

Ginger as a tenderizing agent for tough meats -A review

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Abstract

Several methods had been followed for tenderizing the tough meats especially those from the spent food animals. Many physical, chemical and enzymatic methods are being practiced commercially. Ginger is one of the natural food ingredients commonly used in the Indian cuisine. This review covers the nature of tough meat from the spent food animals and utilization of ginger as a tenderizing agent for those meats. The effect of ginger in tendering the spent animals' meat has also been discussed.

Key words: Ginger; tenderization; tough meat

Introduction

Tenderness is considered to be the most important organoleptic characteristic of meat (Lawrie, 1991). In aged animals, fiber hypertrophy is accompanied by maturation of the endomysium, perimysial thickness and the formation of non-reducible cross-links between the collagen molecules (Robins *et al.*, 1973). Toughness in spent hen meat is primarily due to increased cross-linking in the connective tissue of older animals (Bailey and Light, 1989).

Meat tenderization would decrease the toughness of the spent meat. Many enzymes are being used commercially for meat tenderization. Though the structural integrity of collagen has been unaffected during postmortem aging of meat (Bailey, 1985), changes in its physicochemical (Stanton and Light, 1990), mechanical (Nishimura *et al.*, 1998), and ultra structural (Liu *et al.*, 1995; Nishimura *et al.*, 1995) properties had been observed. Bannister and Burns (1972) studied the collagen properties and myofibrillar protein changes of spent hens in relation to growth, with no clues about the postmortem collagen degradation. Kondaiah and Panda, (1992) reported that tenderness of the spent hen meat could be improved by degradation of collagen, thereby expand the market for the spent hen meat and increase its value.

Ginger

Ginger rhizome has been investigated as a source of plant proteolytic enzyme (Thompson *et al.*, 1973; Syed Ziauddin *et al.*, 1995). The ginger protease is a thiol proteinase with an optimum activity at 60°C. Rapid denaturation of the enzyme occurs at 70°C. Its proteolytic activity on collagen appears to be many times greater than that on actomyosin and the combined proteolysis of these two muscle proteins resulted in significantly more tender meat (Thompson *et al.*, 1973). Ginger belongs to Zingiberaceae family from which the rhizome part is used for food and medicinal purpose. This plant produces an orchid like flower with greenish yellow petals streaked with purple colour. It is cultivated in areas characterized by abundant rainfall. Native is Southern Asia, cultivated in tropical areas such as Jamaica, China, Nigeria and Haiti and it is an important spice crop in India (Bajaj, 1989). Choi and Laursen (2000) reported that ginger proteases were similar to the papain family of cysteine proteases and contained two isoforms, GP-I and GP- II, which were 83% similar in amino-acid sequence. Ginger possesses a mixed composition of zingerone, shogaols and gingerols (Ademola *et al.*, 2004), responsible for the pungent taste of ginger (Sharma, 2002).

Ginger contains up to 3% of an essential oil that causes the aroma of the spice (O'Hara *et al.*, 1998). Gingerol increase the motility of the gastrointestinal tract and have analgesic, sedative and antibacterial properties (Malu *et al.*, 2009). Recently there is a great importance of the consumption of ginger due to its medicinal property. Ginger stimulates the production of saliva (O'Hara *et al.*, 1998). It promotes the release of bile (Opdyke, 1974; Kato *et al.*, 1993). It is used as a stimulant and carminative and also for dyspepsia and colic (O'Hara *et al.*, 1998). Ginger may also decrease joint pain from arthritis, may have blood thinning and cholesterol lowering properties and may be useful for the treatment of heart diseases and lungs diseases (Opdyke, 1974; Kato *et al.*, 1993; Kuschener and Stark, 2003). Ginger is effective for treating nausea caused by seasickness, morning sickness and chemotherapy (Ernst and Phittle, 2000).

