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Omega-3 fatty acids, nutrient retention values, and sensory meat eating quality in cooked and raw Australian lamb

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ABSTRACT

This study evaluated omega-3 intramuscular fatty acids in the *longissimus thoracis et lumborum* of commercially prepared Australian lamb loin chops. Meats, denuded of external fats were cooked by means of conductive dry-heat using a fry grilling hot plate, to a core temperature of 70 °C. An untrained consumer panel assessed meat appearance, aroma, tenderness, juiciness, taste and overall liking. Results showed no compositional alterations ($P > 0.05$) to omega-3 fatty acids due to cooking treatment, whereas on absolute terms (mg/100 g muscle) omega-3 fatty acids significantly ($P < 0.05$) increased. The mean EPA + DHA content of the cooked meat at 32.8 ± 2.3 mg/100 g muscle exceeded the minimum 30 mg/100 g per edible portion required for the defined Australian classification as 'source' long-chain ($\geq C_{20}$) omega-3 for cooked lamb. A 3.4% intramuscular fat content in the initial raw meat was sufficient to maintain acceptable overall sensory eating quality. Results endorse the application of this cooking method to enable delivery of health beneficial long-chain omega-3 fatty acids of commercially prepared Australian lamb loin chops to consumers without impediments to sensory eating properties.
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1. Introduction

For meats, Davey and Gilbert (1974) classically defined cooking as the heating of meat to a sufficiently high temperature to denature proteins. However, a more comprehensive definition presented by Lagares (2010) classified the cooking of meats as the thermal processing meat undergoes, involving a whole series of physicochemical, biochemical and microbiological phenomena, which defines the quality and the organoleptic properties of the finished product. It has been proposed that due to heat induced lipid oxidation, undesirable modifications in nutritional fatty acid compositional values in meats can arise as a result of cooking processes (Weber, Bochi, Ribeiro, Victorio, & Emanuelli, 2008). With regard to this, the health benefitting omega-3 long-chain ($\geq C_{20}$) polyunsaturated fatty acids (LC-PUFA) - eicosapentaenoic (EPA, 20:5ω3) and docosahexaenoic (DHA, 22:6ω3) - are defined as the most susceptible (Legako, Dinh, Miller, & Brooks, 2015; RodriguezEstrada, Penazzi, Caboni, Bertacco, & Lercker, 1997; Watkins et al., 2014). However, Alfaia et al. (2010) stated that discrepancy exists between studies assessing changes of meat fatty acids as a response to different cooking methods. This can be regarded as a function of cooking technique, as well as the physical and chemical nature of meats subject to cooking application.

Grilling (BBQ/pan frying/broiling) is a popular dry-heat method of cooking commercially prepared lamb loin meat cuts amongst Australian consumers (Thompson, Gee, et al., 2005). Moreover, Meat Standards Australia (MLA, 2015) promotes this methodology as the preferred practice to ensure satisfactory eating quality of lamb loin chop meat cuts; however, the available information assessing this method of cooking these meat cuts has been geared primarily toward assessing sensory eating quality aspects (Pannier, Gardner et al., 2014; Thompson et al., 2005; Watson, Gee, Polkinghorne, & Porter, 2008). Scant, if any research other than that of Hoke, Buege, Ellefson, and Maly (1999) is available directly assessing meat fatty acid properties of commercially prepared loin chops sourced from Australian lambs. Indeed, on the whole, when compared to the plethora of studies assessing fatty acid compositions of the intramuscular fat component of raw lamb meat, relatively few studies have assessed how these properties are affected by cooking treatment (Badiani et al., 2004; Badiani et al., 1998; Campo et al., 2013; Knight, Knowles, Death, Cummings, & Muir, 2004; Maranesi et al., 2005; Sainsbury, Schonfeldt, & Van Heerden, 2011).

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Likewise, determination of retention values (RV%), a tool that enables the calculation of the loss/degradation or increase of nutrients in foods during cooking (Alfaia et al., 2010; Lopes, Alfaia, Partidario, Lemos, & Prates, 2015), has been relatively unemployed to evaluate the fatty acids contained within lamb meats, with only meagre data available (Badiani et al., 2004; Badiani et al., 1998; Knight et al., 2004; Maranesi et al., 2005). This sparseness of literature is surprising given the importance cooking has as a culinary procedure to enable the safe consumption of meats.

Nutritionally, lamb meat, despite its perception as an unhealthy highly saturated fatty acid product (Ponnampalam, Mann, & Sinclair, 2006; Vera et al., 2009), has been presented as a product capable of delivering the health benefitting omega-3 LC-PUFA (EPA, DHA, docosapentaenoic acid (DPA, 22:5ω3)) to those who cannot readily consume marine-based foods (Ponnampalam et al., 2009). However, there is now concern amongst the Australian sheep meat sector that targeted selectivity for larger leaner lamb carcasses may inherently lead to meat that is perceived as sub-par in terms of sensory eating quality (McPhee, Hopkins, & Pethick, 2008). This aspect has been previously identified amongst young highly muscled lean cattle and modern pig genotypes (Pethick et al., 2005; Pethick, Harper, Hocquette, & Wang, 2006). Consequently, there is need to persistently evaluate the extent to which leaner healthier lamb meat products can be delivered to consumers before these meats begin to hinder sensory eating quality traits. In this respect, Hopkins, Hegarty, Walker, and Pethick (2006) defined an optimal minimum fat content of 5% within the lean muscle prior to cooking, whereas Savell and Cross (1988) reported a window of 3–7% is sufficient.

