The effect of fat on the eating quality of pork
Ensuring the best eating quality
Ensuring the best flavours
The effect of cooking fat on the eating quality of pork

How to get the best eating quality of pork

DANISH TECHNOLOGICAL INSTITUTE

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The cooking of pork

Ensuring tenderness and juiciness

Cooking meat correctly is essential to ensure the best possible result. But what actually happens to meat during cooking? And how can this explain the differences in eating quality? These questions have been addressed in a number of studies at the Danish Meat Research Institute.
In this article, you can learn how - and why - the right cooking method ensures the best eating quality.

By Margit D. Aaslyng and Camilla Bejerholm, Danish Meat Research Institute

Changes during cooking

Over 70% of meat is actually water, with proteins accounting for nearly 25% and fat around 3%. Most of these proteins are structured around myofibrils or long threads running parallel to one another. Myofibrils mainly consist of two different types of proteins - myosin and actin. They are surrounded by connective tissue, which also consists of proteins. When meat is heated, the proteins start to denature, changing their structure. They shrink and lose the water that was previously bound in the cavities around the myo-fibrils. Different proteins denature at different temperatures. Myosin starts to denature at a temperature of around 40°C (see Figure 1), which means that the meat starts to become tougher than when raw. As the temperature rises, the meat starts to shrink - first transversely, reducing the diameter of the meat and then longitudinally, making the cut of meat shorter. During this process, the open structures in the meat also start to close as the entire cut of meat shrinks.

As the temperature reaches 50°C, water is forced out of the meat. This cooking loss increases almost linearly with the increasing core temperature until around 70°C, at which point the rate of increase starts to decline. The connective tissue proteins start to denature at around 60°C. Initially, the connective tissue hardens, but then it becomes soft in contrast to the myofibrillar proteins. This means that muscles rich in connective tissue and muscles with little connective tissue react differently to the cooking temperature.

Sealing the meat

"Brown the meat in a frying pan and seal in the juices before cooking" has been the traditional advice in cooking meat. But, is it actually possible to seal the meat in this manner? In a study, pork loin steaks were browned in a frying pan at three different temperatures: 150°C, 185°C, and 225°C and were com-pared with steaks that had not been browned. The cooking of the meat was then finished in an oven, and the steaks were weighed at core temperatures of 60°C, 70°C, and 80°C (see text box 1). The results showed that browning had no effect on the cooking loss. Water, which can no longer be bound in the meat due to the protein denaturation, is forced out. It is therefore not necessary to brown the meat to avoid cooking loss, though it does help enhance meat flavour.

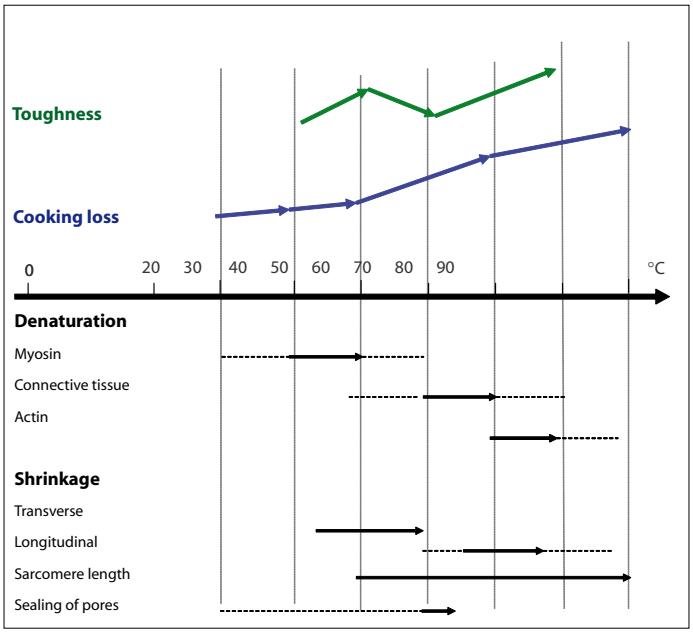
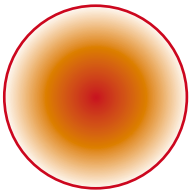
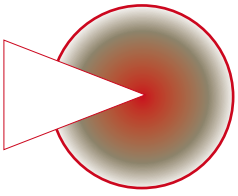


Figure 1. Changes in the meat during cooking. Note how the changes in toughness correlate with denaturation of myosin and connective tissue and with shrinkage of the meat.

