MEAT TECHNOLOGY UPDATE
Cutting edge technology for the meat processing industry

Meat technology update

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The effect of diet on sheepmeat flavour

- **The vast majority of pastures and feeding systems produce sheepmeat of highly acceptable quality and flavour.**
- **There are some pastures or feeding systems that can directly, or indirectly, have a positive or negative influence on sheepmeat flavour. These need to be identified and processes put in place to ensure consumers in Australia, and overseas, always have a good eating experience.**
- **In order to minimise any off-flavour associated with sheep fed brassica crops, sheep should be removed from brassica crops for 2 weeks prior to slaughter.**
- **Grazing sheep on pastures high in protein (e.g. clover, lucerne) can increase the occurrence of 'pastoral' flavour in meat. The perception of 'pastoral' flavour as unacceptable may depend on habituation and prior experience.**
- **Consumer acceptance of the flavour of 'mutton', or 'pastoral' flavour could be assisted by masking the flavour with seasoning such as herbs and spices.**

Introduction

Flavour is an important sheepmeat quality trait. Flavour is comprised of aroma (volatile) and taste (non-volatile) compounds. Aroma is perceived during eating by olfactory receptors in the nose, and taste is perceived by receptors in the mouth and throat. Fresh, uncooked meat is quite bland; it is only as a result of cooking that meat flavour develops. The resulting characteristic flavour is regarded as typical for a given species, e.g. lamb, beef, pork etc. During cooking, the non-volatile components of lean and fat tissues undergo a complex series of heat-induced reactions that generate a large number of volatile aroma products. The compounds formed are mainly derived from two distinct reactions that occur during the cooking process: Maillard reactions between amino acids and reducing sugars; and thermal degradation of the lipid components to produce volatiles.

Historically, most attention has been given to undesirable sheepmeat flavour attributes, such as 'mutton' and 'pastoral' flavours. 'Mutton' flavour, associated with the age of the animal, is more common in cooked meat taken from older sheep; while 'pastoral' flavour has generally been related to the pasture diet fed to the animal pre-slaughter. Branched chain fatty acids are recognised as the main compounds which contribute to 'mutton' flavour, while 3-methylindole ('skatole', also a contributor to 'boar' taint in pigs) and 4-methylphenol (*p*-cresol) are the main compounds which have been implicated in 'pastoral' flavour. Diet can also have other effects on the flavour of sheepmeat, aside from pastoral flavour. This MTU discusses the overall effect of different pre-slaughter diets on sheepmeat flavour.

Sensory evaluation

Sensory evaluation of cooked sheepmeat is usually performed with either consumer panels (untrained or naive) or trained sensory panels. Consumer panels rate the cooked meat based on their experience of the product quality. Some of the factors that consumers assess include tenderness, juiciness, liking of the smell and overall flavour. Consumers can give an 'opinion' of the meat, which will be based on their experience. A trained sensory panel is used as an objective measurement tool where the panellists are taught to identify and quantify specific sensory attributes (aroma, flavour, texture and mouthfeel) and rate them in the cooked meat product. It is an objective process that can quantitatively measure complex flavour attributes, which may not be easily measured using conventional instrumental techniques. A trained panel, by the nature of the training involved, cannot be used to give an 'opinion' of the meat. Meat Standards Australia runs consumer panels where the product is linked between tasting sessions, and a standard cooking and presentation approach is used for all tasting sessions, thus providing objectivity.

Chemistry and linkage to sensory

Volatile compounds are measured using gas chromatography-mass spectrometry (GC-MS). Volatile analysis involves extraction and concentration, chromatographic separation,

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detection and quantification. Considerable effort has been made to characterise the volatile compounds associated with cooked sheepmeat. Despite reports of hundreds of volatile compounds in the literature, few studies have demonstrated which of them are important to the aroma. In fresh food products, there are usually only a small number of the total volatile compounds that actually contribute to the aroma. In order to identify the 'odour-active' volatiles, a more specialised technique is required: gas chromatography-olfactometry (GC-O). In GC-O (Figure 1), the volatile extracts are subjected to chromatographic separation and instrumental detection; and also simultaneously 'sniffed' by a human assessor and the odour intensity is rated. Ideally, GC-O is performed by a panel of assessors (similar to using a trained sensory panel) to account for human variability in sensitivity for different aroma compounds. The aim of this type of research is to identify which volatile compounds are the most significant contributors to the cooked meat aroma.

