EFFECTS OF SEX, MUSCLE TYPE, MARINADE COMPOSITION AND METHOD OF COOKING ON THE YIELD AND SHEAR FORCE VALUES OF ELK MEAT

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Background

Elk is the second largest member of the deer family, exceeded only by moose in body size. There are an estimated 100,000 farmed elk in North America (Thorleifson, 2002). The elk industry thrives mainly on revenues from velvet antler production, although the market for elk meat is growing. There is a general perception that meat from elk is leaner and less tender than beef, but there is not enough published data available on carcass and meat quality characteristics of elk for comparison. The main problem concerning elk meat in the marketplace is its inconsistency, both in terms of the quality and quantity. So, further processing may be desirable to improve the sensory characteristics of elk meat to make it a viable red meat option for consumers. Injection of salt and phosphate formulations into primal meat cuts is routinely practiced by industry to enhance the tenderness and juiciness of fresh meat products; this is especially true for the pork industry (Vote *et al.*, 2000). Polyphosphates are commonly used in the production of value-added red meat and poultry meat products. Sodium phosphate has been reported to improve protein solubility and water-binding capacity, which increase both the tenderness and juiciness of the meat product.

Objectives

The present study was designed to assess the effects of various concentrations of sodium tripolyphosphate (STPP) in the marinade on the yield and tenderness of moisture-enhanced elk loin and top round roasts.

Methods

History of animals and post-mortem treatments before sampling: Four intact males and 4 females, aged between 3-5 years and 13-16 years, respectively (carcass weight 163±25 kg) were slaughtered at a local provincially-inspected slaughter facility. After ageing for 10 days, the top rounds and short loins were separated, vacuum packaged and shipped to the Department of Applied Microbiology and Food Science, University of Saskatchewan, for this study.

Sampling and processing procedures: Eight paired venison loin (*longissimus lumborum*, LL) and top round were trimmed of any visible fat. From the top rounds, the *adductor* muscles were removed and only *semimembranosus* muscle (SM) was used for this study. The samples were stored at -30°C and only one pair of sides was injected at one time, after thawing (at 4°C for 72 hours). LL and SM from each side of the carcass were divided into 2 equal portions to yield 4 sections, each from the 2 muscle groups per animal. Brine solutions were injected to achieve the following concentrations of salt and phosphate in the finished marinated product, and treatments were rotated to be representative in all 4 muscle portions: 0% NaCl and 0% STPP (non-injected control), 0.5% NaCl and 0.3% STPP (injected A), 0.5% NaCl and 0.2% STPP (injected B) and 0.5% NaCl and 0.1% STPP (injected C).

The sections designated for marination were injected to a target weight gain of 10% of the original mass using a multi-needle injector (Model No. FGM20/40, Fomaco Reiser, Burlington, ON, Canada). Injected sections were equilibrated for 5 min following injection to allow for drainage and were then re-injected with a hand-held injector to compensate for any deviation from the target weight. After injection, the muscle samples were vacuum packaged and stored overnight at -1°C. Next day, each muscle section was carved into 2 equal-sized roasts.

Cooking of steaks and evaluation of tenderness: One of the roasts was baked in a preheated oven at 165°C, while the second was steam-cooked in a smokehouse (single truck Alkar smokehouse, Alkar, Lodi, WI, USA) to a final internal temperature of 71°C. Before thermal processing, thermocouples were inserted into the geometric centre of the roasts. The temperatures of the oven/smokehouse and roasts were monitored by the thermocouples. The probes were attached to a scanner and a computer that recorded the change in temperature every 30 s. The cooking time and yield of the roasts were also recorded. After cooling to an internal temperature of 50°C, cooked roasts were stored at 4°C overnight. The following day, 6-8 cores (1.27 x 1.27 x 3.81 cm) were removed from each roast parallel to the direction of the muscle fibres. These cores were equilibrated at room temperature for an hour before shear force measurements were taken. Tenderness was determined using a Food Technology Corporation TMS-TP Texture Press (Rockville, MD, USA), TMS-90 Computer, and a Model Warner-Bratzler Shear Test Cell with a FTA 300 Transducer. At the time of cutting cores for shear force analysis, samples were removed from the centre of the roasts for determination of expressible moisture (EM). Expressible moisture was determined by the modified method as described by Dhanda *et al.*, 2002.

Statistical analysis: Effects of sex (2; male and female), muscle type (LL and SM), injection treatment (4; injected A, injected B, injected C and non-injected) and cooking method (2; dry- and moist-heat) on yield and tenderness were analyzed by a 4-factorial design using the General Linear Model (GLM) procedures of the SPSS statistical package (SPSS, 2001). All possible 2, 3 and 4 way interactions were tested but found to be non-significant; only the main effect means have been presented. Significance levels between treatments for a particular parameter were assessed at α=0.05.