Pan-frying temperature:
150°C - moderately hot
180°C - hot
225°C - very hot.



Core temperature:
60°C - red
70°C - light- just changed from rose
80°C - well-done - grey



Text box 1.This text box describes the different pan frying temperatures and the colour of pork at the core temperatures mentioned in the paragraph "Sealing the meat"

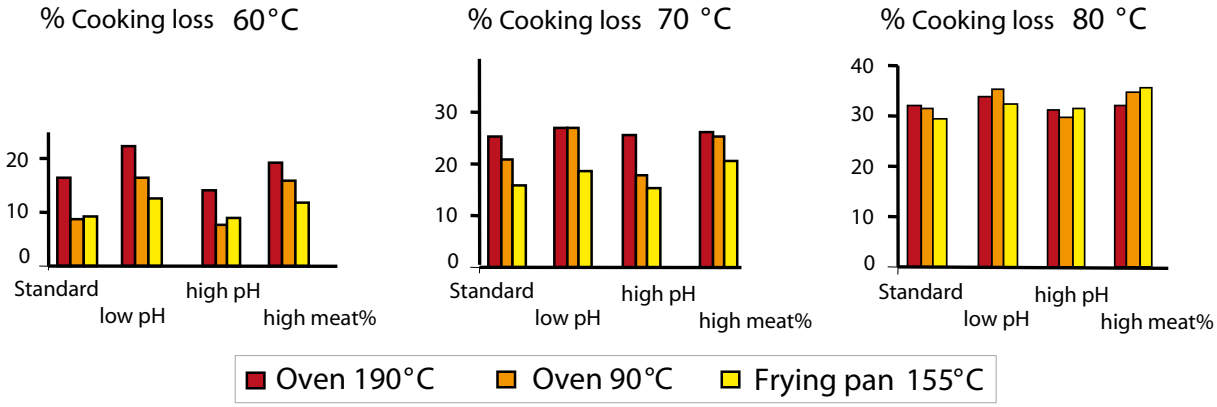


Figure 2. Relationship between cooking loss (pork loin) and raw meat quality, cooking method and core temperature.

Core temperature is important for cooking loss and juiciness

Cooking loss was measured for the different raw meat qualities at different core temperatures. Pork loin without fat was cooked in an oven at high and low temperatures, and pork loin steaks were fried in a pan (see Figure 2). At a core temperature of 60°C, the cooking loss was highest when cooking in an oven at high temperatures. This was possible because it was actually the core temperature that was being measured. It must be assumed that the temperature close to the edge of the roast was higher at the high oven temperature than at the low oven temperature. The proteins in this part of the meat will therefore have denatured to a greater extent and will have forced more water out of the meat. It can also be seen that meat with low pH at this temperature has a higher cooking loss than other kinds of meat. This is because meat with low pH contains more loosely bound water that leaves the meat more rapidly in the form of cooking loss. The longer the meat is cooked, the greater the cooking loss. At the same time, the differences in cooking loss are reduced, being affected by both the cooking method and the quality of the raw meat. At 80°C, the cooking loss is high, irrespective of the raw meat quality and the cooking method used, since both the myofibrillar proteins and the connective tissue have practically finished changing their structure at this temperature. Any water that can actually leave the meat has effectively disappeared at a core temperature of 80°C.

For that reason, the core temperature is the most important parameter in determining cooking loss. How-ever, if the core temperature is not too high, gentle cooking at low oven temperatures will also result in lower cooking loss than cooking at high oven temperatures.