Accordingly, the purpose of this study was to evaluate intramuscular fatty acid properties and retention values, with emphasis on long-chain omega-3 fatty acids, as well as sensory eating quality attributes of the separable lean muscle component of Australian lamb loin chops as based upon procedures previously defined by Hopkins, Hegarty, and Farrell (2005). The working hypothesis for this study was that grilled commercially prepared lean Australian loin chops have the capacity to provide health benefitting intramuscular long-chain omega-3 fatty acids to consumers without impeding sensory eating quality characteristics.

2. Materials and methods

2.1. Animals and meat samples

The use of animals and their applications for this study was granted pre-approval from the University of Tasmania Animal Ethics Committee. This approval is granted in accordance with the 1993 Animal Welfare Act and the 2004 Australian Code of Practice for the Care and Use of Animals for Scientific Purposes.

Full details of experimental protocols relating to animals, management, slaughter and sample collection have been previously provided in detail (Flakemore, Balogun et al., 2014; Flakemore, McEvoy et al., 2014). Briefly, forty (40) samples of *longissimus thoracis et lumborum* (LTL) prepared as commercial loin chops were acquired from the carcasses of 20 F_1 ewe and wether lambs comprising varying proportions of purebred and 1st-cross Merino lambs. The distribution of sample numbers by dietary supplementation level, sex and sire breed of the Australian prime lambs used for the study are presented in Table 1. Two loin chops (approximately 300 g) were taken from each carcass - one chop designated for raw meat analysis, and the other for cooked meat analysis. The carcasses were sourced from an experimental flock of twenty-four (24) individually housed lambs (4 Merino females were not slaughtered but retained for breeding purposes, thus bringing the final sample size to 20). All lambs were provided 1000 g/day of a concentrate containing degummed crude canola oil in various proportions for an experimental period of 63 days. Additional ad libitum lucerne hay was supplied to each animal. The lambs from the experimental group were six-months of age at the onset of feeding trial with an average initial liveweight of 30.3 kg ± 4.9 kg at an average body condition score of 2.10 ± 0.29. Loin chop samples were excised from each carcass at the 12th and 13th rib interface one week after animal slaughter and carcass chilling, placed in ice, transported for approximately 1 h, and stored at −20 °C at the University of Tasmania cold room until required for examination and analysis.

2.2. Cooking method and consumer sensory evaluation

Cooking and sensory evaluation of meats was undertaken over a single session, with procedures based on the protocol outlined by Thompson, Gee, et al. (2005). All twenty (20) loin chops designated for cooking treatment were defrosted overnight in a domestic refrigerator at 4 °C. Prior to cooking, each loin chop was denuded of all subcutaneous and overlaying fat, and cooked using conductive dry-heat on a Barbeques Galore G Series 4 burner (input: 20 MJ/h per burner) grill unit using the fry grilling hot plate, with heat control knobs set to the '*High*' cook setting. Loin chops were cooked without the use of cooking oils or other additives. Internal meat temperature was monitored using handheld instant-read food thermometers, and removed from the cooking surface when an internal core temperature of 70 °C degrees was attained. After cooking, each meat sample was rested for approximately 3 min, sliced from the bone, and cut into pieces of approximately 1 cm^3. At this stage a sub-sample (approximately 10–15 g) of cooked meat from each muscle sample was re-stored at −20 °C until analysed. The remaining freshly cooked loin chops from each carcass were served on plates and subjected to sensory analysis utilising a nine-person untrained consumer panel of volunteer University of Tasmania staff and students. Each panellist tasted a cube from each carcass culminating in a total of 20 cubes per member, giving 180 replications, thus providing adequate statistical robustness and vigour for analysis, and proportional to Thompson, Pleasants, and Pethick (2005) reporting 10 consumer responses per sample are significant to detect between-sample differences. Samples identified only by their live animal and carcass numbers were randomly served to the panel members who were also given the opportunity to test each sample as many times as desired. In- between meat samples water and dry wafer crackers were consumed by panellists to neutralize taste buds and minimize cross-sample contamination. Each panellist evaluated the meat for appearance, aroma, tenderness, juiciness, taste, and overall liking. Sensory panel means were originally determined on a 10 point hedonic scale (10 being highest satisfaction), which were subsequently multiplied by 10 for alignment with Meat Standards Australia 100-point continuous line scale (Thompson, Gee, et al., 2005; Watson et al., 2008) prior to statistical analysis.

Table 1
Distribution of sample numbers by dietary supplementation level, sex and sire breed of raw and cooked *longissimus thoracis et lumborum* muscle tissue of Australian prime lambs.

Treatment		Supplementation level			Gender		Sire breed		
Raw	Cooked	Control	High	Low	Wethers	Ewes	Dorset	White Suffolk	Merino
20	20	6	7	7	12	8	8	8	4

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