Spent meat

In meat obtained from young animals, myofibrillar components contributed the toughness known as actomyosin toughness or myofibrillar toughness, at the same time as from old animals the toughness of meat was caused by connective tissue and known as background toughness (Singh and Panda, 1984). The degree of tenderness can be related to those of connective tissue, myofibrils and sarcoplasmic proteins (Lawrie, 1991). Postmortem shortening due to permanent actomyosin bond formation during the development of rigor mortis contributes to the muscle stiffening (Forrest *et al.*, 1975). The meat obtained from such stiff muscle is considered as tough meat. It has long been recognized that the tenderness of meat increases when it is conditioned and for this purpose venison is regularly aged (Lawrie, 1991). Locker (1960) reported that rapid chilling of meat resulted in tough meat due to muscle contraction. This phenomenon is known as cold shortening (Dransfield, 1994). Lawrie (1991) reported that cooking coagulated the proteins of myofibrils resulting in toughness. Meat from spent layers is dry, tough and strong due to its high collagen contents and cross linkages (Awosanya and Faseyi, 2001). The amount of intramuscular connective tissue, the length of sarcomere, and the activity of endogenous proteolytic enzymes influenced the toughness of meat (Kemp and Parr, 2012). Changes in myofibrillar proteins are responsible for the actomyosin toughness that in connective tissue cause the background toughness (Chen *et al.*, 2006). Naveena *et al.*, (2011) reported that myofibrillar toughness is affected by the development of rigor-mortis and tenderization caused by the enzymatic breakdown of the contractile proteins. Devine *et al.* (2006) stated that low ultimate pH was necessary to

obtain optimum tenderness. Wada *et al.* (2002) reported that plant thiol proteases, such as papain, bromelain, and ficin, affect the structure of myosin and actin filaments.

Tenderization effect of ginger on tough meat

Ginger rhizome has been shown to have a powerful proteolytic enzyme, which can be used as tenderizing agent for tough meat (Lee *et al.*, 1986) with an additional antioxidant property (Mansour and Khalil, 2000). The ginger protease 'zingibain', a thiol proteinase obtained from ginger rhizome, a natural spice, has an advantage over other tenderizing agents that it has optimum proteolytic activity at 60°C, which is desirable (Naveena and Mendiratta, 2001). Naveena *et al.* (2004) reported that cheaper and easily available ginger rhizome could effectively be used for tenderization of tough meat. They compared the tenderizing effect of 2% cucumis extract, 5% ginger extract or 0.2% papain on tough buffalo meat and found that the shear force value was significantly lower in all the treatments compared to the control which was due to the increase in the solubility of collagen, sarcoplasmic and myofibrillar proteins. In addition, the sensory attributes such as flavour, juiciness, tenderness and overall acceptability were significantly improved in the treatments compared to control. Anandh and Lakshmanan (2014) prepared smoked buffalo rumen meat products from 3 times blade tenderized buffalo tripe with 5.0% ginger extract and found that the ginger extract treated smoked buffalo rumen meat product was better for acceptability upto storage of 15 days at 25±1°C under aerobic packaging.

Naveena and Mendiratta (2001) reported that ginger extract showed proteolytic activity, resulting in an increase in collagen solubility and proteolysis in ginger extract treated spent hen muscle. They found that the ginger protease was a thiol proteinase with an optimum activity at 60°C with proteolytic activity on both collagen and actomyosin producing more tender meat and the tenderness scores were higher in samples treated at post-chilled stage where 3% of GE was used for tenderization. Similarly, Syed Ziauddin *et al.* (1995) who studied the effect of ginger extract on buffalo meat using SDS-PAGE technique reported that there was an improvement in colour, appearance, juiciness and tenderness of beef samples treated with ginger extract and suggested that ginger extract could be used as a good source of proteolytic enzyme for tenderization of buffalo meat. Thompson *et al.*, (1973) observed that the combined proteolysis of collagen and actomyosin protein fractions by the ginger protease resulted in significantly more tender meat and opined that a possible advantage of zingibain over papain and ficin for meat applications was the greater proteolysis of collagen in comparison to actomyosin. Naveena and Mendiratta (2001) observed that there was no significant difference in cooking yield, pH and moisture content between control and ginger extract treated samples, whereas there was reduction in shear force values and improvement in the sensory scores for colour, appearance, juiciness and tenderness and overall acceptability in the latter than the former. Based on the sensory scores and physicochemical properties they recommended that treatment with 3% ginger extract was optimum for tenderization of spent hen meat. Lee *et al.* (1986) explained that higher concentration of ginger extract extensively degraded the myofibrils and the degradation appeared to begin at I band of each sarcomere and progressed towards the M line. Bhaskar *et al.* (2006) treated breast and leg muscles of spent hen with 2.5% (w/w) of ginger powder obtained by ethanol treatment of Bangalore variety rhizome and observed lower shear values and higher sensory scores with a marginal improvement in flavour compared to the control samples. An increased proteolysis by ginger enzymes was indicated by lower numbers of protein bands formed in the electrophoretic pattern of ginger powder-treated muscles compared to control. In addition, chicken kabab, prepared from the meat treated with ginger powder, was found to be tender and scored high for sensory flavor and texture quality. They recommended that the proteolytic activity rich ginger powder could also find application for improving the quality of traditional products.

