Effect of muscle, ageing and packaging on marker volatiles for beef flavour

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Abstract

Many of the key flavour impact compounds for cooked beef are present at very low concentrations and are challenging to analyse. Marker compounds for desirable flavour have been identified and may be used to monitor flavour-forming reactions. In this paper, this approach is used to follow the impact of muscle, ageing and packaging on grilled beef flavour.

Different muscles and ageing periods show some alterations in the profile of marker volatile compounds that may reflect changes in consumer perception. Some significant and consistent differences are observed between muscles and ageing periods, while grilled beef that has previously been modified atmosphere packed, vacuum packed and over-wrapped show differences in numerous volatile flavour compounds, especially in the products of lipid oxidation.

This approach is yielding a new understanding of the factors affecting the formation of flavour compounds in cooked beef, which could enable new processing methods to be proposed to manage flavour formation in commercial beef products.

Introduction

Consumer assessments of beef from across Europe have shown that palatability is not as consistent as might be expected from a high value product [1]. The proportion of beef judged to be “unsatisfactory” ranges from 19.5% for grilled sirloin and 25% grilled rump to 54% of roasted topside. An inconsistency in quality delivered to the consumer was one of the catalysts for the development of “Meat Standards Australia” (MSA), a cuts-based quality assurance grading scheme developed by Australian scientists [2,3]. This system is now widely used in Australia, and has been tested and found effective in other countries including South Korea, Northern Ireland, Ireland, USA, New Zealand, France and Poland [4].

Despite its effectiveness at predicting eating quality and tenderness, there is some evidence that the MSA prediction of flavour for some consumers could be improved [5]. Flavour can be as important as tenderness for consumers [5,6]. For this reason, studies have been conducted to determine the relationship between volatile flavour compounds in beef and consumer-perceived quality.

Many of the key flavour impact compounds for cooked beef are present at very low concentrations and are challenging to analyse. Therefore, marker compounds for desirable flavour have been proposed [7] to provide a cost-effective and accessible method of monitoring flavour-forming reactions. In this study, this approach is used to follow the impact of muscle, ageing and packaging on grilled beef flavour.

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Experimental

Materials

Beef was obtained from an experiment conducted in Australia, which investigated the impact of muscle, packaging and ageing on sensory quality. Samples were blast frozen after the designated ageing period and selected samples were transported frozen to Northern Ireland by commercial courier. Samples from three muscles (striploin, fillet and rump), three packaging methods (modified atmosphere packaging (MAP with 80% O_2:20% CO_2), overwrapped (OWP) and vacuum skin packaging (VSP)) and three ageing periods (14, 21 and 49 days) were selected for analysis. Table 1 summarises the treatments evaluated and the numbers of samples analysed for volatile compounds.

Table 1: Experimental design

Cut	Muscle	*Abbreviation*	*Ageing*	*MAP**	*OWP*	*VSP*	*Total*
Striploin	*Longissimus thoracis/ lumborum*	STR045	14	4	5	5	14
			21	4	5	4	13
			49	2	4	5	11
Fillet	*Psoas major*	TDR062	14	5	5	5	15
			21	5	4	5	14
			49	4	5	4	13
Rump	*Gluteus medius*	RMP131/ RMP231#	14	4	5	5	14
			21	5	4	4	13
			49	4	5	6	15
				37	42	43	122

** MAP = modified atmosphere packaging; OWP = overwrapped; VSP = vacuum skin packaging.*
 # RMP131 and 231 are two parts of the same muscle; similar numbers of samples were taken from each: 22 from RMP131 and 20 from RMP231.

Analysis

Beef was grilled according to the standard MSA protocol for "medium" cooked beef [8] and the volatiles were collected using Solid Phase Micro Extraction, prior to analysis by electron impact GC-MS, as described previously [9]. The results were statistically analysed using linear mixed methodology, using restricted maximum likelihood (REML) estimation.

Results and discussion

Differences between muscles and ageing periods are significant for some compounds but generally small, while those caused by packaging are more extensive.

Effect of muscle

Comparison of the volatile compounds from different muscles (Figure 1) shows the quantities of selected compound classes (Strecker aldehydes and ketones) from the grilled muscles, relative to that obtained from striploin, which was common to both trials. Of the Strecker aldehydes, only benzaldehyde showed a significant difference between muscles (P=0.018), with striploin producing less than the other muscles. Other Strecker aldehydes showed a non-significant trend also towards lower quantities in striploin. This agrees with previous findings [9] that benzaldehyde (but not the other Strecker aldehydes) were lower in striploin than tenderloin, rump or topside. Three ketones showed significantly higher levels in tenderloin than the other muscles, with 2-butanone showing a similar non-significant pattern.

