MEAT TECHNOLOGY – INFORMATION SHEET

Cutting edge technology for the meat processing industry

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Tallow

Tallow is the melted fat from rendered animal bones and soft tissues. Used as a generic term, tallow is simply rendered fat. More specific terms such as beef tallow, mutton tallow, poultry tallow or lard (for pig fat) are used to denote the species of origin.

Tallow consists mainly of triglycerides which are a combination of fatty acids (mainly oleic, palmitic and stearic) and glycerol. The composition of the fatty acid depends on the type of raw material used to prepare the tallow.

The colour of tallow is determined by breed and/or cleanliness of raw materials, with temperature and pressure during processing possibly impacting the bleach. Melting and solidification points are affected by the type of raw material used.

Tallow quality is influenced by 10 factors: free fatty acid, colour, moisture, insoluble impurities, unsaponifiables, titre, iodine value, peroxide value, stability and polyethylene. The relative importance of these measurements in the overall assessment of tallow quality depends on the intended use of the tallow.

Methods for making measurements of tallow quality and where these methods are used are prescribed by the American Oil Chemists' Society. Uniform interpretation of tallow quality can be made by trading partners.

Free fatty acid

Free fatty acid is a measurement of the extent of hydrolysis of triglycerides. The measurement is made by extracting free fatty acids in hot alcohol and titrating with standard alkali. In animal tallows. Free fatty acids are usually expressed as oleic acid.

Free fatty acids are generated by enzymic hydrolis of fats in raw material before rendering takes place. Thus, the measurement can be used as a guide to the freshness of raw material at the time it is rendered.

When the temperature of rendered material reaches about 65°C, enzymic activity stops and hydrolysis of triglycerides ceases. If finished tallow contains moisture and protein, however, bacterial growth can be supported and further hydrolysis and increase in free fatty acid occurs.

Colour

Tallow colour can be measured in the raw state or after the tallow is refined and bleached.

The principal scale for measuring the colour of raw tallow is the FAC scale devised by the Fat Analysis Committee of the American Oil Chemists' Society. To measure FAC colour, tallow is filtered and compared with

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FAC colour standards. The natural colour of tallow is white to light yellow, with colour affected by contamination and lack of care. For example, excessive heat causes redness, blood causes brown colouration, and chlorophyll from grass causes a green tinge.

FAC colour relates directly to the cleanliness of raw material. For example, tallow from fat and bone should produce tallow with FAC colours of 1 to 7 while tallow from well-washed beef gut could have FAC colour of 11A. A tallow colour of more than 21 is indicative of unwashed raw material consisting of a high proportion of gut and a low proportion of fat and bone. The highest colour on the FAC scale is 45.

Refined and bleached colour is measured after free fatty acids have been neutralised, the resulting soaps removed by sedimentation and filtration, and the neutralised fat bleached with a standard bleaching earth. The tallow colour is then compared with a combination of colour standards whereby red, yellow and blue colour standards can be superimposed to match the tallow colour.

Bleached red colour is determined by the amount of pigment in the raw material and the temperature reached during rendering. Producing tallow with high FAC colour and low bleached red colour is possible. This is what happens with wet rendering.

In batch dry rendering, if the raw material contains a lot of unwashed gut, the FAC colour will be high and the bleached colour stands a risk of also being high. If the end-point temperature of the cook can be controlled at below 128°C, the bleached colour should be reasonable - for example, below 2 red, even if the FAC colour is high.

The higher the temperature, the more the pigments will be fixed in the tallow. If the pigments are fixed, they cannot be bleached out and the red colour will be high.

Moisture, insoluble impurities and unsaponifiables

Moisture, insoluble impurities and unsaponifiables are often grouped under the acronym MIU, since the three contribute to the purity of a tallow.

Moisture is determined by measuring the loss of weight on heating a tallow sample at 101°C. The amount of moisture in tallow depends on the efficiency of the washing and clarifying procedures used after rendering.

Insoluble impurities, which are measured by dissolving tallow in a solvent and filtering the fatty solution, are usually finely divided particles of protein, bone and fibre.

