

Meat technology update

99/7 – December 1999
Reprinted November 2006

Beef fat quality

Carcase fat plays an important role in many areas of meat quality. Surface fat prevents rapid chilling of the underlying muscle tissues, thereby reducing the likelihood of cold-shortening and reducing weight loss during chilling.

Fat hardness/softness directly affects efficiency of processing and fat also contributes to the desirable eating attributes of meat. In terms of meat quality, fat quality attributes of colour, hardness and texture are important for certain markets. The quality of fat can markedly affect the carcass value at the wholesale level—particularly that for the Japanese market, which prefers soft white fat.

Yellow fat is perceived by some consumers to be undesirable, as they believe that it is an indication of meat from old or otherwise inferior cattle. However, this is not necessarily so and there is no evidence that fat colour, in its own right, affects the palatability of the cooked product.

Fat hardness

While extended grain feeding improves fat colour and leads to greater product uniformity, in Australia it often leads to an increase in fat hardness. Feedlot cattle, particularly those destined for the Japanese market, are generally large

carcasses greater than 300 to 400 kg. Because of their size and the feeding regime to which they have been subjected, such carcasses commonly have excessive fat thickness and fat that is often very hard when chilled. Although carcass fat of pasture-fed beef may also become hard when chilled, it is not as great a problem as with the carcass fat of grain-fed cattle. In addition, reports from Japan and the US suggest that fat from their cattle seems softer. The Japanese market highly regards fat that is soft, finely textured and with satin-like appearance. Such soft translucent fat, with its relatively low melting temperatures, contributes to desired mouth feel and flavour attributes of the meat when cooked.

The nature of fat on Australian beef carcasses can vary significantly, from very soft and yellow on old cows to very hard and white on long-term grain-fed cattle. Pasture-fed and short-term grain-fed cattle, however, can have hard fat. Hard fat of beef carcasses is a problem confronting the Australian meat industry, having implications in areas of industrial relations, workplace safety—including repetitive strain injuries, abattoir efficiency and meat quality.

Commercial practice requires rapid chilling of carcasses after slaughter, but when carcass fat temperature falls below about 10°C it often becomes relatively hard and is more difficult to cut.

Fat tissue is composed of fat cells embedded in a connective tissue matrix.

About 85% of the fat tissue is made up of triglycerides within fat cells; each triglyceride is made up of three fatty acids in a molecular form. The remainder of the fat tissue is mainly comprised of moisture (~12%) and connective tissue (~3%). Although collagen of various types and degrees of cross-linking is a major structural component of fat tissue and does affect the texture, the hardness of carcass fat at a given temperature is determined mainly by its overall fatty acid composition and by the molecular make-up of the triglycerides. Saturated fatty acids such as palmitic and stearic acids have high melting points (65-70°C) and their presence contributes to hard fat, whereas unsaturated fatty acids such as palmitoleic and oleic acids have low melting points (0-15°C) and confer softness. The overall melting temperature of fat, therefore, will depend largely on the proportion of these individual fatty acids.

Besides the fatty acid and triglyceride composition affecting hardness in its own right, fat structure at the molecular level may change with time of storage at a given temperature. Such changes in triglycerides result from molecular rearrangement of their constituent fatty acids to more stable forms and these changes are associated with hardening of fat. Thus, carcass fat will continue to harden up to a certain point, as it remains in a chiller at a constant temperature. Therefore, apart from some degree of surface drying, which also causes hardening, carcasses chilled for three days are usually more difficult to bone than those chilled for 24 hours.

Subjective measurements of fat hardness

Hardness of fat on a carcass at a given temperature can be assessed using a subjective finger probe method. This is commonly achieved by pressing the subcutaneous fat with a finger. Chilled beef carcasses are often subjectively checked by this method to ensure that they are suitable for boning. In Japan, particularly with the high-grade carcasses, fat is appraised by placing a thumb on the cut surface at the quartering site and assessing the melting

properties of the fat. Such assessment is a component of the *fat colour, lustre and texture* score that affects overall meat quality grade.

Variation of fat composition

As mentioned above, fat hardness of beef carcasses at chiller temperatures is variable. The major components of fat tissue responsible for hardness are the high melting point saturated fatty acids. The amount of stearic acid in fat is quite variable across groups of cattle and a relationship between its content and subjective hardness measurements has been shown. It is likely that this fatty acid plays a key role in determining fat hardness.

