Fibre-type composition influences the formation of odour-active volatiles in beef

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Objective: Flavour is a key driver of consumer liking of beef, and it is largely dependent on the formation of odouractive volatiles during cooking. Different beef cuts are known to have different organoleptic properties, however, the causes of these differences are not well understood. Beef cuts from different anatomic positions are known to have different fibre-type composition, which is the proportion of type I and type II fibres in the muscle. And the difference in chemical characteristics between type I and type II fibres, including pH, antioxidant capacity, heme protein, and free ionic iron, could potentially influence the formation of odour-ac- tive volatiles in beef during cooking. We hence hypothesised that the flavour of beef is influenced by its fibre-type composition.

Method: To test our hypothesis, we combined ground *masseter* (M), which is entirely composed of type I fibres, and *cutaneous trun- ci* (CT), which has a predominance (92%) of type II fibres (IIA and IIX), to prepare beef patties with five different fibre-type pro- portions being 100% M, 80% M and 20% CT, 60% M and 40% CT, 40% M and 60% CT, 20% M and 80% CT, 100% CT. The pat- ties were cooked on a Silex clamshell grill set at 180°C until the internal temperature reached 75°C, and the volatiles were extracted using solid-phase microextraction and analysed using gas chromatography-mass spectrometry. The antioxidant capacity of raw patties was measured using 1,1-diphenyl-2-picrylhydrazyl (DPPH) scavenging assay, and the pH of raw patties was measured using a WP- 80 pH meter. The total heme protein concentration in raw patties was measured using both spectrometric method and high-performance liquid chromatography, and the free ionic iron in raw patties was measured using ferrozine assay. Analysis of Variance (ANOVA) was performed on volatile data and chemical characteristics of raw patties using Genstat 19th edition. Regression analysis, including stepwise regression and linear regression, was performed using the caret package in R using odour-ac- tive volatiles as responses (Y) and chemical characteristics of patties as predictors (X) to further investigate their relationships.

Results and Discussion: Our study showed that odour-active volatiles in cooked beef differed significantly with their fibre-type com- positions. Beef patties with higher percentage of type I fibre had a higher concentration of 3-methylbutanal (7.11 mg/kg, 5.44 mg/ kg respectively; SED = 0.56) and 3-hydroxy-2-butanone (16.22 mg/kg, 9.86 mg/kg; SED = 0.74) relative to that with higher percentage of type II fibre ($P < 0.05$ for both). These volatiles are associated with desirable odour attributes, such as brothy, meaty, and buttery, and thus contribute to the flavour liking of beef. In contrast, beef patties with higher percentage of type II fibre had higher hexanal (210 mg/kg, 150 mg/kg; SED = 25), heptanal (24.70 mg/kg, 14.10 mg/kg; SED = 3.65), pentanal (14.94 mg/kg, 11.40 mg/ kg; SED = 1.12), and 2-pentylfuran (1.92 mg/kg, 0.91 mg/kg; SED = 0.38) compared to that with higher percentage of type I fibre ($P < 0.05$ for all). These volatiles are also reported to be odour-active and are important contributors to flavour of cooked beef. But at elevated concentration, hexanal, heptanal, and pentanal may cause undesirable odours and negatively impact on flavour liking of beef. Pyrazines play important roles in beef flavour but their concentrations were not affected by fibre-type composition in the present study. Therefore, beef with different fibre-type compositions formed different volatile profiles during cooking, and we speculated that this can help explain why flavour of beef differs between cuts. But this speculation needs to be tested in sensory as- sessments in future studies. Patties with higher percentage of type I fibres had higher values compared to those with higher percent- age of type II fibres for pH (6.19, 5.83; SED = 0.05), antioxidant capacity (0.72, 0.65; SED = 0.015), total heme protein (5.02 mg/g,
2.61 mg/g; SED = 0.36), and free ionic iron (5.89 µg/g, 3.50 µg/g; SED = 0.26) ($P < 0.05$ for all). Regression analysis indicated that some of these chemical characteristics can individually explain differences in two odour-active volatiles being 3-hydroxy- 2-butanone and pentanal. The concentration of 3-hydroxy-2-butanone increased with the pH of patties (regression coefficient = 18.25, variance explained = 60.70%, $P < 0.001$), and this could be attributed to the conducive effect of high pH on Maillard reac- tion, which is an important intermediate in the formation of 3-hydroxy-2-butanone. The concentration of pentanal decreased significantly with the antioxidant capacity of patties (regression coefficient = -47.90, variance explained = 53.70%, $P < 0.001$). Pentanal is formed by lipid oxidation, which may be inhibited by endogenous antioxidants. The difference in other odour-active volatiles could not be explained by the above characteristics in regression analysis (variance explained < 30%) and thus requires further investigation in future studies. Overall, our study showed that fibre-type composition plays an important role in the volatile profile and flavour of beef, but the underlying mechanism needs further investigation.

Key words: Beef, Volatiles, Fibre-type composition, Gas chromatography-mass spectrometry