PE4.33 Effect of ginger extract on quality attributes of beef biceps femoris 122.00

Surendranath Suman (1) spsuma2@email.uky.edu, P Joseph(1), K McClelland 1, S Li 1 G Rentfrow 1 Y Xiong 1
(1)Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, United States of America

Abstract- **Our objective was to evaluate the usefulness of aqueous ginger extract in injection-enhancement solution to improve the quality attributes of beef Biceps femoris (BF) muscle. Whole-muscle BF was injected to 110% green weight with enhancement solutions containing either 3% aqueous ginger extract (GEX) or no ginger extract (CON; control), vacuum packaged, and stored at 2°C for 7, 14, or 21 days. Lipid oxidation, instrumental color, and Warner-Bratzler shear force were evaluated on 1.92-cm steaks sliced from the whole-muscle. While lipid oxidation was lower in GEX samples than in controls, GEX treatment did not influence color parameters of BF steaks. Throughout the storage, GEX steaks demonstrated lower shear force values than control ones. Our findings indicated that aqueous ginger extract can be utilized in enhancement solutions to improve tenderness of beef BF and for value-addition of underutilized muscles in beef round and chuck.**

S. P. Suman (corresponding author) is with the Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, USA (Phone: +1-859-257-3248; Fax: +1-859-257-7537; E-mail: spsuma2@email.uky.edu).

P. Joseph is with the Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, USA (E-mail: pjose3@uky.edu).

K. McClelland is with the Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, USA (E-mail: kmcclelland@uky.edu).

S. Li is with the Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, USA (E-mail: sli7@uky.edu).

G. Rentfrow is with the Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, USA (E-mail: gkrent2@uky.edu).

Y. L. Xiong is with the Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, USA (E-mail: ylxiong@uky.edu).

Index Terms **— Biceps Femoris, Ginger extract, Lipid oxidation, Tenderness.**

I. INTRODUCTION

Biceps femoris (BF) is profiled as one of the sizeable and tough muscles in the round, having abundant connective tissue [1]. Retail cuts containing BF are tough, often fail to meet consumer expectations on tenderness, require moist heat cooking, and therefore underutilized [2]. Several investigations documented high shear force values for BF muscle, indicating the challenges in marketing retail cuts containing this muscle [3, 4]. These attributes make BF a suitable muscle model for tenderization studies.

Injection of enhancement solutions is one of the several technologies adopted by the meat industry to improve quality attributes of less tender beef cuts [5, 6]. Previous research investigated the effects of injection-enhancement, using solutions containing phosphate and salt, on quality attributes of BF [7-9]. The observations indicated potentiality of injection-enhancement to improve quality attributes of whole-muscle BF. Nevertheless, these studies suggested the necessity of further research in this area.

Proteolytic enzymes are known to improve meat tenderness by degrading myofibrillar and connective tissue proteins. Proteases from ginger rhizome (*Zingiber officinale*) have unique substrate specificity for cleaving proteins with proline residues [10]. The unusual preference for proline makes ginger proteases an attractive tool for cleaving collagen, which contains large amounts of proline and is abundant in tough beef muscles [11]. The tenderizing effect of ginger extract was investigated in chunks of meat from cattle [12], spent-buffalo [13], sheep [14], and spent-hen [15]. These reports indicated the suitability and potential of ginger extract for tenderization of tough beef whole-muscle cuts.

Tenderization of BF by incorporation of food-grade proteases in enhancement solution is a practical approach for increasing the value of beef round. Unlike other proteolytic meat tenderizers that have to be used in pure form, those from ginger can be used as crude aqueous extract. Besides proteases, ginger extract is an excellent source of several natural antioxidants [16]. Ginger extract inhibits lipid oxidation in fresh minced meats [17-20]. Incorporation of ginger extract in enhancement solution would be a logical strategy to improve the quality attributes of whole-muscle beef BF. Nonetheless, investigations were not undertaken to evaluate the potential use of ginger extract in injection-enhancement solutions. Therefore, our objective was to investigate the effect of aqueous ginger extract enhancement on the quality attributes of beef whole-muscle BF.

II. MATERIALS AND METHODS

Ginger Extract

Fresh aqueous ginger extract was prepared as previously described [15]. Fresh ginger rhizomes obtained locally were peeled, sliced, and blended with an equal quantity of chilled double-distilled water in a waring blender for 2 minutes. The homogenate was squeezed through two layers of cheese cloth. Required quantity of ginger extract was added at 3% w/w basis to an enhancement solution containing 3% salt and 3% phosphate.