Intensity of tenderness

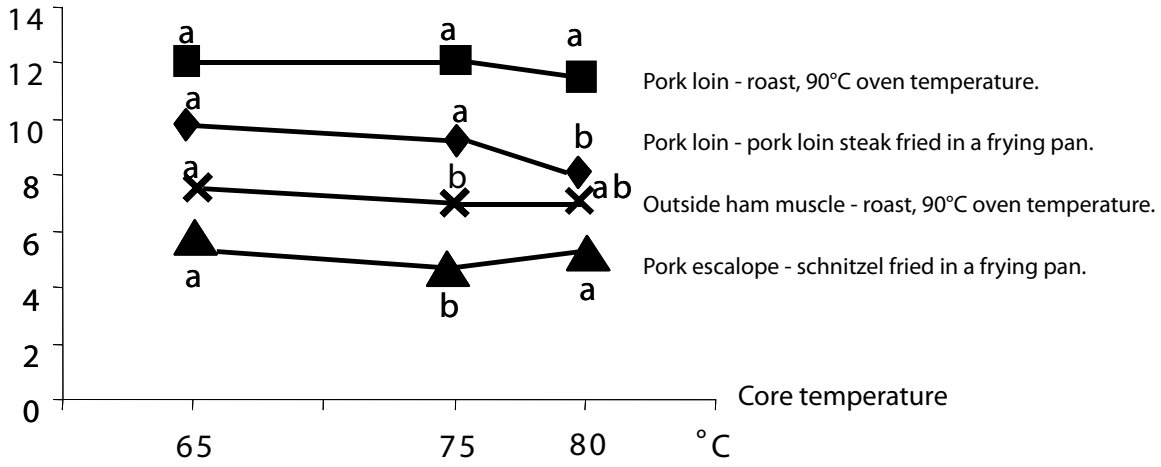


Figure 3. Relationship between tenderness and core temperature according to cooking method and muscle. Different letters indicate that there was a significant difference in the tenderness of the same meat type/cooking dependent on the core temperatures.

The relationship between cooking loss and the juiciness of the meat

Reducing cooking loss is important since it directly affects the juiciness of the meat. Advanced measurements have shown that the degree of juiciness in the meat can largely be explained by the distribution of the water in the meat. The larger the pores in the cooked meat, the juicier the meat will be. When the meat shrinks and forces out the water, the size of the pores changes, and the meat seems less juicy during chewing, even though there is a lot of water left in the meat. The higher the cooking loss, the less juicy the meat will be.

Core temperature and tenderness

Results vary as to the extent to which the tenderness of pork changes with increased core temperatures. The results in Figure 3 show that the tenderness will not change substantially with an increased degree of cooking in the case of a pork loin, a muscle containing relatively little connective tissue, when it is cooked gently in an oven (90°C). However, if pork loin steaks are cooked in a frying pan, they become less tender, though only at very high core temperatures. For a pork escalope, which is relatively rich in connective tissue, the tenderness starts to decrease at even lower levels between 65°C and 75°C, meaning that the connective tissue hardens during this temperature range. This takes place both when the meat is cooked as a roast in an oven or as slices in a frying pan. When the temperature is increased to 80°C, the connective tissue will start to become softer, and the meat will again start to become more tender.

Slow cooking results in lower cooking loss

Although the core temperature is very important, the cooking time is also important. At a fixed core tem-perature (68°C), the cooking loss is significantly lower at a low oven temperature than at a high oven temperature (see Figure 4). This is also reflected in the fact that the meat is more juicy and tender at the low oven temperature. The protein denaturation does not harden the myofibrils or expel as much water during a longer cooking process at a lower temperature.

Slow cooking and a low core temperature

In order to minimise cooking loss and obtain the maximum juiciness and tenderness in the meat, the core temperature is critical. If the core temperature is kept low, this will result in a juicy piece of meat. How-ever, the cooking time is also important. When cooking in an oven, a low oven temperature (90-120°C) is recommended as this will increase both the tenderness and juiciness of the meat.

