrix, and then progressively reduce the connective tissue fibers to an amorphous mass. Pawar et al. (2003) used papain and trypsin which resulted in release of amino acids due to protein hydrolysis in chevon.

Spices are generally used to impart characteristic flavour and colour to meat products. Spices such as ginger show tenderization effect also. Wild pomegranate seed powder is used as spice and there is need to explore its tenderizing

ability. Damania (2004) reported that pomegranate (*Punica granatum*) is an important source of bioactive compounds and its therapeutical and medicinal values are well acknowledged in traditional medicine systems like ayurveda and are also well enumerated in folklore. Although there is traditional practice of meat tenderization using pomegranate juice, no scientific literature exists on the use of pomegranate seed powder or rind powder as tenderizing agent. Ozkal and Dinc (1994) reported that tannins and phenolics are abundant in pomegranate rind. Keeping in view the growing interest in use of natural products to improve quality of foods, pomegranate rind powder also offers great potential as source of antioxidant substances and may contain proteolytic substances. Hence a blade tenderizer was developed and this study was carried out to evaluate the tenderizing effect of blade tenderizer, wild pomegranate rind and seed powder and papain in goat meat.

Materials and methods

Raw materials

Meat sample Hind leg portion of goat carcass (male, 10 months) was obtained from a local retail meat shop within 3–4 h after slaughter. Meat was brought to laboratory and chilled for 4 h. Meat chunks (~3 cm thick) were prepared from the chilled muscle and used for marination.

Pomegranate rind powder and pomegranate seed powder Wild pomegranate seeds and uniformly cut pieces of wild Pomegranate rind were dried in a tray dryer (Narang Scientific Works, New Delhi, India) at 60 °C for 48 h. After cooling they were powdered in a heavy duty kitchen grinder and sieved using a sieve, ASTM No. 10 (1.65 mm) respectively. Finely powdered seed and rind powders were packed in polyethylene bags and stored for further studies.

Papain Papain enzyme procured from standard firm (HIMEDIA, Mumbai, India) was used.

Experiments

Tenderization with blade tenderizer A hand held blade tenderizer was developed. It consists of blade assembly and an ergonomically designed handle which fits into hand. The blade assembly consists of an array of surgical blade holders (handles cut to reduce size) welded on a rod with 1 cm gap between each blade holder. Sterile surgical blades were fixed to these handles. Goat meat chunks cut into uniform pieces (~3 cm thick) divided into two parts each weighing 200 g. Control samples were not incised and

Table 1 Quality of PSP treated goat meat chunks

Treatment	Cooking yield	pH	After marinating			After cooking			Sensory Scores				
			L	a	b	L	a	b	Colour	Flavor	Tenderness	Juiciness	*OA*
Control	55.7±1.28^{b}	6.4±0.24^{b}	49.2±3.62^{b}	5.1±0.88^{a}	7.5±3.33^{a}	46.5±4.24^{a}	3.6±0.90^{a}	9.0±1.22^{a}	6.1±0.78^{b}	5.7±0.92	5.5±0.64^{a}	5.8±0.90	5.9±0.76
PSP 2%	47.0±1.94^{a}	5.5±0.83^{a}	44.6±3.337^{b}	7.7±0.66^{b}	14.6±4.53^{b}	30.4±4.28^{b}	5.3±1.01^{b}	7.4±1.99^{b}	5.5±0.50^{a}	5.8±0.73	5.9±0.66^{b}	6.2±1.00	6.4±0.64
PSP 4%	48.3±0.82^{a}	5.4±1.29^{a}	45.4±3.68^{b}	7.8±1.87^{b}	15.2±5.34^{b}	21.8±2.57^{c}	5.5±0.41^{b}	7.8±2.52^{b}	5.4±0.69^{a}	5.7±0.82	6.2±0.65^{c}	5.7±0.72	6.0±0.61
PSP 6%	48.6±1.54^{a}	5.2±0.43^{a}	39.1±1.92^{a}	8.5±1.83^{c}	14.1±5.60^{b}	27.2±1.94^{d}	5.6±1.26^{b}	8.8±3.26^{b}	5.5±0.68^{a}	5.8±0.79	5.8±0.79^{b}	5.8±0.98	6.2±0.84

Each value is mean ± SD (n=6)

Means bearing same superscripts column wise do not differ significantly (p<0.05)

PSP Pomegranate Seed Powder

OA Overall acceptability

treated samples were incised with blade tenderizer. After half an hour, samples were cooked at 15 psig for 15 min with addition of 2% (w/w) salt.

