18 Meat Flavour
Wayne Pitchford

Learning objectives

At the end of this topic you should be able to:

- demonstrate an understanding of the effects of cooking on flavour.
- demonstrate an appreciation for the complexity of flavour causing compounds and flavour analysis.
- be able to list common meat flavour descriptors.
- demonstrate a thorough understanding of major factors causing differences in meat flavour between species and some important flavour issues.

Key terms and concepts

- Flavour descriptors
- Fatty acid composition
- Lipid oxidation
- Warmed-over flavour
- Maillard reactions
- Mutton-odour, boar taint

18.1 Introduction

Tenderness is the most important determinant of consumer acceptability of meat, especially beef. This has led to the development of the World-leading grading system, Meat Standards Australia. However, once meat is tender, the primary determinant of acceptability is flavour.

Flavour perception has been defined as "the sensations perceived by the tongue, mouth, throat and nose when an object is eaten" (Caul, 1957). The mouth senses factors such as astringency, bite, burning, cooling, numbing and coating (Meilgaard et al. 1991). The tongue (taste buds) is responsible for the four basic taste sensations (sweet, sour, salty and bitter) and umami (described later) sensations could be added to this. Lastly, and probably most importantly, odours are detected in the nasal passage and affect the overall flavour experience, and after-tastes and after-feels that occur.

Raw meat is tasty (blood-like, metallic) rather than flavourful. It provides salts, savoury amino acids, but offers little in the way of aroma (McGee 2004). Although over 1000 compounds have been identified in the volatiles released from warm meat, the exact contribution of each compound to meat flavour is not yet known. Flavour assessment continues to be as much an art as science.

The focus of this lecture is on what we traditionally term meat, i.e. muscle. There is not scope to include offal products, preserved or processed meats. I have also chosen to focus on meat from cattle, sheep, pigs and poultry. Game meats and fish are also outside the scope of this lecture.

18.2 Effects of cooking

More details on cooking will be given in a later lecture (28) by John Thompson. However, some introduction is required here since meat flavours are primarily released only after cooking.
Becoming edible
When meat is heated, its appearance changes. The primary change noticed is from red to pink and then to a grey-brown colour. This is caused by denaturation of myoglobin. The first change from red to pink occurs at around 50°C. The next change from pink to grey-brown occurs around 60°C. The denaturation of myoglobin parallels the denaturation of fibre proteins, and this makes it possible to judge the doneness of fresh meat by colour (McGee 2004). More specifically, a rare steak (red in middle) would be heated to an internal temperature of 50°C, medium-rare to 55°C, medium (pink in middle) 60°C, and well-done (no red or pink) 70°C as outlined in Figure 18.1. Cooking young, tender meat above 70°C will cause it to become stiff and dry. Thus, the key to cooking meat properly is knowing when to stop!

Figure 18.1 MSA diagram of doneness in steak. Source: MSA (2006).

Once around 70°C, if cooking continues then connective-tissue collagen will dissolve into gelatin (jelly!). To prevent drying out at the same time, slow cooking is generally done with a moist heat and results in the delightful texture of slow-cooked meats, long braises and stews. Slow cooking is important for cuts with high levels of connective tissue, those in the animal that do the most work. Thus, collagen levels are higher in muscles that are lower down the legs (e.g. lamb shanks) and lowest in those along the back (loin).

Browning
At temperatures above 150°C, meat will "brown" and aroma compounds are formed. The reactions that cause this involve interactions between simple sugars and amino acids and are totally different from those affecting "doneness". These reactions are responsible for the superb flavour of bread crusts, chocolate, coffee beans, dark beers and roasted meats. They were discovered by Louis Camille Maillard around 1910 and since that time have been termed "Maillard reactions". In meat, these result from dry cooking (grill, bake, fry and dry roast). Common flavour descriptors of Maillard products are savoury (peptides, amino acids), floral (oxazoles), onion or meatiness (sulphur compounds), vegetables and chocolate (pyrazines) and caramel (McGee 2004).