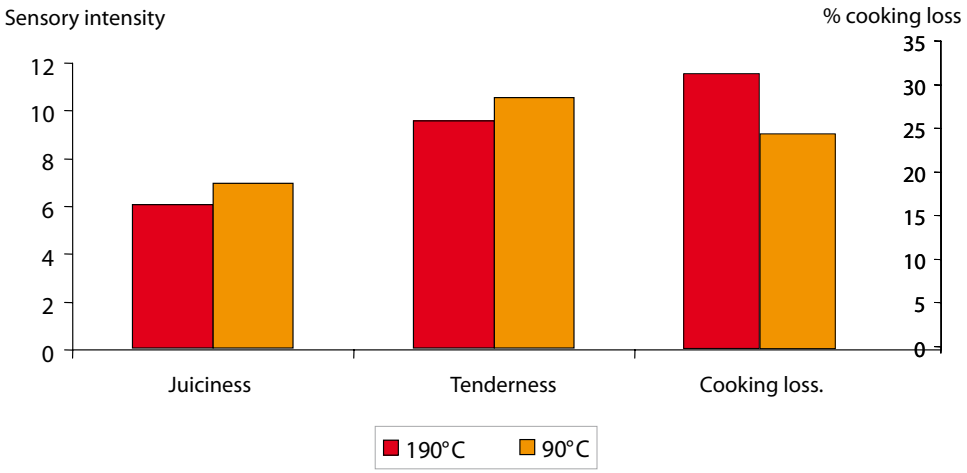


Figure 4. Juiciness, tenderness and cooking loss of pork loin cooked in an oven to a core temperature of 68°C at a high and a low oven temperature (190°C and 90°C), respectively.

The cooking of pork

Ensuring the best flavour

Ideally, pork should have a pleasant 'fried' meat flavour, with no aftertaste. In its raw state, meat has an insipid aroma, and it is only during cooking that molecules are formed to deliver its unique flavour and taste. This article examines how cooking affects the flavour of meat and how to obtain a delicious-tasting product every time.

By Margit D. Aaslyng and Camilla Bejerholm, Danish Meat Research Institute

Flavour is delivered by taste molecules that bind to the tongue and by aroma compounds that are transported from the oral cavity and up into the nose as we eat. The volatile aroma compounds are essential for our ability to perceive the flavour of meat. That is why food is tasteless when we have a cold and our sense of smell is dulled. It has been shown that if we eat meat without these volatile aroma compounds entering the nose, the primary taste sensations are sourness followed by a salt taste. It is vital to understand how these volatile compounds are released when working to improve the flavour of pork. Finally, the oral cavity's perception of temperature (for example, cold,warm or burning), via the trigeminal nerve, is also crucial to understanding our appreciation of flavour.

The complex chemistry of flavour

When meat is heated, a cascade of chemical reactions is set in motion. Amino acids react with carbohydrates, resulting in a 'fried' or 'roasted' meat flavour. The reaction is known as the Maillard reaction, named after Louis Camille Maillard, who discovered it in 1912. It is the same basic reaction that occurs in coffee during roasting and in bread during baking.

The initial reaction does not produce a marked flavour, due to the small number of compounds formed at this early stage. However, as cooking progresses, compounds such as pyrazines, thiophenes and furanones are formed (see Figure 1). The resulting compounds and the amounts formed depend both on the kind of amino acids and carbohydrates present and on other conditions, such as the pH of the meat and, more importantly, the temperature of the heat source. While Maillard reactions can take place at low temperatures, it is only when the temperature exceeds a level of around 120 °C that the reaction rate influences flavour formation. The higher the temperature, the greater the number of different volatile compounds influencing the flavour.