Unsaponifiable material is the fatty residue after exhaustive saponification of tallow with potassium hydroxide. Tallow contains naturally occurring unsaponifiable materials such as sterols but may also be contaminated by mineral oils.

Titre

Titre is a measurement of the solidification point of fatty acids in the tallow. Tallow is saponified with potassium hydroxide to extract fatty acids, and the solidification point temperature of the fatty acid is measured when the acids are cooled at a constant rate while being stirred.

Titre reflects the solidification point of a tallow and is related to the species of animals represented in the raw material. Fats from different species produce various titres of tallow:

Poultry	31° - 35°C
Horse	36° - 38°C
Pig	36° - 40°C
Cattle	42° - 45°C
Sheep	45° - 48°C

Iodine value

Iodine value is a measurement of the uptake of iodine by tallow and indicates the degree of unsaturation in the tallow.

Animal fats are highly saturated, and measurements of the degree of unsaturation , such as iodine value, can be used as an alternative to titre as a guide to the relative hardness of a fat. Hard fats such as mutton tallow are highly saturated and have low iodine values.

Peroxide value

Peroxide value is determined by measuring the amount of iodide oxidised to iodine by peroxides and other oxidising agents in tallow, under the specific conditions of the tests. The measurement is used as a guide to the degree of oxidative rancidity in tallow, with lower values being best.

Peroxide value is affected by the amount of naturally occurring anti-oxidant in the tallow and the presence of metal catalysts such as copper.

Stability

The stability of a tallow is its ability to resist oxidation. One measurement of stability is the active oxygen method (AOM). In this test, tallow is aerated under standard conditions and the change in the peroxide value of the tallow is measured at various time intervals. Results are reported as the time required for tallow to reach a peroxide value of 100 milliequivalents per kg. This type of test is empirical but can be used to identify tallow which will oxidise rapidly.

Polyethylene

If raw materials are contaminated with polyethylene, the polyethylene will melt and disperse in the tallow during rendering. Tests to measure polyethylene in tallow involve filtering polyethylene from solutions of tallow in chloroform or similar solvent.

Uses and Relative Values of Tallow

Tallow is used worldwide for edible purposes. Tallows may be used in bakery shortenings, frying oils and margarine manufacture.

Pre-treatments of edible tallows include fractionation into oleo and stearine fractions, neutralisation of free fatty acids, bleaching and deodorisation. Because refining losses and yield for each of these processes are affected by the tallow quality, processors require tallow which gives low losses and high yield of the more valuable fractions of tallow. Edible tallow must also be stable so resulting products have a reliable shelf-life and do not become rancid prematurely.

The important quality characteristics of edible tallow are moisture and impurities, free fatty acid, colour, stability and titre.

Moisture and impurities should be low because they represent a direct refining loss and can generate increases in free fatty acids by supporting bacterial growth.

Free fatty acids are removed from edible tallow by saponification with caustic soda, followed by water washing, to wash out the soluble soaps. In addition to a direct refining loss equivalent to the free fatty acid content of the tallow, some triglycerides could also react with the added caustic soda, causing further losses. Once soaps are formed, they act as emulsifiers and allow some tallow to mix with water and be washed out with the fatty acid soaps. Tallow lost in this way is at least equivalent to the quantity of free fatty acid, with 1% free fatty acid resulting in 2% refining loss. It is not unusual for tallow losses to be three times the free fatty acid level, particularly if the initial free fatty acid level is high.

Tallow used for margarine and shortening is bleached to remove colour. The bleaching earth used to remove colour also absorbs tallow, and tallow losses equivalent to the weight of bleaching earth used are experienced during bleaching. The amount of bleaching earth used relates to the amount of colour in the tallow.

Stability of tallow may not be important if anti-oxidants are added to the finished product. However, if the use of added anti-oxidants is not permitted, the tallow should have good stability.

If a tallow if fractioned into oleo and stearine fractions, the titre can give an indication of the likely yield of each fraction. Low titre tallow will produce more oleo and less stearine fraction.

Another common use of tallow is in soap manufacture. The quality characteristics of soap-grade tallow are similar to edible tallow for many of the same reasons.