Evaluation of tenderizing effect of pomegranate seed powder (PSP) About 200 g goat meat chunks (~3 cm thick) were dipped in marinating solution containing 600 ml distilled water (control) and different levels of PSP viz. 2% (w/w), 4% (w/w) and 6% (w/w). Meat chunks were dipped in glass beakers containing the marinating solution and kept at 4±1 °C for 24 h. After 24 h of marination, meat chunks were washed and drained. After this, salt (2% w/w) was added to each sample and samples were cooked in autoclave at 15 psig for 15 min. All the cooked samples were evaluated for pH, cooking yield, instrumental colour, shear force value and sensory attributes.

Evaluation of tenderizing effect of pomegranate rind powder (PRP) About 200 g goat meat chunks (~3 cm thick) were dipped in marinating solution containing 600 ml distilled water (control) and different levels of PRP viz. 2% (w/w), 4% (w/w) and 6% (w/w). Meat chunks were dipped in glass beakers containing the marinating solution and kept at 4±1 °C for 24 h. After 24 h of marination, meat chunks were washed and drained. After this, salt (2% w/w) was added to each sample and samples were cooked in autoclave at 15 psig for 15 min. All the cooked samples were evaluated for pH, cooking yield, instrumental colour, shear force value and sensory attributes.

Comparison of different methods of tenderization The tenderizing effect of 4% PSP and blade tenderizer was compared with control and 0.2% papain treatment. Gerelt et al. (2000) and Naveena et al. (2004) used 0.1% papain and 0.2% papain respectively for tenderization of meat. The treatment with 0.2% papain was chosen to get the maximum tenderizing effect. Four samples were prepared and evaluated as mentioned above.

Analysis of samples

pH and cooking yield For pH determination 10 g of muscle sample blended with 50 ml chilled distilled water. The pH was measured using a digital pH meter (Deluxe pH meter model-101E, Electronics India). Cooking yield was determined by dividing cooked product weight by the raw weight and multiplying by 100.

Tenderness To determine the tenderness, peak shear force was measured using TA-HDi® Texture Analyzer (Stable Microsystems, UK) using Krammer shear cell. Krammer shear cell of 5 blades was modified to single blade cell. Shear force was measured in this cell using 80 g meat sample.

Instrumental colour A Mini Scan XE Plus colourimeter (Hunter Associates Laboratory Inc., USA) was used to obtain Hunter Lab 'L' (lightness; higher the 'L' value, the lighter the colour), 'a' (red-green spectrum; higher the 'a' value, the redder the colour), and 'b' (yellow-blue spectrum; higher the 'b' value, the more yellow the colour) values on meat chunks using D 65 illuminant and the 10° standard observer settings. Readings were obtained at four locations on the exposed meat chunk surface, avoiding large pieces of connective tissue or fat particles and average values are reported.

Sensory analysis The sensory evaluation of the cooked goat meat chunks was done by a semi trained panel of 10 members for determining the attributes like colour & appearance, juiciness, tenderness, flavour and overall acceptability of the cooked chunks using 8-point descriptive