Kim and Lee (1995) observed that inclusion of ginger extract at 0.5 to 1.0% (w/v) in the marination of marginally acceptable lean beef improved tenderness by 20-30% in the absence of 2% salt and by 35-45% in the presence of 2% salt. As well, ginger extract retarded the development of rancidity and increased shelf-life of precooked lean beef two-fold in saran-wrap (no vacuum) storage at 4°C. Misook Kim *et al.* (2007) observed digestion of type I collagen from calf skin and rat tail by ginger protease GP2 is shown to occur at 22°C, well below the denaturing temperature of the intact triple helical structure. Multiple discrete cleavage sites were identified within the triple helix of native bovine collagen. Ginger extract was rated best with respect to the sensory parameters among various tenderizing agents used (Olorunsanya and Omiyale, 2009) where they observed that stitch pumping of 3% ginger solution into the spent layer meat was an efficient way to tenderize the meat without much affecting the physicochemical qualities of the meat. Pawar *et al.* (2007) prepared patties incorporating the chevon marinated in ginger rhizome extract at 1, 3, 5, and 7% along with 600 ppm of ascorbic acid, 2% sodium chloride and 0.5% sodium tripolyphosphate and observed that the ginger rhizome extract treated chevon patties received a higher score for colour, tenderness, flavour, juiciness, springiness and overall acceptability in which the myofibrillar and sarcoplasmic proteins were degraded at all levels of marination to a significant extent. Yusop *et al.* (2012) assessed

the influence of processing method and holding time on the physical and sensory qualities of cooked marinated chicken breast fillets wherein they conducted the sensory evaluation and analyzed the sensory attributes such as colour, aroma, toughness, juiciness and overall acceptability. Tough aged camel meat marinated in 30% ginger extract levels increased the values of water holding capacity, cooking yield, solubility of collagen, sarcoplasmic and myofibrillar proteins and decrease in shear force, with best tenderization effect (Abdeldaiem *et al.*, 2014). Long-Li Tsai *et al.* (2011) observed the effects of ginger extract marination on the changes in Muscovy duck breast muscle where pectoralis muscles of male Muscovy ducks marinated for 14 days in ginger extract at 5°C had lower TBARS with more rapid degradation of titin, myosin heavy chain, desmin and α -actinin and 32- and 30-kDa troponin-T degradation components were also generated. Sodium dodecylsulfate poly-acrylamide gel electrophoresis (SDS-PAGE) analysis has been widely used for the studies on digestion mechanism of meat proteins besides sophisticated techniques such as enzyme activity estimation, myofibrillar fragmentation index, hydroxyproline measurement, and scanning electron microscopic studies to assess the tenderness of meat (Maiti *et al.*, 2008).