Effect of diet on cooked meat flavour

The use of pasture-based finishing diets, compared to grain-based, can impact on the sensory properties of the cooked sheepmeat (Table 1). Pasture diets, in comparison to grain, may introduce different flavours to the final product which are often perceptible by trained sensory and consumer panels. Depending on the consumer (cultural background, prior lamb consumption, habituation to meat from pasture or grain-fed animals), the flavour of cooked pasture-fed sheep may be described as typical 'sheepmeat' or 'lamb', or unfamiliar and potentially unacceptable.

Some differences have been described for the meat flavour of sheep grazing on different pastures and forages. For example, in comparative trials of different pasture species, unacceptable flavours have been found by trained panels for white clover, lucerne, phalaris, rape (*Brassica* sp.) and related brassica feeds (see Table 1). Other studies have reported no differences in sensory panel assessments between meat from sheep grazing forage species such as tropical legumes vs grass and chicory vs lucerne. The stage of growth for pasture species and also time of year can influence the water-soluble carbohydrate content, crude protein % and digestibility, all of which can potentially impact on the occurrence of off-odours and flavours in ruminant meat. Importantly, the majority of pastures and feeds do not create flavour or odour problems in the meat; however, and of equal importance, the forages that have potential to impact on product quality need to be identified, in order to minimise any risks of the consumer getting a poor eating experience.

In some instances, the impact of pasture species on sheepmeat flavour can be significant. One example is forage rape or canola (Figure 2) and anecdotal evidence suggests that certain Brassica crops in common use may impart negative flavour attributes in lamb. A diverse range of *Brassica* species is available and used in Australia, which naturally vary widely in glucosinolate and protein content. There is speculation that Brassica with high glucosinolate content may impact on flavour, through sulphur-containing breakdown products, although this still needs to be proven. In addition, pasture diets with high protein content have been implicated with the pastoral flavour notes found in lamb. Grain-finishing diets are also increasingly used, although how grain-fed lamb flavour differs from other diets requires clarification.

Effect of diet on aroma (volatile) compounds

Lactones are important aroma and flavour compounds that are found in many natural products. Higher levels of γ-lactones have been found in the meat taken from grain-fed sheep, and are believed to be derived from the free fatty acids that are present in the grain. δ-lactones have been reported to be high in the meat obtained from pasture-finished animals. Different synthetic pathways exist for the formation of the γ- and δ-lactones.

Both 3-methylindole and *p*-cresol have been implicated as the main contributors to 'pastoral' flavour. Pasture has a high protein-to-readily fermentable carbohydrate ratio, and the protein from pasture is more readily digestible in the rumen compared to that available in grain and concentrate diets. Additionally, substantial degradation of feed protein to amino acids occurs in the rumen, which allows a higher availability of peptides and amino acids for absorption, which cannot be fully incorporated into microbial protein since insufficient energy is released from carbohydrate metabolism. Tryptophan and tyrosine, both amino acids, are transformed by rumen bacteria to form 3-methylindole and *p*-cresol, respectively. Usually, these compounds would be metabolised by the liver after release into the blood supply from the intestine; but, when in excess, some will escape liver metabolism and be released into the blood supply resulting in deposition into fat tissue.

Table 1. Impact of feeding regimes on sheepmeat flavour

Feeding system	Impact on flavour
Pasture compared to concentrates	
Pasture vs grain concentrate	'Lamb' flavour higher in concentrate
Pasture vs lucerne or maize concentrate	'Sheepmeat' flavour higher for pasture
Ryegrass vs concentrate	'Off' odours/flavours in ryegrass-fed meat
Mixed pasture vs grain-based or poor quality dry feed	No difference between pasture vs grain
Pasture vs concentrate vs pasture/concentrate	Lower acceptance of pasture-fed animals
Other comparisons	
Rape vs pasture	Stronger, less acceptable flavour for rape
Perennial ryegrass + other grasses vs grain-based	'Sheepmeat' flavour higher for pasture than grain
Saltbush vs barley/lupin/hay	No difference

Diet has also been implicated in the formation of branched chain fatty acids (BCFAs), regarded as the main contributors to 'mutton' flavour. Higher concentrations of these compounds have been observed in animals receiving a grain-based finishing diet prior to slaughter. This has been attributed to carbohydrate availability in the diet since higher amounts are associated with grain and concentrates compared to pasture-based diets. Although it might be logical to assume that grain-dominated diets result in increased 'mutton' flavour in the cooked meat, cereal grains differ in their propensity to generate BCFAs, so some care is required in extrapolating this observation.