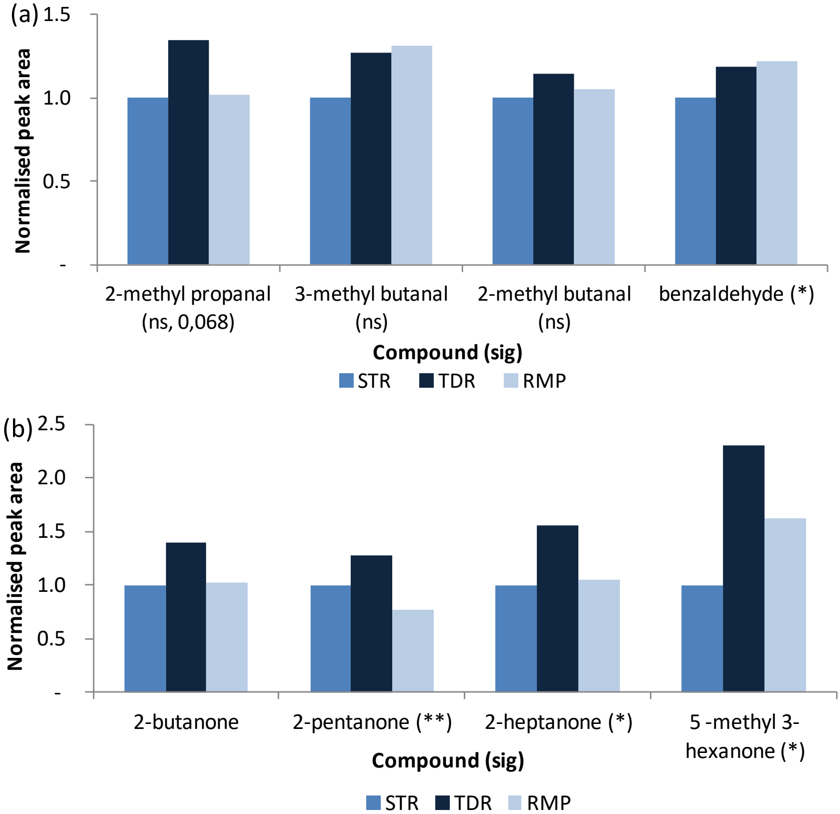

Figure 1 (a – b). Relative qualities of Strecker aldehydes (a) and ketones (b) from grilled beef, different muscles, shown relative to striploin, STR045 = 1. Abbreviations and replication may be found in Table 1.

Previous research [9] showed a similar pattern for 2-propanone ($P<0.001$) and 2-butanone (ns), but did not report findings for the remaining ketones. Most of the remaining volatile compounds were not significantly different between muscles. These results indicate that different muscles produce a similar balance of volatile compounds on grilling, but with some significant and consistent differences. The changes in flavour formation pathways reflected by these differences may contribute to variations in flavour between muscles.

Effect of ageing

Figure 2 shows the effect of ageing from 14 and 21 to 49 days on selected volatiles. While there were few significant differences, there were some trends, with the C7 to C9 n-aldehydes showing an apparent increase at 21 days that was not replicated at 49 days (Figure 2). The large variation within treatments for these compounds meant that these results were generally not statistically significant and further analyses are ongoing to clarify these effects. The Strecker aldehydes, heterocyclic compounds and C4 ketones formed by the Maillard reaction showed no significant effects of ageing and nor were there significant ageing x muscle interactions (results not shown). Research has shown that the concentrations of sugars, amino acids and ribonucleotides increase with age [10, Farrell, unpublished data], and it might have been expected that the volatile products would follow a similar pattern. Only 3-methylbutanal and 2-methylbutanal showed a non-significant trend correlating with ageing (results not shown).

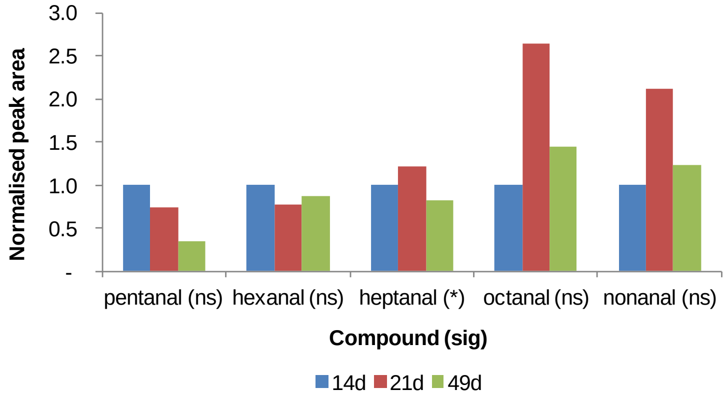

Figure 2: Relative qualities of n-aldehydes from grilled beef from different muscles, shown relative to 14 days = 1. Abbreviations and replication may be found in Table 1.