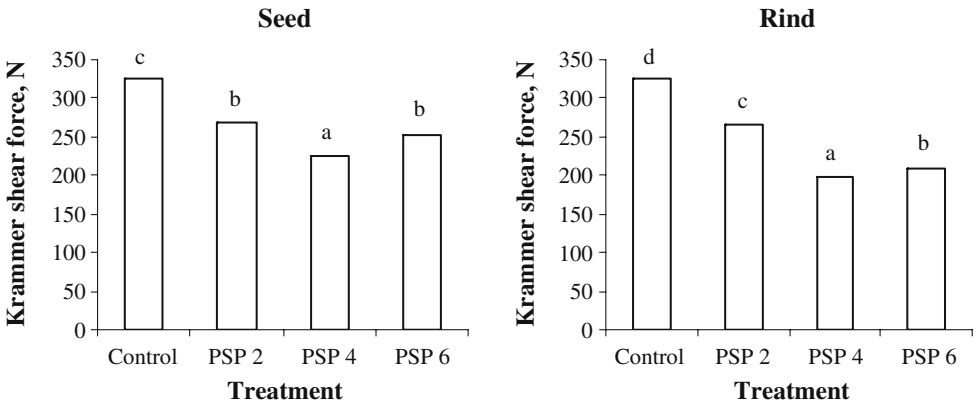


Fig. 1 Tenderizing effect of pomegranate seed and rind powder (2%, 4% and 6%). PSP = Pomegranate Seed Powder, PRP = Pomegranate Rind Powder and 2,4 and 6 represent per cent. Each value is mean (n=6). The bars bearing same letter on top do not differ significantly (p<0.05)

PSP= Pomegranate Seed Powder, PRP= Pomegranate Rind Powder and 2,4 and 6 represent per cent. Each value is mean (n=6). The bars bearing same letter on top do not differ significantly ($p < 0.05$)

scale, where 8-extremely desirable, 1-extremely undesirable (Keeton 1983).

Statistical analysis Each parameter was determined experimentally with six samples. The data obtained was analyzed using SPSS (SPPS version, 12.0 for windows, SPSS; Chicago, IL, USA). The least significance difference (LSD) was calculated at $P<0.05$.

Results and discussion

Evaluation of tenderizing effect of pomegranate seed powder Marinating goat meat with PSP affects the physico-chemical and sensory attributes (Table 1). Marination with PSP significantly ($P<0.05$) decreased cooking yield but no significant difference was noticed among different treatments of PSP. Similarly pH also significantly ($P<0.05$) decreased in treated samples as compared to control. This is due to acidic pH of PSP. Devatkal et al. (2010) also reported decrease in pH with PSP treated goat meat patties. Mendiratta et al. (2000), Thompson et al. (1973) found reduction in shear force values with ginger extract treatment in sheep meat. Syed-Ziauddin et al. (1995) and Naveena and Mendiratta (2001) reported same effect for buffalo meat and spent hen meat respectively.

Results of instrumental colour evaluation of PSP treated samples are given in Table 1. Compared to raw samples, 'L' values were significantly ($P<0.05$) lower in 6% PSP sample and no significant difference was noticed for 2% and 4% PSP samples as compared to control. Increase in level of PSP significantly ($P<0.05$) increased redness 'a' values and yellowness 'b' values. In cooked samples L values were significantly ($P<0.05$) higher in control as compared to treated samples. Hunter 'a' and 'b' values increased and 'L' values decreased due to PRP as compared to control. There was no definite trend in colour values due to different levels of PSP. However all 'L', 'a' and 'b' values decreased due to addition of PSP in marinating solution. The dark colour of treated samples maybe due to reactions of colouring substances in PSP. Treatment with 2, 4 and 6% PSP significantly ($P<0.05$) reduced the shear force indicating improved tenderness of goat meat. PSP reduced the shear force values and improved tenderness of goat meat as compared to control (Fig. 1).

Tenderness scores were significantly higher for PSP samples than control. Other attributes did not vary significantly among the samples. Sensory evaluation results indicated significantly higher ($P<0.05$) colour values in control and there was no significant difference among other treatments (Table 1). Based on colour and texture properties 4% PSP was considered as the optimum level for tenderization.