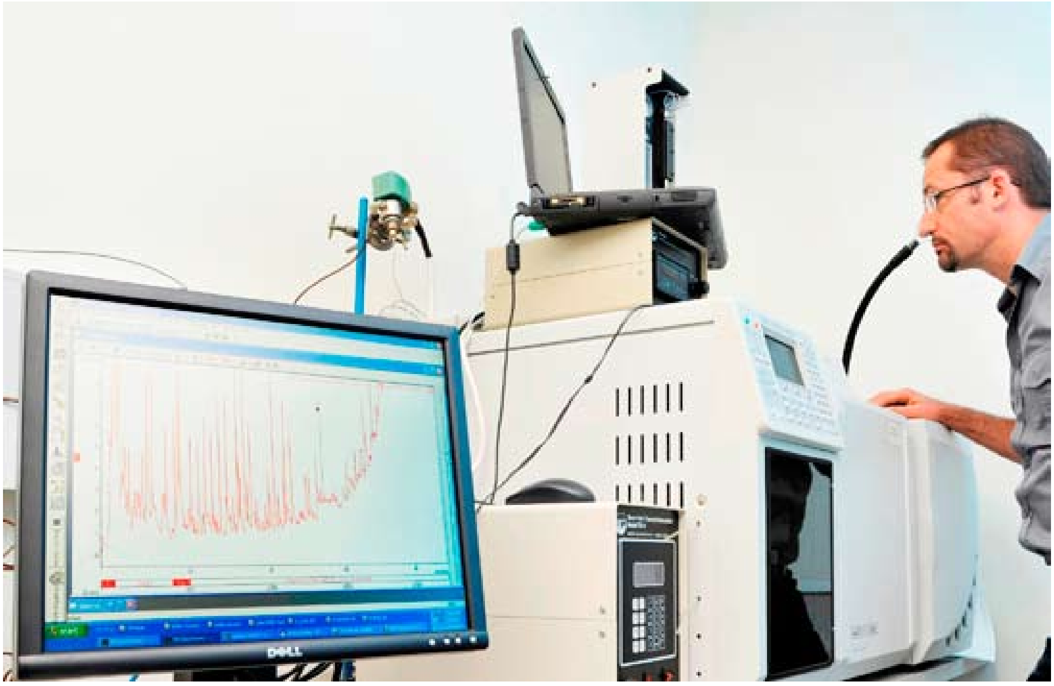

Figure 1: Sniffing aroma on a GC-olfactometer

Taste compounds in meat

To date, research relating to non-volatile taste compounds in lamb meat specifically, and meat in general, has been fairly limited; but, in recent years, interest in this area of research has been increasing. There is a wide range of compound classes that can contribute to the taste of meat and related products. These are, namely: organic acids (e.g. lactic and succinic acids); compounds derived from lipid precursors (short-chain fatty acids); sugars (such as glucose and fructose); peptides and free amino acids (produced from enzymatic hydrolysis of muscle proteins); nucleotides; and Maillard reaction products.

Low molecular weight, water-soluble compounds (namely sugars, amino acids and other nitrogenous components) are important as:

(a) background basic taste attributes (sweet, sour, salty, bitter and umami) as well as complex sensations such as mouth-fullness; and

(b) precursors of the characteristic aroma (meaty flavour) of cooked meat.