When cooking a stew it often recommended to "brown" the meat before adding water. This allows both the inclusion of intense and desirable flavours as well as dissolving collagen with the slow, moist cooking. Another common method for roasts is to cook at a relatively slow temperature but have a high temperature at the start or end to achieve browning of the surface while preventing drying out of the bulk of the meat. Cooking at 175°C can be a reasonable compromise (McGee 2004).
Notes – Lecture 18 – Meat Flavour

It is also common during Maillard reactions for interactions with lipids. The result being species specific caramelised flavours. At very high temperatures, Maillard products can further react resulting in unpleasant burnt and bitter flavours that should be avoided.

**Umami**
As has already been explained, meat flavour results from interactions between thousands of volatile compounds. However, the level of complexity is increased even further by compounds that alter (intensify, modify or mask) the flavour of food (Maga 1998). Amino acids are important for the browning reactions and most tasty amino acids are perceived as either sweet or bitter by the taste buds on the tongue. However, glutamic acid and some peptides have a unique taste that is often described as savoury, brothy and umami (Japanese for delicious). Glutamic acid comprises about 20% of muscle protein but the well known form of glutamic acid is monosodium glutamate (MSG). MSG is commonly used in Asian cooking to enhance or strengthen desirable flavours common in meats. The effect is larger in pork and chicken than in beef.

### 18.3 Lipid-derived off-flavours

When fresh meat is frozen, unsaturated fats are slowly oxidised and rancid or off-flavours slowly accumulate. This may occur without bacterial growth which would mean the meat if “off” and unsafe to eat. It is for this reason that quality of frozen fish and poultry declines after only a few months, pork after 6 months, lamb and veal after 9 months and beef after about a year (McGee 2004).

While cooking many desirable flavour compounds are formed from reactions between amino acids and lipids. However, many of these compounds are unstable and susceptible to oxidation. This damage occurs slowly in the refrigerator and more rapidly when reheating. The result is a characteristic “Warmed-Over Flavour”, also termed “Meat Flavour Deterioration”. The flavours that develop are described as stale, cardboard, or rancid. A traditional way to avoid these flavours when eating left over roast meats is to serve cold meat with hot vegetables rather than also heat the meat. The flavour deterioration occurs much less in cured meats where nitrite is used as a powerful antioxidant. C-W Chen and Ho (1998) stated that warmed over flavours are very common in poultry meats and could be worse in turkey because of its higher concentration of polyunsaturated fatty acids in the meat phospholipids.

### 18.4 Causes for differences between species

The cause of differences in flavour between species was thought to be quite simple. In the early 1960’s, Hornstern and Crowe (1960, 1963) heated aqueous extracts of beef, pork and lamb and found they had similar aromas whereas heating the fats resulted in aromas characteristic of the species of origin. Thus, the conclusion was that lean meat of different species tastes the same and species differences in flavour must be due to differences in the fat. However, it is now known that this was an oversimplification and that lipid-derived volatiles have an important role in desirable meat aroma directly and as intermediates for other compounds.

A number of flavour studies have been done by mixing lean mince of one species with fat of another in an attempt to identify differences between species (Mottram 1998). At this point it is important to distinguish between structural fats (phospholipids) and storage fats (triacyl glycerides). The structural fats form the basis of cell walls of all cells, including muscle cells. Storage fats are located close to muscle and are sources of energy for the muscles when needed. Storage fat is visible in three depots that are important for meat quality. Subcutaneous fat is important on the outside of the carcase (under the skin, hence the name) and is often trimmed. Intramuscular fat is between muscles and can be trimmed in large cuts of beef, but rarely in smaller lamb. Intramuscular fat (marbling) is within the muscle, flecks of white fat between the red muscle bundles.

Many aroma compounds are fat soluble and are stored with the triacyl glycerides. There tends to be larger differences in flavour between fatter animals, but species differences in flavour of lean meat do exist. It is now known that primary species differences are due to volatiles arising that are formed from interactions between breakdown products from the muscle protein (especially high sulphur amino acids) and the phospholipids during heating. Although specific compounds have not been identified, aldehydes are major lipid degradation products and are probably responsible for certain species characteristics (Mottram 1998).
Fatty acid composition

Storage fats in ruminants tend to comprise high levels of saturated and to a lesser extent mono-unsaturated fatty acids whereas structural fats comprise higher levels of poly-unsaturated fats. It is now well accepted that high levels of saturated fat intake can increase the risk of heart disease. Thus, there is great consumer interest in meats that have "better" fat composition. As outlined by our group in Adelaide (Siebert et al. 1996), lean meats are often reported as having higher levels of unsaturated fats simply because the laboratory has measured total fatty acid composition. Hence, those with lower fat content (less storage fat) have less saturated fat simply because the structural fats are a greater proportion of the total (Figure 18.2) and visa versa, a simple dilution effect.