Beef processing and storage

Eight (n = 8) BF muscles, 48 h post-mortem, from USDA Select grade beef carcasses were obtained from the University of Kentucky's USDA-inspected meat laboratory. All external fat and adjacent muscles were removed. Each muscle was divided into two equal length sections, and one of the two injection-enhancement treatments were assigned randomly to each section. Ginger extract-enhanced (GEX) and control (CON) sections were pumped to 110% of green weight using a multi-needle injector. GEX samples were enhanced with a solution containing 3% fresh aqueous ginger extract, 3% salt, and 3% phosphate, whereas controls were injected with an enhancement solution containing 3% salt and 3% phosphate. Injected muscle sections were vacuum-packaged and stored at 2°C for 7, 14, or 21 d. At the conclusion of each aging period, muscle sections were removed from the vacuum-sealed bags, and two 1.92-cm thick steaks were sliced. The remaining intact muscle section was vacuum-packaged and stored at 2°C. One steak was used for analysis of pH, lipid oxidation, and instrumental color, whereas the second steak was utilized for determining Warner-Bratzler shear force.

Analysis of pH

The pH of the muscle sample was determined as previously described [21]. Duplicate 5 g samples of meat were homogenized in 25 ml distilled deionized water, and the pH was determined using a pH meter.

Lipid oxidation

Lipid oxidation was measured using the thiobarbituric acid assay [22]. Five grams of meat was mixed with trichloroacetic acid, homogenized in a blender, and filtered. One ml of filtrate was mixed with 1 ml of 20 mM thiobarbituric acid and incubated at 25°C for 20 h. The absorbance of samples measured spectrophotometrically at 532 nm was reported as thiobarbituric acid reactive substances (TBARS).

Instrumental color evaluation

CIE L^*, a^*, and b^* values were measured employing a HunterLab LabScan XE colorimeter (Hunter Associates Laboratory, Reston, VA, USA) with illuminant A and a 4.45-cm diameter aperture [23]. Five readings were recorded randomly on each steak and averaged for statistical analyses.

Warner-Bratzler shear force

Steaks were cooked to an internal temperature of 71°C in a George Foreman clam-shell grill (Salton Inc, Columbia, MO, USA). After a 2 h cooling period at room temperature, five 1.27 cm diameter cooked steak cores were removed parallel to the muscle fiber direction. Cores were sheared through the center with a Warner-Bratzler shear device attached to an Instron 4301 Universal Testing Machine (Instron, Canton, MA, USA) at a crosshead speed of 200 mm/min, and the mean of the five measurements were determined [24].

Statistical analysis

Data were analyzed using analysis of variance and mean separation procedures of the General Linear Model (GLM) of SAS [25]. Eight replicates (n = 8) were utilized in this study. Differences among means were detected at 5% level using the least significance difference (LSD) test.

III. RESULTS AND DISCUSSION

The pH of BF muscle was not influenced by ginger enhancement ($P > 0.05$). Both GEX and CON samples showed pH between 5.45 and 5.55, which is in the optimal pH range for the proteolytic activity of ginger extract [26].

Ginger enhancement and storage did not influence ($P > 0.05$) a^* and b^* values (Table 1). On the other hand, L^* values declined ($P < 0.05$) progressively in both GEX and CON steaks during storage in a similar manner. These results indicated that enhancing whole-muscle beef BF with ginger extract would not, adversely, impact color and thus may not possibly influence consumers' purchase decisions at the point-of-sale, which primarily is based on fresh meat color.

Throughout the storage, lipid oxidation was lower ($P < 0.05$) in GEX steaks than in CON samples (Table 1). Lipid oxidation increased ($P < 0.05$) in CON samples over storage; TBARS increased ($P < 0.05$) from d 7 to d 14 and then plateaued in controls. CON samples on d 14 and d 21 did not exhibit any differences in TBARS. In contrast, TBARS values were not different ($P > 0.05$) among GEX samples on d 7, 14, and 21. Antioxidant effects of ginger were previously reported in ground pork patties [17], ground chicken [18], pre-rigor beef strips [19], and ground beef [20]. Our findings are in agreement with these reports and indicated that ginger extract is effective in curtailing lipid oxidation in beef whole-muscle BF cuts.