Table 2 Quality of PRP treated goat meat chunks

Treatment	Cooking yield	pH	After marinating			After cooking			Sensory Scores				
			L	a	b	L	a	b	Colour	Flavor	Tenderness	Juiciness	*OA*
Control	55. 7±1.28^{b}	6.4±0.24^{b}	49.2±3.62^{b}	5.1±0.88^{a}	7.5±3.33^{a}	46.5±4.24^{a}	3.7±0.90^{a}	9.0±1.22^{b}	5.9±0.85^{b}	5.7±0.55	5.6±0.68^{a}	5.6±0.91	6.0±0.66
PRP 2%	54.0±0.97^{b}	5.8±0.54^{a}	43.1±3.33^{a}	9.7±1.30^{b}	20.3±7.30^{b}	23.0±3.20^{b}	4.4±0.54^{b}	8.0±1.86^{a}	5.8±0.49^{b}	6.0±0.77	6.2±0.81^{b}	5.8±0.81	6.1±0.58
PRP 4%	53.7±0.65^{b}	5.4±0.62^{a}	41.8±2.32^{a}	9.7±1.11^{b}	20.3±7.35^{b}	21.2±0.96^{b}	4.1±1.11^{b}	7.0±2.07^{a}	5.3±0.67^{a}	5.6±0.56	5.5±0.59^{a}	5.4±0.75	5.8±0.53
PRP 6%	53.3±1.57^{b}	5.4±0.76^{a}	41.5±2.72^{a}	8.0±1.34^{c}	19.2±6.38^{b}	27.9±1.55^{c}	4.7±1.08^{b}	8.1±2.68^{a}	5.5±0.63^{a}	5.4±0.64	5.6±0.60 ^{a}	5.5±0.44	5.7±0.47

Each value is mean ± SD ($n=6$)

Means bearing same superscripts column wise do not differ significantly ($p<0.05$)

PRP Pomegranate Rind Powder

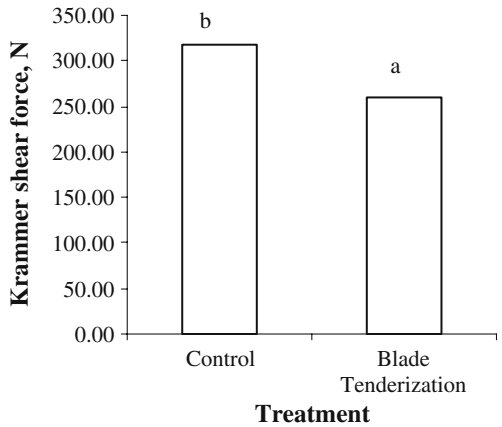
OA Overall acceptability

Evaluation of tenderizing effect of pomegranate rind powder Marination with PRP caused a minor decrease in cooking yield (Table 2). Treatment with PRP reduced pH significantly ($P<0.05$) as compared to control. Devatkal et al. (2010) attributed this effect to acidic pH of PRP extract. Treatment with 2, 4 and 6% PRP significantly ($P<0.05$) reduced the shear force indicating improved tenderness of goat meat. PRP reduced the shear force values and improved tenderness of goat meat as compared to control (Fig. 1).

Results of instrumental colour evaluation of PRP treated samples are given in Table 2. In raw samples, 'L' values were significantly ($P<0.05$) higher in control and significantly lower in 4%. Increase in level of PRP significantly ($P<0.05$) increased redness 'a' values and yellowness 'b' values. In cooked samples 'L' values were significantly ($P<0.05$) higher in control, and significantly lower in 4% PRP sample. Hunter 'a' values ($P<0.05$) increased and 'b' values ($P<0.05$) decreased due to PRP. This resulted in dark appearance of cooked meat chunks. Devatkal et al. 2010 also observed similar darkening of PRP incorporated goat meat patties.

Sensory evaluation results indicated significantly lower ($P<0.05$) colour values in 4% PRP and 6% PRP treatments (Table 2). Tenderness scores were significantly higher ($P<0.05$) for 2% PRP samples than control. Other attributes did not vary significantly among the samples. Samples treated with PRP got lower score for colour in sensory evaluation and there was adverse effect on taste of treated meat. There was no significant change in other sensory properties flavour, juiciness and overall acceptability.

Tenderization with blade tenderizer Incising the goat meat with a blade tenderizer significantly decreased the cooking



Each value is mean (n=6). The bars bearing same letter on top do not differ significantly (p < 0.05)

Fig. 2 Tenderizing effect of blade incisions. Each value is mean ($n=6$). The bars bearing same letter on top do not differ significantly ($p<0.05$)

Table 3 Quality of blade incised goat meat chunks

Treatment	Cooking yield	pH	After marinating			After cooking			Sensory Scores				
			L	a	b	L	a	b	Colour	Flavor	Tenderness	Juiciness	*OA*
Control	65.7±0.54^{b}	6.4±0.24	49.2±3.62^{b}	5.1±0.88^{a}	7.5±3.33	46.5±4.24	3.6±0.90^{a}	9.0±1.22	6.7±1.13	6.5±0.80^{a}	6.2±0.88^{a}	6.5±1.01	6.7±1.07
Blade Incision	61.5±1.20^{a}	6.5±0.53	46.2±2.13^{a}	6.2±0.35^{b}	7.3±1.27	44.6±0.93	4.4±0.94^{b}	7.3±2.47	6.8±0.67	7.0±0.59^{b}	6.6±0.65^{a}	6.2±0.88	6.7±0.59