Soap-grade tallow is not refined before use and does not suffer the refining losses which occur with edible tallow. However, high free fatty acid levels in soap tallow reduce the recovery of glycerol which is an important by-product of the soap-making industry.

Tallow is bleached before it is used to make soap, with highly coloured tallows requiring extensive bleaching resulting in product loss. If a tallow has residual colour after bleaching, it is not suitable for making the more valuable white toilet soap. Tallow with high bleached colour is used in lower value products such as laundry soaps.

The amount of polyethylene in tallow has particular significance in soap-making. When soap is dried, polyethylene is burnt and produces black specks in the soap. Polyethylene is also hazardous in all types of tallow processing. The danger is that polyethylene may solidify as tallow is cooled and be deposited on equipment and in pipelines and valves.

Other uses for tallow include the production of fatty acid and stock feeds. In fatty acid production, glycerol is a valuable by-product and, as in soap manufacture, glycerol recovery is reduced as the free fatty acid content of the tallow increases. Titre also has some significance in fatty acid production because it relates to the type of fatty acids in the tallow.

Because the value of tallow used as stock feed is less than that for the other major use, lower quality tallow is tolerated. The energy value of tallow used as stock feed can be reduced, however, by diluents such as moisture and insoluble impurities.

Stock feed tallow requires good stability because it may be unpalatable to livestock if it becomes rancid. Stock feed tallow isn’t highly influenced by free fatty acid levels and colour, although tallow with very high free fatty acid levels – in excess of 50% - may be corrosive and may be unpalatable to some animals.

Table 1 summarises the typical quality specifications of different grades of tallow. The price differential between different grades of tallow fluctuates but feed grade tallow is likely to be half the value of edible tallow. Under rules of the American Oils and Fats Association, penalties are imposed if tallow suppliers do not meet contract specifications.

MIU is generally less than 1% for high quality tallows, and less than 2% for lower quality tallows.

TABLE 1 Typical quality specification of different tallow grades.

Tallow Grade	Use	Typical Quality Specifications		
		FFA%	FAC Colour	Bleached Colour
Edible	Edible	0.5	3-5	0.2 Red
Prime	Some edible use after refining	2	11A	0.5 Red
Inedible 1st	Soap	1-2	11B-17	1 Red
2nd	Fatty acid	<4	17-19	1.5 Red
3rd		<5	21-23	1.5 Red
Stock feed		10-20	>23	>2 Red
Stock feed		Over 20	>23	>2 Red

Effect of Processing on Tallow Quality

Raw material storage

The fat portion of raw material for rendering consists of triglyceride with a small proportion of other non-saponifiable lipid such as phospholipid, and sterols. After the death of an animal, triglycerides may be hydrolysed by lipolytic enzymes, resulting in a gradual increase in free fatty acids. Hydrolysis of triglycerides is partly due to enzymes which occur naturally within the animal – for example in the gut – and partly due to the growth of bacteria capable of lypolytic activity.

Increases in free fatty acid in raw materials during storage can be minimised by controlling the growth and spread of bacteria within the raw material mass. To do this, the raw material should be stored in as dry a condition as possible – for example in well-drained storage vessels.

Material such as dead stock and Saveall greases are usually heavily contaminated with bacteria and are a rich source of lipolytic activity. These materials should be kept separate from freshly collected raw materials. Similarly, raw material storage and handling equipment should be cleaned regularly to prevent a build-up of stale material which can seed fresh material with large numbers of bacteria.

As far as possible, raw material should not be cut open or reduced in size before storage. If material is cut, enzymes and bacteria contained within gut material are released and the surface area of material exposed to bacterial contamination is increased.

Preparation of raw material

Coloured pigments contained in paunch and intestinal contents can discolour tallow. To prevent this discolouration, it is necessary to cut open and wash gut materials. Well washed gut material produces tallow with FAC colour of about 11A-17. Unwashed material produces tallow with FAC colour of 19 and above.

Sizing is another important aspect of raw material preparation. Sizing is the process of cutting raw material pieces to a more-or-less uniform size through a hogger, prebreaker or mincer. The benefits of sizing depend on the type of rendering system being used. If raw material pieces are reduced to a uniform size – for example a maximum size of about 100 mm across – the pieces can be cooked more quickly and uniformly during rendering. This reduces the chance of overcooking through use of high temperature or prolonged rendering times, which produces scorched and discoloured tallow and causes small pieces of raw material to disintegrate into fine particles.