Fatty acids in the meat are another important source of flavour compounds. The unsaturated fatty acids are degraded by oxidation during cooking. The kind of compounds formed depends to a large extent on the kind of fatty acids present in the meat. Many of the unsaturated fatty acids are present in the membranes - the so-called phospholipids - and these are considered to be the most important acids for flavour formation. In cases where the Maillard reactions require high temperatures to contribute to flavour formation, the degradation of fatty acids will start at very low temperatures. The degradation of other compounds in the meat, for example thiamine, can also contribute to the overall taste sensation, al-though more research is needed to understand this process more fully

Group of compounds	General aroma	Approx. threshold value
Pyrazines	Roasted, nutty	ppb-ppm
Thiophenes	Roasted. If the sulphur atom (S) is in the 3rd position, they have a meat aroma. Otherwise an onion aroma	ppb
Furanes/furanones	Roasted, caramel, burnt	ppb-ppm
Aldehydes (from lipid degradation)	Green, fatty, fruity	pb-ppm

Figure 1. Examples of groups of compounds formed during heating of meat

Cooking longer at the same temperature

"It doesn't taste of anything – so let's fry it a bit longer". This is a tempting thought perhaps, but actually prolonged cooking of meat at the same pan temperature does not have much of an effect. As shown in Figure 2, the intensity of the 'fried' meat flavour of pork loin steaks does not increase significantly from a core temperature of 65°C until it reaches 80°C. This is because the volatile flavour compounds formed are the same at the same pan temperature. Prolonged cooking of the meat at the same temperature results in the formation of more of the same kind of compounds rather than other compounds which con-tribute more to a 'fried' meat flavour.

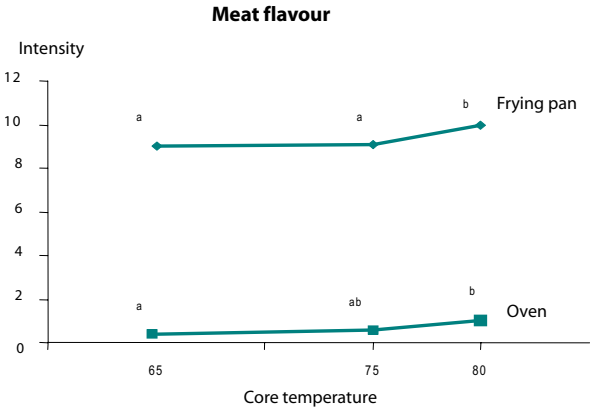


Figure 2. 'Fried' meat flavour of pork loin without fat cooked as pork loin steaks in a frying pan (155°C) or as a roast in an oven (90°C) to three different core temperatures. Different letters indicate a significant difference in cooking loss within the same cooking method.

Temperature is the most important factor when frying

The meat aroma and flavour, which are achieved slowly at moderate pan temperatures, are achieved faster when the pan temperature is increased. As shown in Figure 3, the meat will have an identical 'fried' meat flavour when fried at a high pan temperature (220°C) to a core temperature of 65°C as when it is fried in a moderately hot pan (155°C) to a core temperature of 85°C. However, the meat will rapidly acquire a 'burnt' flavour if it is fried too long at the high temperature. There are two reasons for this. Firstly, the hot frying pan causes the formation of other volatile compounds, and secondly, some of the compounds formed at low temperatures become degraded at high temperatures.

The rate of the Maillard reactions depends on both temperature and water. The higher the water activity, the less the meat will brown. It is therefore recommended that meat is dried off before frying. Studies have shown that it is very important that the pan is hot when the meat is placed in it. Any water on the surface of the meat will evaporate, allowing the Maillard reactions to take place.

The temperature in the oven is also important

Oven temperature also has a significant effect on meat flavour. At an oven temperature of 90°C, the surface of the meat never reaches the temperatures at which the Maillard reaction starts to influence flavour formation. The meat is not browned, and the meat flavour is not as intense. At 140°C, some browning can be achieved and tasted (see Figure 4). If meat is cooked at a low oven temperature, it is a good idea