Species differences continue to be promoted based on fatty acid composition. Some representative composition values are as shown in Table 18.1. Note the high level of Linoleic and other PUFA in phospholipids compared with tri-acyl glycerides. Compared with beef, lamb is very high in Stearic acid. Japanese and Korean beef are very high in Oleic acid. Pork and poultry are very high in Linoleic and quite high in Oleic acid. Kangaroo has very low levels of saturated fat in adipose. Marine mammals (Whale) and fish have very high levels of PUFA. Deer is high in both Stearic and Linoleic acids.

Figure 18.2 Relationship between fatty acid composition and fat content of beef muscle.

Source: Siebert et al. (1996)
Notes – Lecture 18 – Meat Flavour

Table 18.1 Fatty acid composition of various species (% of total fats) Source: Compiled from:
1 Siebert et al. (1996)
2 Pitchford et al. (2002) (C18:2 and PUFA unpublished but same data set)
3 Stephens (2001)
4 Enser et al. (1996)
5 Siebert et al. (2000)
6 Engelke et al. (2004) (Total fat data unpublished by same data set)
7 Suzuki (2005)
8 USDA Nutrient Data Laboratory (2005).

<table>
<thead>
<tr>
<th>Phospholipid</th>
<th>Palmitic C16:0</th>
<th>Stearic C18:0</th>
<th>Oleic C18:1</th>
<th>Linoleic C18:2</th>
<th>PUFA (&gt;2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Beef</td>
<td>13.1</td>
<td>12.6</td>
<td>23.8</td>
<td>22.2</td>
<td>10.7</td>
</tr>
<tr>
<td>Tri-acyl glyceride</td>
<td>29.0</td>
<td>13.8</td>
<td>39.5</td>
<td>1.3</td>
<td>0</td>
</tr>
<tr>
<td>Korean Beef</td>
<td>25.2</td>
<td>9.3</td>
<td>46.5</td>
<td>1.8</td>
<td>0</td>
</tr>
<tr>
<td>UK Beef</td>
<td>26.1</td>
<td>12.2</td>
<td>35.3</td>
<td>1.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Australian Lamb</td>
<td>29.6</td>
<td>28.0</td>
<td>30.9</td>
<td>1.9</td>
<td>0.7</td>
</tr>
<tr>
<td>UK Lamb</td>
<td>21.9</td>
<td>22.6</td>
<td>28.7</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>UK Pork</td>
<td>23.9</td>
<td>12.8</td>
<td>35.8</td>
<td>14.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Kangaroo</td>
<td>18.1</td>
<td>12.7</td>
<td>31.5</td>
<td>4.4</td>
<td>6.6</td>
</tr>
<tr>
<td>Total fat</td>
<td>28.4</td>
<td>47.7</td>
<td>12.7</td>
<td>3.1</td>
<td>24.7</td>
</tr>
<tr>
<td>Japanese Beef</td>
<td>28.4</td>
<td>13.5</td>
<td>44.9</td>
<td>7.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Japanese Pork</td>
<td>16.9</td>
<td>4.2</td>
<td>26.9</td>
<td>2.0</td>
<td>16.4</td>
</tr>
<tr>
<td>Minke Whale</td>
<td>17.3</td>
<td>4.3</td>
<td>12.7</td>
<td>0.6</td>
<td>49.8</td>
</tr>
<tr>
<td>Pacific Cod</td>
<td>19.0</td>
<td>3.3</td>
<td>13.0</td>
<td>2.6</td>
<td>24.7</td>
</tr>
<tr>
<td>Sardine</td>
<td>22.8</td>
<td>6.3</td>
<td>36.5</td>
<td>21.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Chicken (whole)</td>
<td>25.9</td>
<td>9.3</td>
<td>43.9</td>
<td>12.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Duck (whole)</td>
<td>20.6</td>
<td>7.8</td>
<td>31.6</td>
<td>24.7</td>
<td>3.9</td>
</tr>
<tr>
<td>Turkey (whole)</td>
<td>19.6</td>
<td>24.4</td>
<td>30.2</td>
<td>14.5</td>
<td>8.0</td>
</tr>
<tr>
<td>Deer</td>
<td>18.1</td>
<td>11.5</td>
<td>24.8</td>
<td>16.1</td>
<td>8.6</td>
</tr>
</tbody>
</table>