Warner-Bratzler shear force of GEX steaks was lower ($P < 0.05$) than that of CON ones throughout the storage (Table 1). In agreement, it was previously reported that marinating chunks of spent-buffalo meat in ginger extract improved tenderness, increased collagen solubility, and resulted in extensive protein degradation [13]. Furthermore, ginger-treated spent-hen meat exhibited an increase in water holding capacity and collagen solubility, with a concomitant decrease in shear force [15]. In the present study, while shear force values in CON steaks decreased ($P < 0.05$) progressively from d 7 to d 21, a similar trend was observable in GEX samples only between d 7 and d 14. Shear force of GEX samples on d 14 was not different ($P > 0.05$) from those on d 21. Findings of the present study suggested that ginger extract can be used in injection-enhancement solutions to improve the tenderness of beef BF and thus improve the retail value of beef rounds.

IV. Conclusion

The results of the present study suggested that utilization of aqueous ginger extract in injection-enhancement solution improved the tenderness of beef BF, an underutilized round muscle. The beef industry could potentially utilize ginger extract enhancement as a strategy to improve the value of underutilized and tough muscles from beef chuck and round. Further studies are underway to determine consumers' response to ginger-enhanced beef and to characterize the proteolytic changes (using two-dimensional electrophoresis and mass spectrometry) in beef due to ginger enhancement.

Acknowledgement

This project was funded by Kentucky beef producers through their $1.00 per-head checkoff and was produced for Kentucky Beef Council.

References

[1] Von Seggern, D. D., Calkins, C. R., Johnson, D. D., Brickler, J. E., & Gwartney, B. L. (2005). Muscle profiling: Characterizing the muscles of the beef chuck and round. Meat Science, 71, 39-51.

[2] Obuz, E., Dikeman, M. E., Grobbel, J. P., Stephens, J. W., & Loughin, T. M. (2004) Beef longissimus lumborum, biceps femoris, and deep pectoralis Warner-Bratzler shear force is affected differently by endpoint temperature, cooking method, and USDA quality grade. Meat Science, 68, 243-248.

[3] Nelson, J. L., Dolezal, H. G., Ray, F. K., & Morgan, J. B. (2004). Characterization of Certified Angus Beef steaks from the round, loin, and chuck. Journal of Animal Science, 82, 1437-1444.

[4] Rhee, M. S., Wheeler, T. L., Shackelford, S. D., & Koohmaraie, M. (2004). Variation in palatability and biochemical traits within and among eleven beef muscles. Journal of Animal Science, 82, 534-550.

[5] McGee, M. R., Henry, K. L., Brooks, J. C., Ray, F. K., & Morgan, J. B. (2003). Injection of sodium chloride, sodium tripolyphosphate, and sodium lactate improves Warner-Bratzler shear and sensory characteristics of pre-cooked inside round roasts. Meat Science, 64, 273-277.

[6] Vote, D. J., Platter, W. J., Tatum, J. D., Schmidt, G. R., Belk, K. E., & Smith G. C., Speer, N. C. (2000). Injection of beef strip loins with solutions containing sodium tripolyphosphate, sodium lactate, and sodium chloride to enhance palatability. Journal of Animal Science, 78, 952-957.

[7] Baublits, R. T., Pohlman, F. W., Brown, Jr., A. H., & Johnson, Z. B. (2005). Effects of sodium chloride, phosphate type and concentration, and pump rate on beef biceps femoris quality and sensory characteristics. Meat Science, 71, 205-214.

[8] Baublits, R. T., Pohlman, F. W., Brown, Jr., A. H., & Johnson, Z. B. (2006a). Enhancement with varying phosphate types, concentrations, and pump rates, without sodium chloride on beef biceps femoris quality and sensory characteristics. Meat Science, 72, 404-414.

[9] Baublits, R. T., Pohlman, F. W., Brown, Jr., A. H., Yancey, E. J., & Johnson, Z. B. (2006b). Impact of muscle type and sodium chloride concentration on the quality, sensory, and instrumental color characteristics of solution enhanced whole-muscle beef. Meat Science, 72, 704-712.

[10] Choi, K. H., & Laursen, R. A. (2000). Amino-acid sequence and glycan structures of cysteine proteases with proline specificity from ginger rhizome Zingiber officinale. European Journal of Biochemistry, 267, 1516-1526.

[11] Choi, K. H., Laursen, R. A., & Allen, K. N. (1999). The 2.1A structure of a cysteine protease with proline specificity from ginger rhizome, Zingiber officinale. Biochemistry, 38, 11624-11633.

