# The effect of internal end-point temperature (cooking doneness) on the mineral composition of grilled lamb

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**Objectives:** Consumers will preference nutritional meat options, as its consumption will promote their health and wellbeing. This has resulted in lamb being marketed as a source of 'healthy minerals' that are necessary within a balanced diet (e.g. calcium, iron, selenium, and zinc). This has also driven innovations that enhance the concentration of these minerals within lamb meat products. It is uncommon to consume uncooked lamb and the literature shows that cooking doneness (internal end-point temperature) can affect the physicochemical properties of red meat (Schwartz et al. 2022). The selection of cooking doneness may, therefore, impact on the nutritional value of lamb meat. In response, this study compared the mineral composition of lamb prepared to four levels of cook- ing doneness (raw, rare, medium, or well done).

**Materials and Methods:** Ten lamb *longissimus lumborum* muscles (LL) were purchased from different retail outlets, each sourced from a different carcass. These were refrigerated overnight to standardise their temperatures and ensure cooking consistency. Four slices, of 1 cm thickness, were prepared from each LL and these allocated to each level of cooking doneness. Slices were cooked independently and consequently, sample slice was the experimental unit. Without oil, samples were cooked using a clam shell grill (GR-4A, Cuisinart Griddler, USA), that was set to 220 ± 10 °C (Thompson et al., 2005), to a rare (internal temperature: 60 °C), medium (71 °C), or well done (77 °C) level of doneness. Temperatures were confirmed using an infrared thermometer. Cooked samples were placed into sealable plastic bags and submerged in an ice slurry to halt the cooking process. All samples were frozen, freeze-dried, and ground prior to their analysis by microwave digestion and inductively coupled plasma-optical emission spectroscopy (Carrilho et al. 2002). The mineral results were reported as mg/100 g to enable comparisons to be made to human nutritional guidelines. The percentage change in sample weight before and after freeze-drying was used to calculated dry matter (DM). Data were analysed in Genstat (21st Edition, VSN International Ltd., www.vsni.co.uk) after initial checks for outliers and errors. Analysis of variance models (ANOVA) fitted with the fixed effects of cooking doneness, the random (block) effects of LL, and the covariate effects of DM were used to analyse the mineral data. The level of significance was set at 5%.

**Results and Discussion:** The majority of minerals were unaffected by cooking doneness, with concentrations found to be consistent across the levels of cooking doneness and comparative to the raw samples. Calcium was the only exception to this finding, with concentrations found to be highest in samples prepared to a well done level of doneness ($P = 0.021$). This result suggests that calci- um is 'concentrated' in lamb prepared to a higher internal end-point temperature, a factor associated with higher cooking losses. The improved concentration of calcium must be considered against the losses in soluble protein, vitamins, and other nutrients - with cooking loss not limited to water. The mineral fraction within cooking losses may be observed from the significant covariate effects of DM on the copper, iron, sulphur, and zinc concentrations of lamb meat, prepared to different levels of doneness. When compared to dietary recommendations for adults, and irrespective to cooking doneness, it was found that a 100 g serve of cooked lamb provides 30-50% of the RDI for dietary iron, 25-40% for dietary zinc, and nearly all the RDI for dietary selenium (NHMRC, 2019). The lamb samples also contributed to the dietary intakes of calcium, copper, magnesium phosphorous, potassium, sodium, and sulphur - noting that the aluminium content is likely a remnant of the grill. The results of this study are limited to the muscle type and cooking methods applied, herein, as previous studies have reported different outcomes for alternative cuts of lamb, inter- nal end-point temperatures, cooking times, and methods of preparation (Purchas et al. 2003; Fowler et al. 2019; Schwartz et al. 2022). In addition, the effect of cooking doneness on oxidisable nutrients, such as the health claimable fatty acids, as well as the sensorial attributes that underpin lamb meat palatability, should contribute to a broader understanding of lamb nutritional value and consumer or retail appeal.

**Conclusions:** This study demonstrated that internal end-point temperature has no practical effect on the mineral content of lamb meat meaning that lamb can be prepared to a rare, medium, or well done level of doneness without compromising its mineral-associated nutritional value to the consumer.

**References:**

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