The Effect of Extended Chilled Storage in CO_2 Atmosphere on the Odour and Flavour of Sheepmeat as Assess by Sensory Panel and an Electronic Nose

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INTRODUCTION

Traditionally, New Zealand has exported most of its sheepmeat as frozen product. However, in a drive to market table-ready cuts of beef and la a carbon dioxide controlled atmosphere packaging system (CAP) was developed so raw product can be shipped chilled (-1.5 C) and still maint a hygienic storage life of at least 16 weeks. In a brief report, Gill (1988) noted that the use of a carbon dioxide controlled atmosphere for chil meat storage "stripped" ovine flavour from sheepmeat and "gamey" flavour from venison. He also commented that with prolonged storage, meat develops "livery" flavours due to peptides formed during the hydrolysis of proteins. Jeremiah *et al.*, (1992) found an unidentifiable aromatic in pork stored for between 6 and 24 weeks in CO_2 at -1.5 C. A livery aromatic was also perceived at 12 and 15 weeks, but was detected at later times. The objective of this study was to compare the cooked odour and flavour of minces from lamb legs stored chilled (- C) in a CO_2 atmosphere or stored frozen (-35 C) in vacuum packs. Sensory panels evaluated the cooked minces for various odour and flavo attributes after 4, 8 and 14 weeks storage. In addition to the conventional panel assessment, samples of both raw and cooked minces (at 14 week were also evaluated using an ALPHA M.O.S Fox 4000 electronic nose.

METHODS

Twenty-seven pairs of lamb legs with ultimate pH values ranging from 5.66 to 5.92 were randomly sorted into three replicate storage time grou An equal number of left and right legs were then divided into two subgroups. Legs of one subgroup were packed in aluminum foil-lined impermeable polypropylene bags containing 1.5 litres of CO_2 (< 500 ppb oxygen) per kg of meat, and stored at -1.5 C. The contralateral legs w then placed in the same type of bag, vacuum-packed, and stored at -35 C. At chosen times legs from each storage treatment were removed fr storage. Before analysis, tempered legs were swabbed for aerobic plate count. Meat pH measurements were done on homogenized samples ab 2 hours after mincing, to allow time for dissolved CO_2 to evolve from the minced meat.

Sensory and Electronic nose analysis

Procedures for sensory evaluation of minced legs were as described previously (Braggins, 1996). Twelve panellists were asked to score for over sheepmeat, foreign, sweet, sour, bitter, metallic, roasty, meaty, livery, stale/musty and rancid odour and flavour. All attributes were scored o scale of 0 to 9 where 0 = no odour or flavour and 9 = intense.

The headspace gas of selected samples of raw and cooked minces from chilled-CO_2 packed and frozen-vacuum packed meat were tested usi a FOX 4000 electronic nose (ALPHA M.O.S. SA, Toulouse, France). The 18 sensors were equilibrated with humidified instrument grade air. T gram samples of minced meat were spread evenly over the bottom of a 20 mm x 20 mm, 120 mL glass jar, purged with humidified instrum grade air and incubated for 10 minutes at 30 C. The equilibrated headspace above the sample was dynamically purged across the surface of t sensors at a flow rate of 150 mL min^{-1} for 3 minutes. Changes in resistence of each sensor were recorded and processed as the change in resisto (R) divided by the resistence of each sensor measured at time zero (R_0).

Statistical Analysis

Sensory panellists' data, aerobic plate count and pH data were analysed by analysis of variance (ANOVA) (Genstat). Electronic nose data w evaluated by Principle Component and Canonical Discriminant Analysis using Unistat Statistical software (version 3.0a, Unistat, Lond England).

RESULTS AND DISCUSSION

Meat pH

The change in meat pH increased with storage time for meat stored in a CO_2 atmosphere at -1.5 C ($P<0.001$) but not for frozen-stored meat. T greatest change (0.48) occurred after 14 weeks of chilled storage. This pH effect was not caused by microbial spoilage ($P > 0.05$) aerobic pl counts between storage treatments at each of the storage times. However, there was an increase ($P < 0.01$) in aerobic plate counts with time the CO_2 packs. The maximum aerobic plate count of 4.0 CFU cm^2 (log_{10}) is not high enough for an effect on meat pH or cooked meat flavo and odour. Similar increases in meat pH during aging have been described previously. Moore and Gill (1987) propose that the pH increase w due to an increase in basicity (decarboxylation) rather than a consumption of lactic acid.

Changes in Sensory Attributes During Storage

Sensory analysis of odour showed that there was a significant decrease ($P < 0.05$) in overall, sheepmeat and sweet odour attributes over time (Ta 1). A livery/offaly odour was significantly higher in the CO_2-packed legs stored at -1.5 C compared with the vacuum-packed lamb legs stor at -35 C for the same period. Sheepmeat flavour tended to decrease over storage time ($p<0.1$) (Table 1). Chilled CO_2-packed meat was less "swe and "roasty" than the frozen control ($P < 0.05$). There was a significant storage effect ($P < 0.01$) and storage x time interaction ($P < 0.05$) livery/offaly flavour. Significantly more panellists ($P < 0.01$ at 4 and 8 weeks; $P < 0.001$ at 14 weeks) detected the livery/offaly flavour in CO_2-packed meat compared with the vacuum-packed control. At 14 weeks this represented 66% of panellists detecting this attribute in CO_2-packed meat compared with 33% of panellists for the vacuum-packed meat. There was also an increase ($P < 0.001$) in the frequency of panellists w scored the livery/offaly attribute with time in the CO_2-packed meat only. The average livery/offaly flavour intensity scores from only th panellists who could detect this attribute were significantly ($P < 0.001$) greater for the CO_2-packaged meat after 14 weeks of storage. In contra the average livery/offaly flavour intensity score remained unchanged over the 14 week storage period for the vacuum-packed meat stored at -3