Each value is mean ± SD ($n=6$)

Means bearing same superscripts column wise do not differ significantly ($p<0.05$)

OA Overall acceptability

Table 4 Quality of goat meat chunks subjected to different treatments

Treatment	Cooking yield	pH	After marinating			After cooking			Sensory Scores				
			L	a	b	L	a	b	Colour	Flavor	Tenderness	Juiciness	*OA*
Control	56.2±0.36^{c}	6.4±0.67^{b}	47.4±0.63^{b}	4.9±0.59^{a}	5.6±0.82^{b}	39.2±2.77^{b}	3.2±0.58^{a}	8.6±0.94^{b}	6.0±0.81^{b}	5.7±0.57^{a}	5.5±0.62^{a}	5.7±0.85^{a}	5.9±0.66 ^{a}
4% PSP	53.6±1.76^{b}	5.4±0.46^{a}	47.6±1.79^{b}	6.7±0.24^{b}	12.0±2.01^{c}	28.3±2.96^{a}	5.3±0.14^{c}	6.3±0.85^{a}	5.3±0.54^{a}	5.3±0.71^{a}	6.2±0.57^{a}	5.4±0.56^{a}	5.8±0.58^{a}
0.2%Papain	43.2±1.32^{a}	6.5±1.02^{b}	49.5±2.24^{b}	4.6±0.94^{a}	3.2±0.53^{a}	45.2±3.40^{c}	3.2±1.46^{a}	8.3±1.40^{b}	6.6±0.87^{b}	6.9±0.59^{b}	6.8±0.64^{c}	6.4±0.82^{b}	6.8±0.68^{c}
Blade Incision	51.5±1.51^{b}	6.6±0.37^{b}	36.6±2.14^{a}	6.1±0.54^{b}	5.1±0.36^{b}	33.6±2.51^{a}	4.0±0.89^{b}	7.3±0.55^{b}	6.3±0.73^{b}	5.7±0.79^{a}	6.0±0.70^{b}	5.7±0.88^{a}	6.3±0.55^{b}

Each value is mean ± SD (n=6)

Means bearing same superscripts column wise do not differ significantly (p<0.05)

PSP Pomegranate Seed Powder

OA Overall acceptability

yield as compared to control (Table 3). Loss of water content during incision and due to rupture of muscle during cooking might have caused the decrease in cooking yield. Blade incision caused no significant change in pH. Further blade tenderization improved the tenderness significantly (P<0.05) resulting in lower shear force value (Fig. 2). According to Pietrasik and Shand (2004), blade tenderization cut the muscle fibres into shorter segments which resulted in improvement of tenderness. Davis et al. (1977) demonstrated the ability of blade tenderization to improve tenderness, but associated disadvantages are higher drip loss and reduced shelf life. Benito-Delgado et al. (1994) reported that blade tenderization was effective in decreasing shear values in post rigor *longissimus* muscle that was harvested from Angus crossbred steers. Schilling et al. (2003) showed synergistic effect of blade tenderization with hydrodynamic shockwave treatment to reduce shear force values in beef.

Results of instrumental colour evaluation showed that in both raw and cooked samples, 'a' values were significantly (P<0.05) higher in blade incised sample and no significant difference was observed for 'L' and 'b' values (Table 3). Sensory scores slightly improved due to incision treatment. Overall results of shear force value & sensory score indicated that blade tenderization maybe useful for tenderization of goat meat.