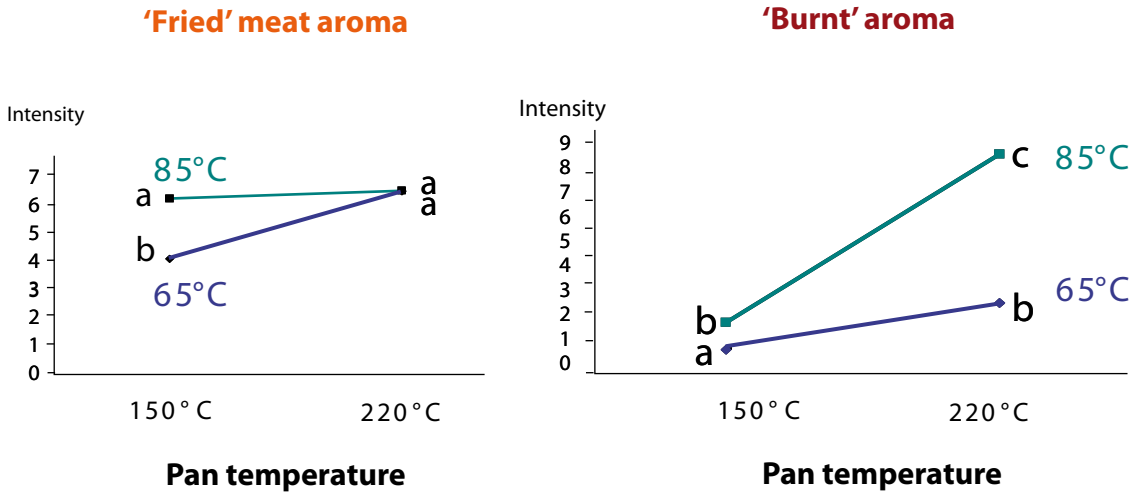


Figure 3. 'Fried' meat aroma and 'burnt' aroma dependent on frying pan and core temperatures. Flavour and aroma followed the same pattern. Different letters indicate a significant difference between the four samples in the same figure.

to brown the meat to achieve the 'fried' meat flavour on the surface. This can be done by browning the roast in a frying pan - either before or after it is placed in the oven. The effect on flavour is greatest when finishing the cooking process by browning the roast. Other meat attributes, such as juiciness and tenderness, are not affected by the browning of the meat.

Cooking method is important for meat colour

The 'brown' colour is dependent on the extent to which a Maillard reaction has taken place and also on the content of flavour precursors in the meat and the frying pan temperature. Another important change in meat colour occurs when the raw red colour turns into a well-done greyish colour. This is caused by denaturation of the myoglobin and by the release of iron from the protein. Denaturation starts around 60°C, with most of the transformation taking place between 60°C and 70°C. If the meat is cooked to a core temperature within this range, small temperature variations will determine how well-done the meat appears. Different muscles can also differ in well-done appearance at the same temperature. If the meat is cooked at a low oven temperature, its temperature will be very similar both at the core and close to the surface. This will therefore result in a uniform red or rose-pink colour across the entire meat when it is sliced. However, at a high oven temperature, the difference in temperature throughout the roast will be greater, and the meat will appear browner close to the surface than at the core.

Key cooking tips

So how do you produce both juicy and great tasting meat? Above all, it is important to stop cooking at the right time. If the core temperature reaches too high a level, the meat becomes dry. It is also important to heat the frying pan well before cooking. When cooking in an oven, low temperatures are recommended, but the roast should also be browned to release the meat flavours. The effect on flavour is greatest if the roast is browned after cooking has been completed.

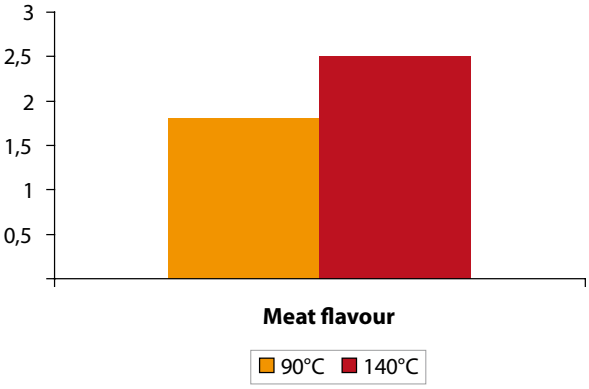


Figure 4. Meat flavour of pork loin roasted at oven temperatures of 90°C and 140°C, respectively.

