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Effect of canola oil emulsion injection on processing characteristics and consumer acceptability of three muscles from mature beef

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ABSTRACT

The study was undertaken to investigate the impact of the combined effect of blade tenderization and canola oil emulsion injection on processing yield and eating quality-related parameters of selected loin and hip muscles (*longissimus lumborum*, *LL*, *biceps femoris*, *BF* and *semimembranosus*, *SM*) from over thirty month (OTM) cattle. Canola oil emulsion injection significantly reduced shear force, increased sensory scores for juiciness and tenderness, and made connective tissue less perceptible. Targeted levels of omega-3 fatty acids can be achieved by the inclusion of canola oil containing marinades/emulsions at levels sufficient to retain omega-3 fatty acids in cooked product. All consumer acceptability attributes of OTM muscles were improved with the use of canola oil emulsion injection treatments without compromising colour although slightly decreasing oxidative stability of BF muscle. Injection of omega-3 oil emulsions in combination with blade tenderization can be effectively utilized to enrich injected products in essential fatty acids and enhance eating quality of OTM beef.
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1. Introduction

An increasing recognition of the health benefits of regular consumption of omega-3 polyunsaturated fatty acids and the introduction of nutritional and health claims for functional foods rich in omega-3 fatty acids have triggered rapid development of processed foods enriched with these compounds (Gonzalez-Esquerra & Leeson, 2001; Metcalf, James, Mantzioris, & Cleland, 2003; Simopoulos, 1999). Most of the research aimed at improving dietary quality of meat has been focused on manipulation of animal feed with attempts to increase the intramuscular omega-3 content accomplished by feeding omega-3 rich diets to ruminants (Raes, De Smet, & Demeyer, 2004; Scollan et al., 2006). Despite the high dietary supply of omega-3, however, the increase of intramuscular omega-3 content was limited because of a high degree of biohydrogenation of unsaturated fatty acids by rumen bacteria (Doreau & Ferlay, 1994; Scollan et al., 2006). To overcome this type of loss of efficiency, targeted levels can be achieved alternatively by direct supplementation of meat products with omega-3 rich sources during further processing. In addition, direct incorporation of omega-3 rich oils may address some issues around meeting consumer expectations for consistent product quality, especially tenderness and juiciness.

Most consumers judge quality and overall acceptability of beef products based on tenderness — a characteristic that has been identified as the single most important palatability factor affecting consumer satisfaction of beef (Boleman et al., 1997; Neely et al., 1998). Perceptions of juiciness and flavour are also important components of palatability. Data from the Commercial Beef Muscle Profiling Research (Beef Information Centre, 2005) showed that after lack of tenderness, poor juiciness was the next most important palatability attribute of round muscles from mature beef that contributed to decreased consumer satisfaction. An unpleasant eating experience can be overcome by the inclusion of omega-3 fatty acids containing marinades/emulsions at levels sufficient to compensate for most of the cooking losses. With the recent move towards moisture enhancement of meat and with the increased acceptance of enhanced product by consumers, now may be an ideal time to consider the inclusion of omega-3 rich sources to marinades to effectively enhance eating quality of mature beef by compensating for cooking losses while enhancing nutritional value. Incorporation of a relatively small amount of a highly concentrated oil-in-water emulsion containing omega-3 fatty acids into meat products would result in products with nutritionally significant levels of these lipids.

The overall objective of this study was to determine the effects of canola oil emulsion injection on processing characteristics, refrigerated storage stability, sensory characteristics and consumer acceptance of three muscles from mature beef.

2. Materials and methods

2.1. Materials

Ten cull cows were conventionally slaughtered at the Agriculture and Agri-Food Canada Lacombe Research Centre (Lacombe, AB, Canada) abattoir. After carcass chilling for 48 h at 4 °C, the *biceps femoris* (BF),

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longissimus lumborum (LL), and *semimembranosus* (SM) muscles were removed from both sides of each carcass, labelled to maintain carcass and side identity, vacuum packaged, and shipped to the Alberta Agriculture and Rural Development Food Processing Development Centre (Leduc, AB, Canada) for processing.

The non-meat ingredients used in the formulations included: food-grade salt (sodium chloride), sodium tripolyphosphate (Newly Weds Foods Co., Edmonton, AB, Canada), soy protein isolate (Archer Daniels Midland Company, QC, Canada) and canola oil (Bunge Canada, Oakville, ON, Canada).

2.2. Product processing and application of treatments

All processing was carried out in a refrigerated pilot plant (<7 °C) at the Food Processing Development Centre. Prior to processing, all muscles were trimmed of all visible fat and connective tissue. The flat side (posterior portion) of each BF had grain that was inconsistent with the fibre direction of the rest of the cut, so it was removed along with the fat seam. One muscle from each carcass pair (left/right sides) was assigned to the non-treated control (C) group and placed directly into vacuum packaging, and refrigerated for 24 h at 2 °C. The other muscle in each pair was designated for emulsion enhancement (E) and was passed once through a Tender Star meat tenderizer (Paulus Stuart, Belgium).

To obtain oil-in-water emulsions, canola oil (30% w/w) was combined with an aqueous phase consisting of soy protein isolate (SPI, added at 10% of the oil concentration), and fixed amounts of salt and sodium tripolyphosphate (STPP), using a high-shear mixer (Admix Inc., Manchester, NH, USA) for a total of 7 min. Ingredient levels were selected to achieve 0.4% salt, 0.3% STPP, 0.5% of SPI and 5% canola oil in the injection-processed products, and canola oil level was selected to deliver the concentration (300 mg omega-3 fatty acids per 100 g serving) required for a nutrition claim (Food and Drug Regulations, 2012), for retail consumers.