Ginger marinades for tough meat tenderization

The crude aqueous extract of ginger had been used commonly in tenderizing the tough meats. Fresh ginger rhizome had been peeled, sliced, blended with the calculated quantity of potable/ distilled water, made in to homogenate and squeezed through a muslin cloth for tenderizing camel meat (Abdeldaiem *et al.*, 2014). Similar methods were followed to formulate ginger extract for tenderizing spent hen meat (Naveena and Mendiratta, 2001; Olorunsanya and Omiyale, 2009) and buffalo meat (Naveena *et al.*, 2004). Instead of blending, Kim and Lee (1995) used pestle and mortar to grind the ginger rhizome with water for tenderizing beef. While tenderizing the Muscovy duck breast muscle, Long-Li Tsai *et al.*, (2012) prepared the aqueous filtrate of ginger rhizome as the previous researchers, further centrifuged, collected the supernatant and saved as the ginger extract.

Superfine grinding technology, a contemporary and useful tool for making superfine powder with good surface properties like dispersibility and solubility (Tkacova and Stevulova, 1998) could be applied in the preparation of ginger marinades for meat tenderization. Zhao *et al.* (2009) investigated the superfine grinding technology in ginger which produced a narrow and uniform particle size distribution in dry ginger. In the procedure, fresh ginger was dried in a mechanical drier at 40°C till the water content reached less than 9% for 6 h. The dried ginger was milled coarse particles by a disc-mill, which were screened through different sized sieves to separate granulates ($d < 1$ mm) (300 and 140 μm); the superfine powders with the size of 74, 37 and 8.34 μm were obtained in an HMB-701 type micronizer (planetary rubbing mill). They found that the specific surface area of the superfine powder was increased after superfine grinding, and had the good fluidity, water holding capacity, water solubility index and protein solubility; the superfine powder was easier to enter into the structure of the foods, so the dispersibility and solubility of superfine powder was good in foods, and the solubility of the nutritive components was increased after superfine grinding, leading to better absorption by the body, which would be more suitable for the development of functional foods than native ginger. Norhidayah *et al.*, (2014) determined the nanostructured ginger rhizome marination on spent hen meat quality, where micron ginger (19.54 μm) was prepared by grinding the dried ginger rhizome with food processor and sieving, the submicron ginger (4.2 μm) was prepared by milling with hammer mill at 2890 rpm and sieving using a 250 μm sieve and the nanostructured ginger rhizome was prepared until the particle size was relatively around 160.5nm in size. A 3% marinade solution (3 g in 100 ml distilled water) was homogenized for 15 minutes using an ultrasonic processor and stored in airtight bottle for further use.

Bhaskar *et al.* (2006) prepared ginger powder from Bangalore and Coorg varieties rhizome by solvent extraction method with ethanol which was found to be better than that prepared by acetone and isopropanol treatments. Ethanol treatment produced 6.9- and 8.3-fold increases in the specific activity of proteases in ginger powder from Bangalore and Coorg varieties, respectively, compared to the activity in fresh ginger. Thompson *et al.* (1973) found that it was advantageous to extract fresh ginger rhizome with acetone to remove pigments which interfered with spectrophotometric analysis of proteolytic activity. They prepared dry ginger protease from the ginger acetone powder by dicing the ginger rhizomes, homogenizing in five parts (w/v) of acetone using a homogenizer, suction filtering the homogenate, rinsing the filter cake with additional five parts of acetone, drying the filter cake in a forced air oven at 40°C until no acetone odor was detectable and pulverizing the dry powder with a homogenizer. This powder was further homogenized with phosphate buffer, the extract was suction filtered and the filtrate was centrifuged. The supernatant was centrifuged, decanted, precipitated and rinsed with acetone and dried to separate the protein part, ginger protease with the proteolytic activity. The ginger protease was reconstituted by dissolving in 0.1 M phosphate buffer (pH 5.0) containing 0.3 mM DTT at a concentration of 0.2 mg/ml for further use to tenderize the meat.