Results and discussion

The cooking yields for the roasts obtained from the injected A (0.3% STPP) and B (0.2% STPP) muscle sections were significantly (P<0.05) greater than those from injected C (0.1% STPP) and control non-injected sections when cooked by either dry- or moist-heat (Table 1). An increase in pH has been reported to improve cooking yields (Dhanda *et al.*, 2002); the pH of injected muscle sections (5.8-5.9) was significantly (P<0.05) higher than non-injected samples (5.6). Furthermore, the injected roasts took less time to reach the desired endpoint temperature (71°C) compared to control ones. The cooking yield was influenced markedly by the method of thermal processing (*i.e.*, dry- or moist-heat); cooking by moist-heat resulted in a significantly (P<0.05) lower percentage of cooking losses than that by dry-heat. In the present study, the mean shear force value of non-injected elk roasts was 63.3 N, which was higher than that reported by Sookhareea *et al.* (1993) for Javan Rusa stags (54 N). Injected roasts had lower shear force values (47.8-49.5 N) compared to control samples (63.3 N). Vote *et al.* (2000) suggested that injecting with phosphate/lactate/chloride solutions produced beneficial effects on the tenderness of beef strip loins compared to paired, non-injected controls. Shear force values did not differ (P>0.05) between marination treatments (*i.e.*, injected A, B and C). LL roasts were significantly ($P<0.05$) more tender compared to SM roasts. Stevenson *et al.* (1992) reported higher shear values for red deer SM compared to LL. Lower tenderness scores of beef SM were associated with lower percentages of soluble collagen and slightly higher total collagen compared to that of *longissimus* muscle (Fishell *et al.* 1985). Moist-heat cooking proved to be better than that of dry-heat cooking as far as the shear force values and water-holding were concerned: this observation was supported by data obtained for yield and EM. There were no significant ($P>0.05$) differences between male and female for the parameters studied except for the cooking time (Table 1).

Results of the present study suggest that marination by injection has a great deal of potential in improving the tenderness and juiciness of elk meat. Although these findings need to be supported by consumer panel and sensory data, at this stage, the 0.2-0.3% level of sodium tripolyphosphate in the finished marinated product seems to be best at improving the cooking yield and tenderness of elk roasts. Processors should be able to successfully use this technology to produce value-added meat products from specialty livestock.

Pertinent literature

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Table 1. Effects of injection treatment, cooking method, muscle type and sex on cooking yield, cooking time, shear force values and expressible moisture levels of elk roasts[u]

Item	Cooking yield[v] (%)	Cooking time/100g[w] (min)	Shear force values[x] (N)	Expressible moisture (%)
Injection treatment				
Non-injected	79.39b	19.90a	63.3a	21.09a
Injected A[y]	83.72a	16.90b	47.8b	20.19a
Injected B[y]	82.64a	17.61b	48.8b	21.70a
Injected C[y]	80.66b	18.61b	49.5b	21.91a
SEM[z]	0.45	0.52	2.35	0.57
Cooking method				
Dry-heat	77.54b	20.07a	57.5a	17.68b
Moist-heat	85.67a	16.28b	47.3b	24.77a
SEM[z]	0.32	0.37	1.66	0.40
Muscle type				
Semimembranosus (SM)	81.08b	17.72a	56.2a	21.49a
Longissimus lumborum (LL)	82.12a	18.56a	48.5b	20.97a
SEM[z]	0.32	0.37	1.66	0.40
Sex				
Male	81.15a	17.28b	50.4a	20.71a
Female	82.05a	19.01a	54.3a	21.74a
SEM[z]	0.32	0.37	1.66	0.40

[u] Within a main effect and in the same column least-squares means without a common letter differ ($P<0.05$)
[v] Cooking yield (%), percentage of meat weight at cooking
[w] Cooking time = (time taken by each roast to reach 71°C from 15°C internal temperature / weight of the steak) x 100
[x] Shear force values (N = Newton, SI unit of force), Newton can be converted into kg force by dividing the N value by 9.80665
[y] Composition of the brine solution in the finished marinated product: Injected A (0.5% sodium chloride and 0.3% sodium tripolyphosphate), Injected B (0.5% sodium chloride and 0.2% sodium tripolyphosphate) and Injected C (0.5% sodium chloride and 0.1% sodium tripolyphosphate)
[z] Standard error of the mean