Other indirect effects

Components of the diet that change the final pH, intramuscular fat, or antioxidant status of muscle can also affect the final flavour characteristics. For example, carnosine, the most abundant dipeptide in skeletal muscle, and vitamin E, a lipid-soluble vitamin derived from pasture, both decrease lipid oxidation. Lipid oxidation in muscle post-slaughter causes deterioration in meat flavour, including the unacceptable 'warmed-over' flavour. Carnosine also has a positive influence on the thermal generation of pyrazines, a class of compounds that contribute to 'meaty' aromas. Differences in diet can impact on other factors which will influence the final flavour characteristics of the meat product. For example, meat from concentrate-fed animals undergoes lipid oxidation more readily compared to that taken from pasture-fed animals, which impacts on the amount of lipid-derived volatiles during cooking. Pastures and feeding systems which allow the adequate deposition of muscle glycogen and also intramuscular fat, by providing adequate energy and protein, will also result in more acceptable flavour in the meat.

Saltbush-fed lamb has been anecdotally reported to have a superior flavour, although the studies comparing saltbush-fed lambs to pasture-fed lambs have found no difference. As saltbush appears to impart higher levels of antioxidants to the muscle, it is possible that the superior taste is associated with prevention of the off-flavour associated with oxidation.

A consumer perspective

An estimated world total of about 1 billion sheep exist for wool and milk production, and slaughter for meat, skin and wool. The largest number are in China, about 130 million, followed by Australia (70 m), India (65 m), Iran and Sudan (50 m each), Nigeria, New Zealand and the UK (30 m each). Most of the sheepmeat produced in China is intended for local consumption. Australia, by contrast, has a high local consumption and, along with its neighbour New Zealand, is a major sheepmeat exporter. In both Australia and New Zealand it can be assumed that a significant fraction of the native population accept the characteristic flavour of locally produced sheepmeat as 'normal'. These populations can be described as habituated to the local product.

The source of sheepmeat for processed foods is usually older ovines, typically mutton, which is a cheaper source than lamb. In these processed foods the meat is usually comminuted, which eliminates any problem of toughness due to muscle origin and animal age; however, mutton is more strongly flavoured and, due to the negative perception by some consumers, its inclusion into meat products is not routinely promoted, e.g. mainstream sausages prepared with mutton are often labelled 'beef-flavoured sausages' to avoid consumer misapprehension. Conversely, this is why 'mutton-flavoured sausages' are never seen.

The aversion to meat taken from older sheep was highlighted in a consumer survey in New Zealand that tested the association between

Figure 2: Canola (brassica) field in Temora, New South Wales (from en.wikipedia.org)

consumer perception of different types of red meat (lamb, mutton, beef, venison) and their perceived taste, quality and healthiness. Consumers were asked to rate expected quality with no actual meat eaten or on view. The perceptions of hogget and mutton were lower compared to the other meats, which included lamb. Whilst a negative perception for mutton might be reasonably founded on flavour differences due to the presence of higher BCFAs, a lower rating for hogget, where the animal may only be older than a lamb by one day, suggests that the mere name hogget has an unfortunate marketing consequence.

Different consumer populations around the world vary in their liking of sheepmeat. In many cases this relates to lack of exposure, familiarity and traditional use of sheepmeat in the local culture and cuisine. Sheepmeat consumption is greater in Australasia than in Japan, and this is reflected in product habituation. Researchers, in a comparative study between female Japanese and New Zealand consumers, spiked beef samples with zero, low and high concentrations of mixed BCFAs and of skatole to simulate nine flavour combinations of sheepmeat fed on pasture, designed to represent a range of sheepmeat typically available to New Zealand consumers. For the Japanese consumers, there was a strict linear decrease in liking as BCFA concentration increased. In contrast New Zealand consumers on average liked a low level of added BCFAs best, similar to those found in young lamb suggesting an effect of habituation and familiarity. The results for skatole were more complicated, but the highest concentration was clearly most disliked by both populations.

Consumers not familiar with the flavour of sheepmeat are likely to be less accepting of this product and so it will remain a challenge to overcome the negative perceptions, whether due to the inherent presence of a 'natural' lamb flavour, or due to the presence of BCFAs which contribute to the 'mutton' flavour. In order to overcome the barriers in these populations, masking lamb flavour with herbs and spices is an obvious path to take. Each culinary tradition has well-defined 'flavour principles' that could be utilised to produce an acceptable meat product suitable for unhabituated consumers. Development of optimised feeds, which impart desirable flavour attributes or, alternately, mask less desirable qualities, may also be an effective strategy for the sheepmeat industry.

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