Table 1 Methods of tenderizing meat with ginger in previous research works

Type of Meat	Approximate size of Meat	Ginger extract type	Concentration of ginger marinade used	Method of meat marination	Researchers
Ovine (Biceps femoris muscle)	100 g sample	Acetone precipitated ginger protease	Dissolved in 0.1M phosphate buffer (pH 5.0) containing 0.3 mM DTT at a concentration of 0.2 mg/ml.	Injected with the enzyme preparation	Thompson et al. (1973)
Lean beef from select grade steer (Loin eye muscle)	4 mm thickness	Fresh aqueous	0.5, 1.0 and 1.5% of the crude extract with or without salt, based on the meat weight	Mixed with the extract and broiled	Kim and Lee (1995)
Spent broiler hen meat (Breast muscle)	Chunks of 2 cm ³	Fresh aqueous	0, 1, 3 and 5% solution	Immersed in extract	Naveena & Mendiratta (2001)
Spent adult female buffalo meat (<i>Biceps femoris</i> muscles)	Chunks of 3 cm ³ size	Fresh aqueous	5% w/v solution	Sprayed over the meat	Naveena et al. (2004)
12-month-old Osmanabadi goat (prerigor biceps femoris muscles)	3 × 3 cm chunks	Fresh aqueous	1, 3, 5, and 7% solution along with 600 ppm of ascorbic acid, 2% NaCl and 0.5% sodium tripolyphosphate.	Immersed in the solution	Pawar <i>et al.</i> (2007)
Spent layers	Whole breast, high & drumstick	Fresh aqueous	3% solution	Chicken part was stitch pumped with 10% of its weight	Olorunsanya & Omiyale (2009)
Muscovy duck meat	5 mm thick pieces	Fresh aqueous (supernatant after centrifugation of the filtrate)	Filtrate obtained from the homogenization of equal quantities of distilled water and ginger	Immersed in extract	Long-Li Tsai et al. (2012)
Aged camel meat	Chunks of 3 cm ³	Fresh aqueous	15, 30 and 45% solution	Sprayed over the meat	Abdeldaiem et al. (2014)
Buffalo rumen meat	Chunks of 2.5 cm ²	Fresh aqueous	5% solution	Immersed in extract	Anandh and Lakshmanan (2014)
Spent hen chicken thighs	100 to 130 g pieces	Micron, Submicron and nanostructured ginger rhizome powder homogenized in distilled water with ultrasonic processor	3% (3 g in 100 ml distilled water)	Immersed in solution	Norhidayah et al. (2014)

Methods of tenderizing meat with ginger

A simple method of immersion of the meat in the ginger marinade solution of various concentrations for different durations had been commonly followed by many researchers (Naveena and Mendiratta, 2001; Long-Li Tsai *et al.*, 2012; Anandh and Lakshmanan, 2014 and Norhidayah *et al.*, 2014). In the preparation of precooked lean beef tenderized with ginger, Kim and Lee (1995) mixed the meat uniformly with the marinade containing ginger extract and broiled for about 4 minutes after a marination time of one hour. Naveena *et al.* (2004) carried out the method of spraying the buffalo meat with fresh ginger extract followed by thorough mixing manually and marinating for 48 h at $4\pm 1^\circ\text{C}$ in polyethylene bags. Similarly, tenderization of aged camel meat chunks was done by spraying the meat with the fresh ginger extract at 15% v/w and thorough mixing by hand where the meat was marinated for 48 h at $4\pm 1^\circ\text{C}$ after placing in polyethylene bags (Abdeldaiem *et al.*, 2014). Previously, Thompson *et al.* (1973) performed injection method, where samples of ovine biceps femoris muscle were injected with 0.05 ml of the ginger protease enzyme preparation per g meat and stored at 5°C for 20 hr. Likewise, Olorunsanya and Omiyale (2009) stitched pumped the chicken breast, thigh and drumstick with 10% of its weight of the ginger solution using a 25 ml syringe needle, packaged the parts individually in polythene bags and stored in a refrigerator overnight to allow for equilibrium. A comparative summary of the methods of tough meat tenderization using ginger has been presented (Table 1).

Conclusion

Ginger extract is an effective meat tenderizer and the tenderization is achieved through its action on both myofibrillar and connective tissue components of toughness. Since ginger is a part of regular Indian cuisine, its use in tenderizing tough meat would not pose aesthetic or safety concerns among the consumers. Hence it has been learned that the use of ginger extract for improving the qualities of tough meat could prove to be a benefit to the meat industry.

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