18.5 Beef

Although Pork is the most highly consumed meat in the World, the flavour of beef has been studied more extensively than any other meat flavour. This is probably due to its greater consumer popularity in developed countries. As with all meats, simply put, beef contains taste-active compounds, flavour enhancers and aroma compounds. Although studied widely, since there are not major problems with beef compared with lamb and pork, dietary manipulation of flavour has not been studied as extensively as expected.

As reviewed by MacLeod (1998), sweetness flavour in meat has been associated with glucose, fructose, ribose and several L-amino acids such as glycine, alanine, serine, threonine, lysine, cysteine, methionine, asparagine, glutamine, proline and hydroxyproline. Sourness stems from aspartic acid, glutamic acid, histidine and asparagine, together with succinic, lactic, inosinic, ortho-phosphoric and pyrrolidone carboxylic acids. Saltiness is largely due to the presence of inorganic solvents and the sodium salts of glutamate and aspartate. Bitterness may be derived from hypoxanthine together with anserine, carnosine and other peptides, and also the L-amino acids histidine, arginine, lysine, methionine, valine, leucine, isoleucine, phenylalanine, tryptophan, tyrosine, asparagine and glutamine. The umami taste has a characteristic savoury quality and is supplied by glutamic acid, mono-sodium glutamate (MSG), 5'-inosine monophosphate (IMP), 5'-guanosine monophosphate (GMP) and certain peptides.

As outlined in the introduction, meat flavour is determined by thousands of volatile compounds. Some of the compounds are their odours that have been identified in beef are shown in Figure 18.3 as reviewed by MacLeod (1998). A useful summary of these would be that they are generally cyclic sulphur-containing compounds. While that could be too general, MacLeod (1998) concluded that a high proportion are derived from reactions which result from the effect of heat on sugars and/or amino acids.
Van den Ouweland et al. (1989 cited by MacLeod 1998) proposed that an essential structural requirement for meaty aroma is a 5- or 6-membered ring, which is more or less planar and substituted with an enol, thiol and a methyl group adjacent to the thiol, as exemplified by the compounds shown in Figure 18.4.

When amino acids such as cysteine and methionine are degraded they release hydrogen sulphide which is then involved in further reactions. MacLeod (1998) also summarised the formation of aroma compounds from reactions between ribonucleotides and hydrogen sulphide (Figure 18.5).
In Japan, beef has a long history of attracting premiums for high quality as defined by high levels of marbling (e.g. http://japanesefood.about.com/cs/beefandpork/a/kobebeef.htm) whereas more recent examples in Australia have focussed on tenderness (e.g. http://www.coorongangusbeef.com.au/Content.asp?regID=16445&id=66893). In general, beef from pasture-fed cattle is described as more meaty and beefy than grain-fed where flavour descriptors such as buttery are more common. Corn feeding for at least 90 days prior to slaughter has been associated with a more desirable flavour (Melton 1990) although in many studies it is difficult to separate the effects of increased fatness from change in flavour per se. Compared with grain-fed beef, grass-fed beef has higher levels of saturated and omega-3 polyunsaturated fatty acids (various reports reviewed by Melton 1990). Theunissen et al. (1979) fed steers diets containing 10 or 20% canola oil or high levels of monounsaturated fat but found they failed to deposit much C18:1 (oleic acid) in muscle tissue. In contrast, recent work by our group in Adelaide with both sheep (Siebert et al. 2000) and cattle (Kruk et al. 2005) has shown that diets low in Vitamin A result in increased intramuscular fat, increased oleic acid concentration and associated decreased melting point of fats.
18.6 Sheep meat

In terms of world-wide consumption, sheep meat has the advantage that it is not taboo for any of the major religions. This is in contrast to beef (Hindu) and pork (Jew and Moslem). However, there are two major limitations to developing new markets for sheep meat. The first is the odour which is especially strong during cooking and is offensive to many. In fact, the Chinese even have a specific word ("soo") describing the smell as sweaty or sour (Wong 1975). The second problem is that the subcutaneous fat is highly saturated (Table 18.1) and hence has high melting point, above body temperature (37°C). The result of this is that the fats can solidify in the mouth leaving a fatty feeling which is especially undesirable to those attempting to eat less fat for health reasons. The high melting point of sheep fat is due to very high levels of stearic acid (C18:0).

