ANALYSIS OF VOLATILE COMPOUNDS IN LAMB MUSCLES INFUSED WITH KIWIFRUIT JUICE

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Introduction

The flavour of cooked meat is an essential component of eating quality and results from thermal breakdown of fats, proteins and carbohydrates. All animal meats have similar composition, however a variety of factors including species, sex, age and processing influence meat flavour. Although gas chromatography in conjunction with mass spectrophotometer (GCMS) has identified hundreds of volatile constituents in food, only a few of these play a significant role in the overall aroma quality[6]. Tenderness is another key aspect of consumer acceptance of meat and in this experiment lamb carcasses were infused with kiwifruit juice containing the protease actinidin to accelerate aging. The objective of this study was to measure the effect of this treatment on the compounds which contribute to meat flavour in the logissimus dorsi (LD) and leg muscles.

Materials and Methods

Eighteen lambs were slaughtered humanely and these carcasses randomly assigned to three groups: infused with kiwifruit juice containing actinidin (K), infused with water (W) and not infused (C)[1]. Following slaughter and infusion the carcasses were stored in a chiller at 4°C for up to 3 weeks. At 24 hours and 3 weeks post mortem samples were taken from the LD and leg and displayed on polystyrene trays for up to 6 days.

For analysis of volatile compounds, 5g samples of lamb were diced finely, placed into a 10mL headspace glass vial, cooked in a water bath at 90°C for 30 minutes, and then stored at 4°C for 6 hours before analysis. An external standard (2-Methyl-2-pentenal & Ethyl trans-3-hexenoate) was added to each sample and their headspace volatiles were adsorbed onto an 85µm stableflex carboxen/polydimethylsiloxane fibre. These volatile compounds were then separated in helium on a Shimadzu GC- 2010 gas chromatograph fitted with a Restek-5MS fused silica capillary column (30.0m x 0.25mmi.d. x 0.25µm) at 280°C with flame ionization detection (GC-FID). Volatile compounds were identified with a Shimadzu GCMS-QP2010 gas chromatograph mass spectrometer under the same conditions as the GC-2010. Mass spectra were matched with the spectra of reference compounds in the NIST EPA/NIH Mass Spectral Library database (National Institute of Standards and Technology, NIST05). Individual peaks were quantified as a ratio to the external standard.

Results and Discussion

Ten groups of volatile compounds were found in LD & leg muscles (Tables 1 & 2). The total amount of volatiles was not affected by type of muscle (LD or leg) or three weeks post-mortem storage but increased dramatically with six day display. Aldehydes were initially present in the highest concentration and varied significantly with postmortem time ($P < 0.001$), display time ($P = 0.045$) and muscle type ($P = 0.05$) but not treatment. Hexanal was the dominant aldehyde (data not shown). Previous research has shown that aldehydes are responsible for cooked lamb aroma[2]. Although ketones derived from oxidation of fatty acids are reported as major aroma compounds which contribute the buttery aroma note to cooked meats[5] only small amounts were detected in this work and no significant differences were found with treatment. However alcohols, derived from oxidative decomposition of fat [7], showed significant increases with display time and were the major contributors to the volatile components after 6 days particularly in the 3 weeks post-mortem LD muscle samples.

Esters were minor components and showed no significant difference among the samples of different treatments. Small amounts of four terpenes, markers of animals fed green forage diets[8], were present in all samples. Although α-pinene and beta-pinene were also detected in Kiwifruit juice, there were no significant differences between the K samples and other treatments. Sulphur compounds result from amino acid degradation and are potent contributors to the meat flavour due to their low thresholds of sensory detection[3]. There were increased ($P < 0.001$) levels of sulphur compounds in the LD muscle following three weeks postmortem storage and six days display. Carboxylic acids were also detected in these aged samples from both LD and leg following 6 days display. Alkanes and two other hydrocarbons ((2Z)-6-methyl-2undecene and toluene) were detected in both LD and leg but showed only small differences with display and post-mortem time. Although hydrocarbons are the main volatiles formed via lipid oxidation, they probably have no significant impact on flavour as they have relatively high odour threshold values[3]. No branched chain fatty acids (BCFAs), reported as responsible for "muttony" flavour[9] , were detected in the present work. However other researchers have had difficulty detecting these compounds[4] and it may be a result of the extraction employed in this study.