In continuous low temperature rendering systems, raw material is minced to a particle size of about 12 mm. Rendering temperatures are below 100°C, rendering times are short and rapid heat transfer is essential. In conventional dry rendering, minced material is likely to produce finely divided particles which are difficult to separate from tallow after rendering.

Rendering techniques

Although wet and dry rendering systems have advantages and disadvantages as far as tallow quality is concerned, wet rendering has the potential to produce a better quality product.

In the traditional wet rendering process, material is boiled by steam injection, and tallow is separated from the wet solids by gravity flotation. The pigments associated with raw materials remain in the water phase and the tallow does not become highly coloured unless particularly dirty raw materials are rendered.

Most of the modern wet rendering systems are continuous, and raw material is rendered by heating for a short time by steam-injection or by steam-heated coils. Tallow is then separated from water and solids in one or two stages of centrifugation. The bleached colour of tallow made by this process is low because tallow is only in contact with the pigments for a short period and the temperature is relatively low. The raw FAC colour of wet rendered tallow may be high if unwashed raw materials are used, but this is not a serious quality defect if the colour can be bleached out easily.

An apparent disadvantage of wet rendering is that natural antioxidants found in animal fats may be washed out in the water phase. The resulting tallow may have poor stability and become oxidised quickly. This quality defect can be overcome by adding antioxidant to the finished tallow.

Tallow produced by dry rendering is likely to be darker and have a higher bleached colour than tallow produced from the same raw material by wet rendering. Typically, dry rendering processes take 1.5 hours or more. During the process, tallow and solids are in contact at temperatures between 100°C and 140°C.

Because pigments cannot be removed in a water phase, the tallow is likely to be discoloured if raw materials are unwashed. At the temperatures used in dry rendering, pigments also tend to become fixed in the tallow and the tallow remains discoloured after bleaching. However, if raw materials are clean and rendered material is not overheated, good quality tallow with low FAC and low bleached colour can be produced by dry rendering.

Tallow separation

The efficiency of separation of tallow from moisture and solids after rendering affects the yield and keeping quality of the tallow.

Tallow is separated from water and solids by gravity settling or centrifugation. In dry rendering, to ease separation, the process requires the addition of 5% - 10% water to ensure that particles of solids suspended in the tallow are fully hydrated. If hydrated solids are not removed from tallow, they can support the growth of bacteria which, in turn, will hydrolyse triglycerides and cause an increase in free fatty acid in the tallow.

For both centrifugal and gravity separation of tallow, the tallow should be 85°-90°C. Sedimentation of solids is retarded at lower temperatures.

Tallow and water should be well mixed to ensure hydration of solids. In gravity settling, sufficient time must be allowed for solids to deposit before tallow is decanted. During this settling time when water, solids and tallow are in contact, there may be an increase in free fatty acids in the tallow, but this can be avoided by keeping settling tanks clean and holding the tallow at above 65°C.

Tallow storage

The main hazards to tallow quality during storage are possible overheating, which can cause an increase in bleached colour, and growth of bacteria, which cause an increase in free fatty acids.

Tallow storage tanks are generally fitted with steam coils for heating purposes. If tallow is allowed to solidify during storage, the tallow in the vicinity of the steam coils may be overheated when the tallow is subsequently melted. Overheating can increase the red colour of the bleached tallow. Overheating of tallow can be avoided if hot water, instead of pressurised steam, is circulated through the coils.

During storage of liquid tallow, solids and moisture continue to settle out and can be drained off regularly. When the tallow is held at more than 65°C, bacterial or enzymic activity does not occur and the tallow should be stable.

If tallow cools below 65°C, bacterial growth in the settled water and solids can result in enzymic activity and increases in free fatty acids. In cases where consecutive additions of tallow to a storage tank are allowed to solidify, there may be several interfaces between added loads of tallow within the tank, with a sediment of water and solids at each interface. Bacterial growth at each interface can cause a dramatic increase in free fatty acid in the stored tallow.