As stated earlier, phospholipids (structural fats) are likely causes of species specific flavours. However, both problems with sheep meat arise from the subcutaneous (storage) fat. Brennan and Linsay (1982 cited by Young and Braggins 1998) clearly showed that fat was the most significant source of mutton flavours. There are no individual fatty acids which show consistent relationships with sheepmeat flavour characteristics, but clear relationships have been demonstrated between branched chain fatty acids (especially 4-methyloctanoic acid) and sheep meat odour (Young and Braggins 1998). In addition, 4-methylnonanoic and 4-ethyloctanoic acids have been characterised as "goaty" and "muttony".

Many amino acids when ingested by ruminants are degraded by the rumen bacteria. In sheep, this accounts for the high concentrations of 3-methylindole also called skatole formed from tryptophan (Claus et al. 1994). Since excretion of skatole and a number of phenols is incomplete, these can accumulate in the body. They are fat-soluble and so accumulate in storage fat. The fact that they accumulate accounts for stronger odours common from older sheep. In addition, as animals age the lean contains more haem iron, present as myoglobin. During cooking haem iron and iron can act as catalysts of lipid oxidation (Young and Braggins 1998) which could lead to increased concentrations of branched chain fatty acids.

Various diets have been fed to sheep in an attempt to increase consumer acceptance. A number of studies have found that high-energy diets result in fats becoming softer (less saturated and more mono-unsaturated fats). Barley fed lambs have been described as "bland" (Locker 1980) but wheat fed lambs had a "terrible smell" resulting from increased concentration of branched chain fatty acids (Oddy 1980). Oats and lupin have resulted in lamb that was "oilier" and "less meaty" than lamb primarily fed lucerne (Hopkins et al. 1995).

Lamb from the Sisteron region of Province in southern France is claimed to have a distinct flavour resulting from grazing wild lavender, thyme and rosemary (http://www.jacktravel.com/HauteProvence/html/Serre_poncon_Sisteron.htm). In Australia, markets have recently been developed for "salt bush mutton" or "Dija" using sheep from arid-pastoral regions that develop a distinct flavour (http://www.prairiehotel.com.au/plate.htm). There are currently experiments underway in Adelaide and New Zealand with the aim of incorporating flavours from specific herbs. The New Zealand work is focussing on thyme, garlic, coriander, lavender (Young and Braggins 1998).

Breed could also be an issue and the Merino is often regarded has having poor quality meat. This is likely because they are often older to reach the same carcase weight and they are more susceptible to high pH rather than breed differences in flavour per se (Young et al. 1993).

There is a much longer history of attempts to reduce mutton odours in the kitchen. Patents have been granted for cooking in the presence of maltol, ethylmaltool, isomaltool, asparagine, glutamine, alanine or glycine which makes sense since sheep meat is lower in glucose than beef or pork (Young and Braggins 1998).

More traditional methods include Rosemary in the roasting pan. There is good anecdotal evidence that this does reduce mutton odours but the mechanism is not clear. Young and Braggins (1998) suggest that either the antioxidant properties of Rosemary modify the oxidations reactions or the volatiles of Rosemary mask the mutton odour directly. Onion and Garlic are also commonly used.
with lamb and could work through similar mechanisms. Garlic is especially useful since high levels of mutton can be used in smallgoods if accompanied by Garlic (Klettner et al. 1989 cited by Young and Braggins 1998). Young and Braggins (1998) also suggested that Cinnamon may have potential as it is common in Middle Eastern but not Western sheep meat cuisine.

**18.7 Pig meat**

J. Chen and Ho (1998) stated that it is generally accepted that meaty notes in pork primarily come from sulphur-containing compounds such as 2-methyl-3-furanthiol and bis(2-methyl-3-furyl)disulphide, which are generated from water-soluble precursors in lean meat and are thus the same across species. Fat and fat-soluble substances contribute to the species differences but characteristic pork flavour cannot be ascribed to any single compound.