Effect of packaging

Changes in packaging caused significant differences in the generation of a number of different volatile flavour compounds (Figure 3). Benzaldehyde ($P < 0.001$) was lowest in modified atmosphere packed (MAP) beef and highest in vacuum packed beef. Other Strecker aldehydes followed the same pattern (though non-significantly), as did dimethyltrisulphide ($P < 0.01$). MAP is reported to cause oxidation of proteins and it is possible that this could affect the concentrations of free amino acids available for the formation of these compounds [11,12]. Strecker aldehydes have been closely associated with desirable flavour of beef for consumers [7,13], so changes in these compounds could contribute to differences in consumer preference between packaging treatments.

Amongst the n-aldehydes, only pentanal shows a significant difference with at least five times more in MAP-packed beef than the other two packaging treatments. The remaining n-aldehydes follow the same pattern as hexanal (shown in Figure 3). Vacuum-packed beef has significantly lower concentrations than overwrapped beef of 5-methyl-3-hexanone and 2-pentyl furan while 3-heptanone and 2-ethyl-1-hexanol are lower in both VSP and MAP beef. These compounds can be formed by oxidation pathways [14-16] and it is possible that the reduced oxygen in vacuum-packed beef and higher oxygen permeability of overwrapped beef has caused this effect. Further studies are ongoing to elucidate these effects.

While products of the Maillard and lipid oxidation reactions often follow a similar pattern, a number of products show different effects due to treatment. In some cases, a significant effect is mirrored by a non-significant trend in related compounds, but in others, there are widely different effects within a compound class. Thus, care will be required when identifying marker compounds for desirable flavour [7] that these apply in all cases.

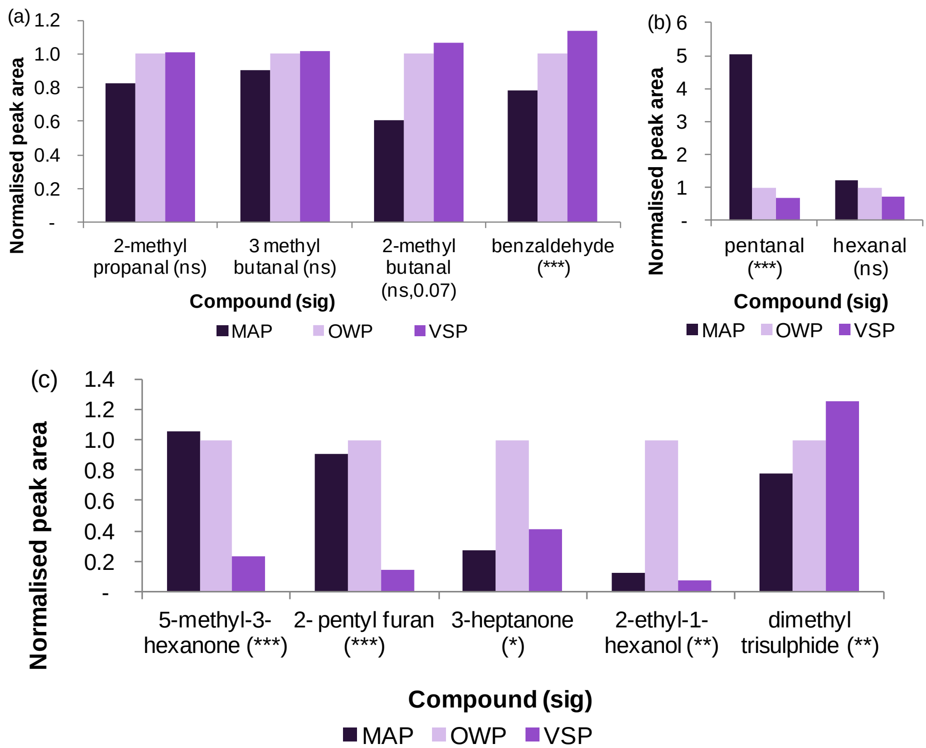

Figure 3: Relative qualities of selected volatile compounds of grilled beef from different packaging methods, shown relative to overwrap (OWP) = 1: (a) Strecker aldehydes; (b) n-aldehydes from Trial 2. Abbreviations and replication may be found in Table 2.

Conclusions

Differences in volatile odour compounds are observed due to muscle, ageing and packaging method. These changes are most extensive due to packaging. The resulting changes in the balance of flavour compounds are likely to alter the flavour profile perceived by consumers.

While products of the Maillard and lipid oxidation reactions often follow a similar pattern, some demonstrate different effects due to treatment. Thus, care will be required when identifying marker compounds for desirable flavour. Further analyses are ongoing to clarify further these effects.

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