The composition of fat tissue in cattle is affected by many factors including breed, sex, diet, weight, age, fatness and environmental effects such as climate and season. However, many of these factors have not been investigated comprehensively. There is evidence that Brahman cattle have softer, more unsaturated fat than that of some other breeds. It has been shown that Brahman-cross cattle, compared to purebred Hereford and various crossbreeds, have softer fat. This has also been shown in a comparison between mature Brahman and Hereford cows. Generally carcass fat becomes more unsaturated with animal age. Subcutaneous fat is likely to be softer when cattle have been sourced from cooler climates. In Australia, grain-feeding, compared to pasture-feeding, often produces harder (more saturated) fat and this differs from many reports from the US that subcutaneous fat becomes more unsaturated with time of grain feeding, although other reports have shown the opposite. Clearly factors such as specific diet, carcass fat thickness, animal age, etc. need to be considered. Feeding of high energy rations to cattle leads to greater fatty acid synthesis in fat tissues and the extent of formation of oleic and other unsaturated fats will depend on specific enzyme activity of that tissue.

Fat in different body locations has different compositions, resulting in fat in deep body

tissues, such as kidney fat, being much harder at chiller temperatures than fat from below the skin.

Some dietary factors affecting fat hardness

Cyclopropenoid fatty acids (sterculic and malvalic acid)

Carcase fat is often harder when cattle have been fed on whole cottonseed. Cottonseed contains significant quantities of cyclopropenoid fatty acids. Although these acids are themselves unsaturated, they have been shown to increase the saturation of the tissue lipid by inhibiting fatty acid desaturation. Cottonseed meals may also contain cyclopropenoic acids but because their fat contents are usually only about one-fifth that of whole cottonseed they are less likely to be a problem.

Branched-chain saturated fatty acids

Branched-chain saturated fatty acids occur widely in ruminant tissues, presumably resulting from formation in the rumen by microbes. These fatty acids have lower melting points (i.e. are softer) than their straight-chain counterparts and are present in some fats at 1-2% of total fatty acids. Specific feeds can influence the proportion of these acids deposited in adipose tissues, e.g. greater proportions of branched-chain fatty acids have been observed in subcutaneous fat of pasture-grazed cattle than in that of grain-fed cattle.

Trans fatty acids

Rumen microbes are also responsible for the formation of partially hydrogenated trans fatty acids from the polyunsaturated fatty acids of the diet. Trans fatty acids behave in a way physiologically similar to saturated acids and also have higher melting points.

Endophyte infection

Endophytic fungus infection of pasture grasses reduces animal performance and causes fat necrosis. This is associated with an increased percentage of stearic and a

lower percentage of palmitoleic and oleic acids in subcutaneous and kidney fat of steers.

Rumen bypass

Ruminants, unlike monogastrics, hydrogenate dietary unsaturated fatty acids in the rumen, so that mainly saturated fatty acids are available for absorption from the gut. However, where fatty acids are protected from hydrogenation or where rumen bypass occurs, unsaturated fatty acids may be absorbed and deposited in fatty tissues producing softer fat. Rumen bypass can occur naturally to a limited extent when coarsely crushed whole seeds or grains are fed to cattle (i.e. escapes rumen hydrogenation by physical protection). Bypass can also occur where the rumen is malfunctioning as in lactic acidosis.

Some years ago, scientists at CSIRO, Division of Animal Production developed a method of modifying fat composition of ruminants. This was achieved by supplementing cattle with treated polyunsaturated fats, which escape the saturation process in the rumen (rumen bypass technology). Such treatment resulted in very significant changes in fat composition. Rumentek Industries Pty Ltd, using primarily mono-unsaturated fats from certain oil seeds, commercialised the procedure. Carcase fat from cattle that were fed this supplement has been shown to be less saturated and therefore softer at chiller temperatures.

Comparison of Japanese and Australian carcase fat composition and hardness

Carcase fat colour, lustre and texture are quality attributes of beef carcase grading for the Japanese meat grading system that contribute to the overall grade of meat quality. Whilst fat colour is largely dependent upon its carotenoid content and can readily be determined subjectively using colour standards, fat lustre and texture are not as easily determined, and which chemical and physical characteristics contribute to these

attributes is not known. These properties of fat are significant in determining overall meat quality and value. Evidence shows that at chiller temperatures fat from Japanese cattle—particularly Wagyu—is markedly softer and has a more lustrous appearance than fat from Australian cattle.

In earlier trials funded by the Meat Research Corporation, fat hardness was assessed subjectively at 4-5 °C and was relatively soft in the samples from Japanese steers and Australian cows, but firm to hard and brittle in most of those from the Australian steers. The total lipid content of fat samples or the connective tissue contents from the various groups did not differ markedly except in the case of the 400 days grain-fed cattle. However, the long-term grain-fed Australian steers had very low connective tissue contents and high lipid contents, probably resulting from the large size of fat cells. The work confirmed that fat from Japanese steers contained more unsaturated fatty acids and was softer than most Australian steer fat samples. Also, pasture-fed steers usually had softer fat than grain-fed cattle and hardness tended to increase with time of grain feeding. Pasture-fed Australian cows had a fatty acid composition similar to that of the Japanese steers.