Comparison of different methods of tenderization Results of comparative evaluation of 0.2% papain, 4% PSP, modified blade tenderizer for tenderizing the goat meat are shown in Table 4. Yield was significantly higher in control followed by PSP, blade incision and significantly (P<0.05) lower in papain treated meat sample. The substantial decrease in cooking yield in case of papain treatment maybe attributed to proteolysis of muscle proteins. Pawar et al. (2003)

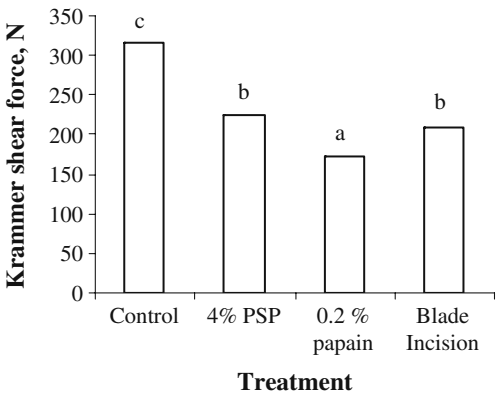


Fig. 3 Tenderizing effect of 4% PSP, 0.2% papain and blade incisions. Each value is mean (n=6), The bars bearing same letter on top do not differ significantly (p<0.05)

observed similar trend for chevon tenderized by papain. The pH was significantly lower in 4% PSP treated meat than others. Though non significant, the pH in papain treated meat slightly increased. The shift in the pH of goat meat after treatment with papain could possibly be because of their protein degradation action.

Shear force value was significantly ($P<0.05$) lower in papain followed by PSP and blade incision than control sample (Fig. 3). All the treatments significantly improved the tenderness of goat meat as there was reduction in shear force values. Increase in tenderness had also been reported by Braghieri et al. (2008) as the ultimate pH falls below 6.0. Kumar and Berwal (1998) reported significant reduction in shear force values of spent hen meat treated with cucumis powder extracted in ammonium sulphate.

In raw samples, 'L' values were significantly lower in blade incised sample and no difference was observed for other samples. In 4% PSP and blade incised samples 'a' values were significantly higher than control and 0.2% papain treated samples (Table 4). The treatment with 4% PSP significantly increased the yellowness ('b' values) and papain significantly decreased the 'b' values. The pigments in PSP appear to impart yellowness to marinated meat samples. In cooked samples 'L' values were significantly ($P<0.05$) higher in papain, and significantly lower in PSP sample. Hunter 'a' values were significantly ($P<0.05$) higher in PSP samples than other treatments. Hunter 'b' values (yellowness) were significantly lower in 4%PSP than other treatments. These measurements suggest that for 4% PSP treated meat the cooking induces dark colour which was also reflected in sensory score of colour for cooked 4% PSP treated meat chunks.

Sensory evaluation results indicated significantly lower ($P<0.05$) colour values in PSP and higher flavour scores in papain. Tenderness scores were significantly higher in papain followed by PSP and blade incised sample than control (Table 4). Papain treated sample showed higher acceptability scores than others. Blade incised sample showed significantly higher overall acceptability scores as compared to control sample. Wheeler et al. (1990) reported that blade tenderization improves tenderness in Brahman and Hereford beef cattle slaughtered at less than 18 months of age by decreasing shear force values and improving consumers' sensory response to myofibrillar tenderness and connective tissue amount. Boleman et al. (1997) and Savell and Shackelford (1992) found that tenderness was the primary economic factor for beef palatability. Although palatability is a complex interaction of tenderness, juiciness, and flavour, tenderness had been found to change significantly ($P<0.05\%$) for all the treatments. Crouse et al. (1991) further stressed that the type of the muscle and age as key factors having influence on shear force value as well as tenderness. Overall acceptability was observed to increase significantly ($P<0.05\%$) for 0.2% papain and blade tenderization. Goat meat treated with 0.2% papain scored higher values for all sensory properties followed by blade incision, and was prominent among others.

Conclusion

Although PRP improved the tenderness, the concomitant adverse effects on taste and colour limit its applicability. The cooked samples treated with papain and blade incisions fared well in sensory evaluation and required lesser shear force compared to 4% PSP and control. 4% PSP (w/w) treatment showed that the treated samples gave marginally better results in terms of peak shear force values compared to untreated sample. Tenderization of goat meat with pomegranate seed powder improved the textural properties marginally though slight adverse colour change had been observed. Therefore, pomegranate seed powder maybe considered to be mixed with other spices for marinating goat meat. The results also suggested that the blade tenderization by giving incisions can be used for tenderization of goat meat.

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