Fat or lean

The effect of cooking fat on the quality of pork 1

Opinions vary as to the extent to which the level of fat affects the eating quality of pork. The flavour is in the fat, and it is a vital contributor to the juiciness and flavour of pork, which would be dry and tasteless without it. Can consumers really enjoy pork as part of a low-fat diet? Here are some views from some experts at the Danish Meat Research Institute.

By Margit D. Aaslyng and Camilla Bejerholm, Danish Meat Research Institute

Fat is present in meat in several places. There is 'intramuscular' fat, which is embedded in the meat it-self. It consists of two main fractions - membrane fat (phospholipids) located in the membranes of the muscle cells and marbled fat (triglycerides), which consists of strands of fat between the muscle cells. Then there is 'intermuscular' fat between the muscles, and 'subcutaneous' fat, which is located between the muscles and the outer rind. The latter two types constitute by far the largest proportion of fat in meat, though they are also the fats that can be most easily removed by those wishing to reduce their intake of fat.

Intramuscular fat provides the meat with tenderness and flavour

In a pork loin, the fat content in the muscle is between 1% and 2%. The amount of fat in a pork fillet or tenderloin corresponds to the amount of fat in a glass of 0.5% skimmed milk. Although this is a relatively low amount, the marbled fat ensures a pleasant eating experience. Marbled fat improves the tenderness of pork loin steaks, regardless of whether they are cooked to a moderate core temperature of 65°C or to a higher level of 80°C (see Figure 1). Irrespective of their fat content, pork loin steaks are juicy when cooked to 65°C. However, if the core temperature reaches 80°C, the intramuscular fat will increase the juiciness of the meat. This effect occurs in meat containing a reasonable level of marbled fat (1.6% - 2.0%) compared with lower levels (< 1.3%). The increased juiciness occurs, even though there is no difference between these products with regard to cooking loss. There is also a small effect on the 'fried' meat flavour. The intensity is higher in the products with a higher level of marbled fat. However, there is no difference recorded in products with higher levels of intramuscular fat. As regards tenderness, it is important to have as high a level of marbled fat as possible, whereas juiciness and flavour are reduced in meat with lower levels of marbled fat.

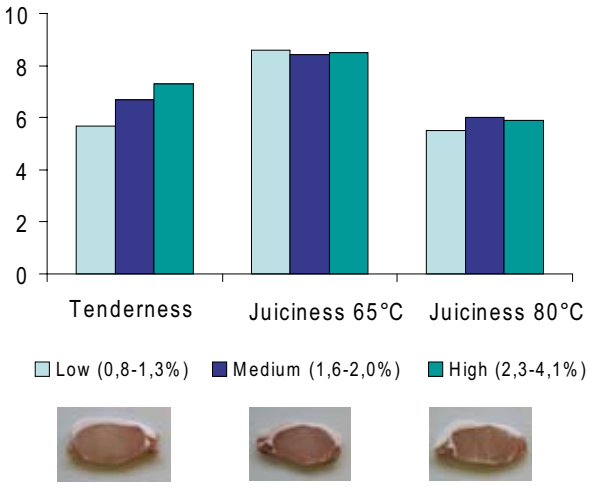


Figure 1. The effect of fat marbling (IMF) on the eating quality of pork loin steaks fried in a frying pan (core temperature 65°C or 80°C respectively, frying pan temperature 155°C, 20 repetitions).

Does the level of visible fat contribute to the flavour and juiciness of pork

No - the eating quality of meat is not affected by cooking with or without the visible fat edge. In tests, steaks were taken from the same cut of pork loin, and a comparison showed no difference in flavour or juiciness, regardless of whether they were cooked with or without the covering fat. However, cooking of standard rib roasts with the fat layer remaining between the muscles, compared with muscles cut and cooked with the fat removed, produced a more 'roast' flavour. In this case, the fat above simply melts down over the meat and deposits flavours on the surface of the meat below.

Fat content in minced pork or pork burgers

Minced meat with a high fat content is often cheaper than the leaner alternative. Many of us like to eat lean meat, and yet there is also a view that meat tastes better if it contains fat. Is this correct and how should this guide our choice of meat?