[12] Lee, Y. B., Sehnert, D. J., & Ashmore, C. R. (1986a). Tenderization of meat with ginger rhizome protease. Journal of Food Science, 51, 1558-1559.

[13] Naveena, B. M., Mendiratta, S. K., & Anjaneyulu. A. S. R. (2004). Tenderization of buffalo meat

using plant proteases from Cucumis trigonus Roxb (Kachri) and Zingiber officinale roscoe (Ginger rhizome). Meat Science, 68, 363-369.

[14] Mendiratta, S. K., Anjaneyulu, A. S. R., Lakshmanan, V., Naveena, B. M., & Bisht, G. S. (2000) Tenderizing and antioxidant effect of ginger extract on sheep meat. Journal of Food Science & Technology, 37, 565-570.

[15] Naveena, B. M., & Mendiratta, S. K. (2001). Tenderization of spent hen meat using ginger extract. British Poultry Science, 42, 344-349.

[16] Masuda, Y., Kikuzaki, H., Hisamoto, M., & Nakatani, N. (2004). Antioxidant properties of gingerol related compounds from ginger. Biofactors, 21, 293-296.

[17] Lee, Y. B., Kim, Y. S., & Ashmore, C. R. (1986). Antioxidant property in ginger rhizome and its application to meat products. Journal of Food Science, 51, 20–23.

[18] El-Alim, S. S. L. A., Lugasi, A., Hovari, J., & Dworschak, E. (1999). Culinary herbs inhibit lipid oxidation in raw and cooked minced meat patties during storage. Journal of the Science of Food and Agriculture, 79, 277–285.

[19] Negbenebor, C., Balami, Y., & Igene, J. (1995). Yield and storage stability of patties from prerigor beef previously dipped in potassium sorbate and ginger solutions. International Journal of Food Science and Technology, 30, 65–70.

[20] Mansour, E. H., & Khalil, A. H. (2000). Evaluation of antioxidant activity of some plant extracts and their application to ground beef patties. Food Chemistry, 69, 135-141.

[21] Strange, E. D., Benedict, R. C., Smith, J. L., & Swift, L. E. (1977). Evaluation of rapid tests for monitoring alterations in meat quality during storage. 1. Intact meat. Journal of Food Protection, 40, 843 – 847.

[22] Yin, M. C., Faustman, C., Riesen, J. W., & Williams, S. N. (1993). α-Tocopherol and ascorbate delay oxymyoglobin and phospholipid oxidation in vitro. Journal of Food Science, 58, 1273-1276.

[23] AMSA (1991). Guidelines for meat color evaluation. American Meat Science Association. Chicago, IL, USA.

[24] AMSA (1995). Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness Measurements of Fresh Meat. American Meat Science Association. Chicago, IL, USA.

[25] SAS (2007). SAS User's Guide version 9.1. SAS Institute Inc., Cary, NC, USA.

[26] Thompson, E. H., Wolf, I. D., & Allen, C. E. (1973). Ginger rhizome: A new source of proteolytic enzyme. Journal of Food Science, 38, 652-655.

Table 1: Effect of ginger extract injection-enhancement on instrumental color, lipid oxidation, and Warner-Bratzler shear force of beef Biceps femoris steaks.

		Enhancement	
Quality Attribute	Storage time (d)	CON	GEX
*L**	7	44.65[a]	44.07[a]
	14	41.85[b]	42.03[b]
	21	40.33[c]	40.71[c]
	SE = 0.77		
*a**	7	32.22	31.20
	14	32.11	31.23
	21	30.84	30.29
	SE = 0.72		
*b**	7	24.52	23.46
	14	23.96	23.04
	21	23.83	22.74
	SE = 0.51		
TBARS	7	0.29[by]	0.21[az]
	14	0.32[ay]	0.22[az]
	21	0.33[ay]	0.22[az]
	SE = 0.005		
Warner-Bratzler shear force (Newtons)	7	44.30[ay]	28.52[az]
	14	34.10[by]	23.13[bz]
	21	25.77[cy]	21.36[bz]
	SE = 3.06		

CON = Control; GEX = 3% aqueous ginger extract in enhancement solution.
[a-c] Means for the same trait in a column without a common letter differ ($P < 0.05$).
[y-z] Means in a row without a common letter differ ($P < 0.05$).
SE = Standard Error