More recently, subcutaneous and intermuscular fat samples were collected from carcasses of four major breeds of steers in Japan: Wagyu, Wagyu x Angus, Dairy and Murray Grey. For comparison, subcutaneous fat samples from carcasses of long-term grain-fed (350-440 days) Angus, Jersey and Angus x Hereford steers, and short-term grain-fed (70-100 days) Murray Grey steers were collected in Australia. Compared with the Japanese samples, which were soft to very soft when assessed subjectively, samples of Australian fat were generally hard and somewhat fibrous in appearance. Markedly different melting patterns were observed for the Australian and Japanese fat samples. The Japanese fat had considerably less saturated and more unsaturated fatty acids, resulting in much higher unsaturated/saturated ratios compared to the Australian samples. This resulted primarily from the high contents of oleic and palmitoleic acids and the low

content of stearic acid of the Japanese samples.

It was concluded that the fatty acid composition and the triacylglycerol structure of fat plays the predominant role in determining the lustre, texture and properties of fat desired by the Japanese market: the soft character of fat from Japanese cattle results primarily from its low content of stearic acid and consequent lower melting temperature. Fat cell size and the lipid and connective tissue contents of fat appear to be less important.

Fat colour

In healthy cattle, cream/yellow fat colour occurs when cattle graze green pasture. This results from the ingestion and absorption of yellow pigments that are present in plants. These pigments have been identified as carotenoids, with beta-carotene being the major component responsible for fat colour in cattle.

The yellow colour of the carotenoids in green plants is not obvious because their colour is swamped by the large amounts of chlorophyll. However, carotenoids are relatively unstable and as soon as grass appears to have dried, their concentration is much reduced. Most grains contain only small concentrations of carotenoids. This is why fat colour decreases when cattle are fed in feedlots.

Beta-carotene is only a minor component (about 5-8%) of the total carotenoids in plants. However, it is selectively absorbed, accounting for more than 80% of the yellow pigments present in beef fat. It should be stressed that beta-carotene is essential to maintain the health and performance of animals. Cattle grain fed for long periods without supplementation can have low vitamin A and carotenoid reserves, and their growth performance can be reduced.

Presently, the only way of reducing fat colour of grass-fed cattle is to move them to a feedlot and feed them a grain-based (low carotenoid) diet for several months. This produces a satisfactory fat colour in most cattle, but *not all* animals will finish with acceptable fat colour. The eventual fat colour

at the end of the grain-feeding period depends in part on the following factors, as well as days on feed and carotenoid concentrations of the diet:

1. The yellowness of the fat of animals when they enter the feedlot
2. The amount of fat that the animal puts on in the feedlot
3. The rate of utilisation of carotene from body fat.

Breed and nutrition may influence the first factor.

Although there are well known differences in fat colour between certain breeds (Channel Island cattle, e.g. Jersey and Guernsey compared with Holstein/Freisian and beef breeds) colour can only develop if the carotenoid pigments are present in their diet. In addition, there appears to be a large difference between individuals of the same breed, even when they have grazed the same pasture, suggesting that individuals have different abilities to absorb, convert to vitamin A and deposit carotenoids in fatty tissues.

These differences are not as great as those known to occur between cattle and some other ruminant species. Unlike cattle, sheep, goats and buffalo have white fat. Some of the difference may be explained by the greater conversion of dietary beta-carotene to vitamin A (a colourless compound) in the gut wall of sheep, goats and buffalo, thus leaving less intact carotenoid to be deposited. However, it is

likely that other factors play an equally important role, in particular, the specificity of the absorption process in the gut.

Nutritional setback can influence fat colour in cattle, as loss of depot fat results in the colour of the remaining fat becoming more intense. This is particularly so in older cattle that have been on changing planes of nutrition for many years. Factors such as dietary protein and fat intake increase carotenoid absorption, whereas any disease or condition of the gut, such as coccidiosis or acidosis, decreases absorption.

The amount of fat an animal puts on in the feedlot is influenced by its breed, sex, and liveweight (at entry) and its growth rate. Excitable animals or animals that grow slowly for other reasons will not fatten; hence their initial fat colour is less diluted than that of cattle that grow and fatten normally. There appear to be individual animal variations in the rate of utilisation of carotene from fat, even in animals of the same age, breed and sex, growing at the same rate, on the same feed ration. The causes of these variations are not known.

Intensity in fat colour may change during chilling and holding of meat. Chilling may influence fat colour in two ways: firstly, through surface drying (intensifying the colour of the external surface), which takes place immediately after skinning and washing; secondly, by cooling and solidifying the fat, the effect of which is to reduce colour intensity - however, the effect of temperature alone is temporary in that it can be reversed.

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