In ruminants, a large proportion of dietary fats are hydrogenated (saturated) in the rumen. However, being monogastrics there exists a real opportunity to alter the flavour of pork through dietary means. Driven by health concerns, there have been a number of studies attempting to alter the fatty acid composition of meat, and more specifically, increase the proportion of n-3 polyunsaturated fatty acids (PUFA). Pasture fed ruminant meats are a relatively good source of n-3 PUFA because of the presence of C18:3 in grass. However, values are much lower in grain-fed ruminants and pigs.

Monogastrics respond well to high quality diets and many sources protein have been tried over the years. Almost 70 years ago, Davies (1939, cited by Melton 1990) concluded that "fishmeal should not be added to swine diets at levels higher than 5% because it imparts a fishy flavour to pork". However, fishy flavour remains an issue for commercial pork. Coxon et al. (1986) also found that feeding fishmeal or fish oil to pigs drastically increased the level of PUFA and they were able to quantify that greater than 0.5% PUFA in bacon resulted in fishy flavours. PUFA are much more susceptible to oxidation than saturated fats and Coxon et al. suggested that oxidation was the cause of the undesirable flavours.

Vitamin E is a powerful antioxidant and inclusion of high levels in diets of pigs, poultry and cattle close to slaughter have resulted in improved flavour and increased shelf life (Jensen et al. 1998).

Many people (especially women) in Australia dislike the flavour of fresh pork meat. Sometimes the flavour is fine and other times it is offensive. A large proportion of pork is marketed as processed meat (e.g. ham, bacon, prosciutto and bratwurst). Thus, it is relatively easy for pork to be transported large distances to market. The result of this is that pork production has focussed on efficiency of production. Large gains have been made but to some extent it has come at the cost of meat quality, especially for fresh meat. Since male animals grow faster and are more feed efficient than castrates or females (gilts), it has become common practice to leave animals entire.

This practice is also common in New Zealand's lamb industry, but carcases are light (around 15kg) and lambs have not reached puberty by the time they have been slaughtered. It is also used in the beef industry where lean meat is required for minced products (http://www.midfield.com.au/bbeef.htm). In Australia, this meat is primarily exported to the USA for the hamburger trade.

Entire males are fine as long as they are slaughtered young. However, if they are slaughtered close to puberty, male hormones (primarily testosterone) are produced. As carcase weight specifications have increased, animals are older at slaughter. In pigs, this leads to the accumulation of androstenedione, indole and skatole (responsible for mutton odour in sheep). Many people find the branched chain fatty acids that form from reactions with these compounds offensive. The fact that it only comes from males explains why sometimes pork tastes great and other times it tastes poor. Do the pig industry a long-term favour and demand pork from gilts or castrates!

**18.8 Poultry**

As outlined by C-W Chen and Ho (1998), compared with beef, chicken has more 2-trans-4-trans-decadienal (described as "fatty") and γ-dodecalactone (tallowy) and less 2-methyl-3-furyl disulphide (meat-like) and methional (cooked potato like).

Compared with chicken, duck meat contains higher concentrations of indole which could be responsible for the specific aroma of duck meat (C-W Chen and Ho 1998). Thialdine is also a possibly
an important flavour contributor to roast duck. C-W Chen and Ho (1998) also stated that a possible desirable flavour contributing compound in turkey is dimethyl disulphide.

Readings
There are no readings for this topic.

Summary
Summary Slides are available on web learning management systems
Hornstein and Wasserman (1987) summarised meat flavour really well as follows:

1. The flavour precursors of lean meats are water soluble;
2. A nonenzymatic reaction between reducing sugars and amino acids may play a role in the development of characteristic lean meat flavour;
3. The similarities in composition of the water-soluble fractions of lean beef, pork and lamb may account for the similarity in flavour of “fat-free” meat from these species;
4. Intact fibrillar and sarcoplasmic protein as such do not contribute to meat flavour;
5. Lipids may contribute to flavour species differences by virtue of their composition and by serving as a reservoir for odouriferous of reactive fat-soluble substances that are characteristic for different animal species.

References
Notes – Lecture 18 – Meat Flavour


Meilgaard, M., Civille, V. and Carr, B.T., 1991 Sensory evaluation techniques. 2nd ed. CRC Press Inc., USA.