Table 1. Ratio of chemical group of volatile flavour of cooked LD muscle

	24 hrs Post-mortem Time						3 wks Post-mortem Time					
	0 d Display Time			6 d Display Time			0 d Display Time			6 d Display Time		
Group	C	W	K	C	W	K	C	W	K	C	W	K
Aldehydes	0.88	1.78	0.65	0.75	1.00	0.56	1.07	0.85	0.37	0.37	0.39	0.29
Ketones	0.05	0.10	0.04	0.05	0.12	0.05	0.06	0.04	0.04	0.30	0.18	0.06
Alcohol	0.10^{a}	0.14^{a}	0.10^{a}	1.72^{ab}	1.96^{ab}	0.78^{ab}	0.30^{a}	0.49^{a}	0.48^{a}	13.40^{d}	4.57^{abc}	10.14^{cd}
Terpenes	0.02^{ab}	0.02^{a}	0.02^{a}	0.40^{a}	0.04^{a}	0.02^{a}	0.07^{ab}	0.15^{b}	0.05^{a}	0.03^{a}	0.04^{a}	0.01^{a}
Sulphur Compounds	0.02^{a}	0.07^{a}	0.05^{a}	0.04^{a}	0.02^{a}	0.02^{a}	0.04^{a}	0.05^{a}	0.03^{a}	0.32^{ab}	0.20^{ab}	1.29^{b}
Hydro-carbons	0.03^{ab}	0.04^{ab}	0.05^{ab}	0.05^{ab}	0.09^{b}	0.06^{ab}	0.03^{ab}	0.04^{ab}	0.03^{ab}	0.02^{ab}	0.02^{ab}	0.02^{a}
Alkanes	0.04^{b}	-	0.01^{a}	-	0.06^{bc}	0.02^{a}	0.04^{b}	0.09^{c}	0.04^{ab}	0.06^{b}	0.09^{bc}	0.09^{bc}
Esters	0.06	0.03	0.09	0.03	0.09	0.04	0.07	0.09	0.07	0.03	0.05	0.05
Carboxylic Acid	0.04	0.09	-	-	0.01	-	-	-	-	0.10	0.11	0.01
Ether	0.03	-	-	0.02	-	-	-	-	-	0.01	-	0.03

Table 2. Ratio of chemical group of volatile flavour of cooked leg muscle

	24 hrs Post-mortem Time						3 wks Post-mortem Time					
	0 d Display Time			6 d Display Time			0 d Display Time			6 d Display Time		
Group	C	W	K	C	W	K	C	W	K	C	W	K
Aldehydes	1.12	0.58	0.67	2.01	2.49	2.46	0.77	0.39	0.45	0.58	0.69	0.49
Ketones	0.03	0.03	0.09	0.07	0.08	0.06	0.07	0.05	0.03	0.17	0.11	0.20
Alcohol	0.10^{a}	0.18^{a}	0.16^{a}	6.12^{abcd}	8.40^{bcd}	5.29^{abc}	0.28^{a}	0.25^{a}	1.66^{ab}	4.34^{abc}	1.11^{ab}	3.63^{bc}
Terpenes	0.07^{ab}	0.06^{ab}	0.02^{a}	0.05^{ab}	0.05^{ab}	0.05^{ab}	0.03^{a}	0.05^{ab}	0.02^{a}	0.04^{a}	0.03^{a}	0.03^{a}
Sulphur Compounds	0.09^{a}	0.04^{a}	-	-	0.09^{a}	0.09^{a}	-	-	-	0.03^{a}	0.02^{a}	0.01^{a}
Hydro-carbons	0.03^{ab}	0.02^{a}	0.02^{a}	0.04^{ab}	0.06^{ab}	0.04^{ab}	0.02^{a}	0.01^{a}	0.02^{a}	0.03^{ab}	0.03^{ab}	0.02^{ab}
Alkanes	0.04^{ab}	0.02^{a}	0.02^{a}	-	0.07^{bc}	0.04^{bc}	0.04^{abc}	0.05^{abc}	0.02^{a}	0.06^{bc}	0.05^{bc}	0.03^{a}
Esters	0.06	0.03	0.06	0.08	0.11	0.14	0.05	0.04	0.05	0.07	0.03	0.03
Carboxylic Acid	-	0.04	-	-	-	-	-	-	-	0.05	0.04	0.06
Ether	-	-	-	-	-	-	-	-	-	-	-	0.03

C: Control treatment; W: Water infusion treatment; K: Kiwi fruit infusion treatment; - = Not detected
$^{a–d}$: Superscripts indicate that both LD & leg muscle in the same group differ significantly ($P < 0.05$);

Conclusions

A total of 10 volatile compound groups were identified in the lamb samples using SPME headspace analysis with GC-FID and GC-MS. Infusion of carcasses with kiwifruit juice for tenderization had only a minor impact on the aroma compounds of lamb and should not change the natural lamb flavour. However the amount and composition of aroma compounds changed with aging and particularly display time with a large increase in alcohols. Lipid oxidation and amino acid degradation were the main pathways leading to increased volatile generation during display.

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