The muscles designated for emulsion enhancement were injected with a single pass through a multi-needle injector (Model No. P154/105 MC2R, Günther, Maschinenbau GmbH, Dieburg, Germany) to 120% of the raw meat weight with the brines described above. Each muscle was weighed before and after injection to determine brine pick-up (injected weight/raw weight × 100). After injection the muscles were vacuum tumbled (5 rpm) for 2 h at 6 °C (AMFEC tumbler, Hayward, CA, USA), then vacuum-packaged (−0.8 bar) and refrigerated (2 °C) overnight.

At approximately 24 h post-injection, all samples (control and injected) were removed from packaging and weighed to determine the drip loss % ([injected wt − wt at 24 h/injected wt] × 100). Each muscle was prepared as a series of 2.54 cm steaks by cutting perpendicular to the long-axis of the muscle fibre orientation. Two steaks from each muscle were transferred to individual Styrofoam® trays and over-wrapped with an O_2-permeable film (30,000 $cm^3/m^2/24$ h; Vitafilm, Huntsman Film Products of Canada, Toronto, ON, Canada). These steaks were stored in a 2.0 ± 1 °C cooler at an average light intensity of 110 lx for instrumental colour evaluation and TBARS measurement over a 6-day period. The remaining steaks were weighed for later thaw loss determination, individually vacuum-packaged, blast frozen, and retained in frozen storage (−30 °C) until required for instrumental and sensory evaluations.

2.3. Instrumental colour

Surface colour of stored steaks was measured objectively using a Minolta handheld spectrophotometer (Minolta CM-2500C, Osaka, Japan) with a 10° observer angle, 8 mm aperture and illuminant A, and calibrated against a white tile immediately before readings were taken. Colour measurements (CIE L^*, a^*, and b^*) were taken at day 0, and after 3 and 6 days of storage under aerobic conditions. After taking the first reading, each sample was rotated clockwise 90° and a second measurement was made. The L^*, a^*, b^* values for each steak were reported as the average of these two readings. Additionally, hue angle was calculated as: $\tan^{-1}(b^*/a^*)$, the saturation index (chroma) calculated as: $(a^{*2} + b^{*2})^{0.5}$.

2.4. 2-Thiobarbituric acid reactive substance (TBARS) test

On days 0, 3 and 6 of aerobic storage, an inner portion of each steak was sub-sampled for TBARS measurement as described by Nam and Ahn (2002). A sample (3 g) was placed in a 50 mL disposable centrifuge tube and homogenized with 15 mL deionized distilled water and 50 μL butylated hydroxytoluene (7.2%) using a Brinkman Polytron (Type PT 10/35; Brinkman Instrument Inc., Westbury, NY, USA) for 15 s at velocity setting 7. The meat homogenate (1 mL) was transferred to a disposable test tube (15 mL), and 2 mL thiobarbituric acid/trichloroacetic acid (20 mM TBA and 15% [w/v] TCA) solution was added. The mixture was vortexed for 10 s and then incubated in a 90 °C water bath for 15 min to develop colour. After cooling for 10 min in cold water, the samples were vortexed and centrifuged at 3000 × *g* for 15 min at 5 °C. The absorbance of the resulting upper layer was read at 531 nm against a blank prepared with 1 mL deionized water and 2 mL TBA/TCA solution using a UV–vis spectrophotometer (Agilent 8453, Agilent Technologies Canada Inc.). TBARS were calculated from a 1,1,3,3-tetraethoxypropane standard curve.

2.5. Cook loss and Warner–Bratzler shear force (WBSF)

Steaks were thawed in a cooler at 4 °C for 24 h, weighed, and cooked using either dry- or moist-heat methods. The steaks assigned to dry-heat cooking were cooked on an electric grill (Garland ED-30B electric grill; Russell Food Equipment, Edmonton, AB, Canada). Steaks were placed on the preheated (210 °C) grill, cooked until the internal temperature reached 35 °C, turned over, and cooked to a final endpoint temperature of 72 °C. After cooking, the steaks were allowed to cool at room temperature for approximately 2 h. Steaks assigned to moist-heat cooking were vacuum-sealed into vacuum pouches (Winpak Ltd., Winnipeg, MB, Canada), cooked in an air-agitated water bath set at 75 °C to an internal product temperature of 72 °C, and cooled with tap water until a core temperature of 25 °C was reached. All steak temperatures were monitored using the thermocouples attached to a scanner (CR 3000, Micrologger, Campbell Scientific Inc., Logan, USA) and computer that recorded the change in temperature at 30 s intervals.

After cooling, cooked steaks were blotted dry with a paper towel and weighed to determine cook loss. Overall cook loss was calculated as the difference between the initial raw weight and weight after cooking, expressed as a percentage of the original raw weight.

The shear force of 8 core samples (1.27 × 1.27 × 2.54 cm) cut parallel to the fibre direction from each cooked steak was determined. Samples were sheared perpendicular to the fibre direction using an Instron Universal Testing System (Model 5565, Instron Corporation, Burlington, ON, Canada) fitted with a Warner–Bratzler shear attachment, a 500 N load cell, and set to a crosshead speed of 200 mm min^{-1}. Data were captured electronically (Bluehill®2 Operating Software, 2005, Instron Corp., Burlington, ON, Canada) and averaged within each steak. Maximum peak force recorded during the test was reported as WBSF.

2.6. Total omega-3 fatty acid content

Total omega-3 fatty acid content of raw and cooked samples from injected treatments was carried out at an independent food testing laboratory according to the approved official methods of AOAC (2000, Method No. 996.06). Total omega-3 fatty acid content was

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