This suggest panellists have different flavour thresholds for this particular attribute (and probably other attributes). This finding can be extrapolated to the general consumer. The reason(s) for the flavour changes that develop in chill-stored CO_2-packaged meat have not been fully elucidated. Greater increases in the pH of CO_2-packed meat over vacuum-packed meat stored at similar temperatures have also been observed by others (e.g. Doherty, *et al.*, 1996). These results and the results of the present study suggest that storage in CO_2 increases the meat pH on aging and might be related to the increase in undesirable livery/offaly odour and flavour and the decrease in sheepmeat odour observed by panellists. Meat of high (> 6.0) ultimate pH also has a decreased overall and sheepmeat odour and flavour compared with meat of low (5.6) ultimate pH (Braggins, 1996). Whatever the cause(s) of flavour changes in high ultimate pH meat and meat stored chilled in CO_2 atmosphere, pH appears to be a common factor.

Table 1.
Mean panel scores for odour and flavour attributes of chilled-CO_2-packed and frozen (minus 35 °C)-vacuum-packed lamb legs stored for 4, 8 and 14 weeks.

Attribute		Weeks of storage			Significance			
		4	8	14	Storage type	Time effect	Storage effect	Storage x time
Overall odour	Vac	5.90	5.27	5.16	5.44	*		
	CO_2	5.88	5.10	5.12	5.37			
Sheepmeat odour	Vac	4.48	4.20	4.00	4.23	*		
	CO_2	4.58	4.15	3.54	4.09			
Sweet dour	Vac	1.89	1.76	1.48	1.71	*		
	CO_2	1.57	1.67	1.15	1.46			
Livery/offaly odour	Vac	0.58	0.46	0.61	0.55		*	
	CO_2	0.91	0.44	1.00	0.78			
Sheepmeat flavour	Vac	4.60	4.52	4.27	4.46	†		
	CO_2	4.47	4.19	3.73	4.13			
Sweet flavour	Vac	2.31	2.29	1.97	2.19		*	
	CO_2	1.85	1.89	1.37	1.70			
Roasty flavour	Vac	0.64	1.00	0.70	0.78		*	
	CO_2	0.51	0.78	0.45	0.58			
Livery/offaly flavour	Vac	0.93	0.69	0.76	0.79		**	*
	CO_2	2.0	1.31	2.53	1.94			

Significance: † $P < 0.1$; * $P < 0.05$; ** $P < 0.01$

Detection of raw and cooked meat volatiles using an Electronic Nose

Canonical discriminant analysis of electronic sensory data of raw minces from lamb legs stored for 14 weeks showed clear discrimination between both storage methods and from blank sampling jars (figure 1). Cross-validation of randomly selected replicate samples showed 'unknowns'(denoted as © in figure 1) associate with their respective parent group. This confirms that the Alpha M.O.S electronic nose could reliably measure differences in volatile compounds between chilled CO_2 -packed and frozen vacuum-packed raw meat. As with the human nose, the electronic nose does not have the ability to identify the compounds responsible for this difference. It is assumed that CO_2 alone is not responsible for the observed difference, as the samples were equilibrated long enough in atmospheric air after mincing to allow dissolved CO_2 to dissipate from the meat. Canonical discriminant analysis of the cooked meat also shows good discrimination between storage treatments and blank jar for such a small exploratory data set (figure 1).

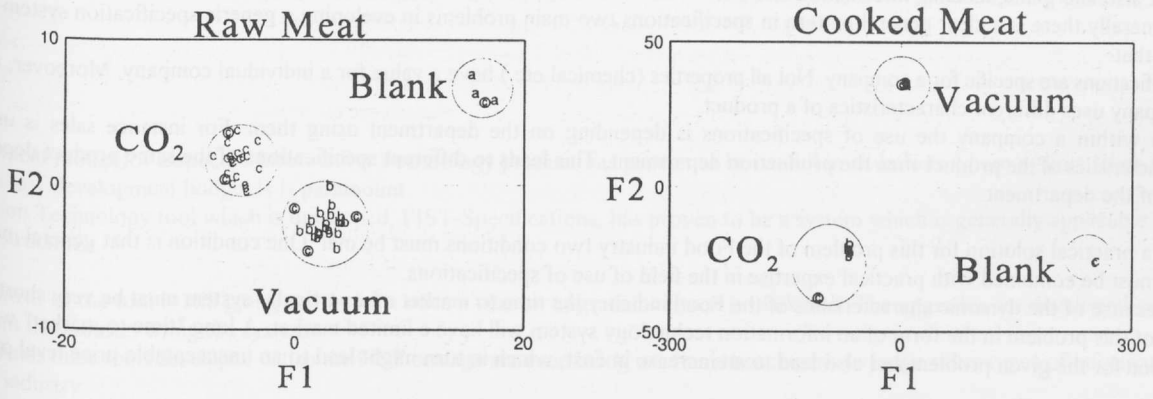

Figure 1.
Canonical Discriminant Analysis plots of raw and cooked minces from lamb legs stored at -1.5°C in CO2 atmosphere and lamb legs stored at -35°C vacuum-packed, and stored for 14 weeks. Cross validation with unknowns (©) showed the analysis was valid.

ACKNOWLEDGEMENTS

This work was supported by the Meat Research and Development Council of New Zealand.

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