A comparison between pork burgers made with minced pork with varying fat contents, from either the shoulder (which is often used for minced meat) or from pork loin (with its lower fat content) showed that the level of fat particularly affects the juiciness, softness and crumbliness of these products after cooking. The higher the fat content of the pork mince,

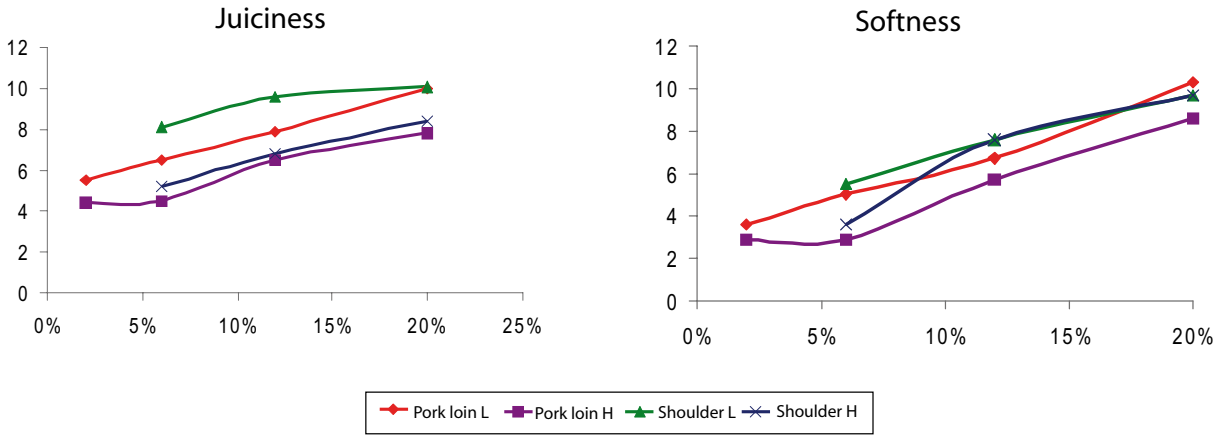


Figure 2. Juiciness and softness of pork burgers with a fat content of between 2% and 20% prepared from minced pork loin and shoulder, cooked to a core temperature of 75°C (L) or 85°C (H) (3 repetitions).

the juicier and softer the resulting pork burgers. However, by lowering the core temperature, you can achieve the same level of juiciness as by using mince with a higher fat content (see Figure 2).

In terms of flavour, it is mainly the 'fatty' flavour, smell and aftertaste which are intensified in meat with a higher fat content.The effect is almost linear: the higher the fat content, the 'fattier' the flavour. At the same time, 'sourish' flavours are reduced, while 'sweeter' and 'porkier' flavours are intensified. However, the differences are not particularly significant. The difference was most pronounced when the fat content was higher, in the range of 6% to 12%, but there was no significant change when the level was increased still further.

Lean and low-fat

It is possible to eat pork as part of a balanced or even low-fat diet if the visible fat, or the outer layer and the fat between the muscles, is removed. Alternatively, it can be an advantage to choose meat with a larger amount of marbled fat. The amount of fat consumed through eating pork is still relatively limited, and the level of marbled fat substantially improves its eating quality. Eating quality is not affected by the visible fat being removed before or after cooking.

Fat or lean

The effect of cooking fat on the quality of pork 2

Opinions vary as to the extent to which cooking fat affects the eating quality of pork. Some people think that meat absorbs cooking fat during the frying process, and there are those who think that it is best to fry in butter. However, what are the facts? And is it possible to eat pork as part of a low-fat diet? These questions have been addressed in a number of studies at the Danish Meat Research Institute.

By Margit D. Aaslyng and Camilla Bejerholm, Danish Meat Research Institute

Although pork itself contains a certain amount of fat, different types of cooking fat are often used for frying. The choice of fat helps determine the flavour of the meat, though it is a common misconception that meat absorbs fat during the cooking process.

Does meat absorb cooking fat or does the fat melt away during the cooking process?

With the fat sizzling, the meat is placed in the pan. When the meat is cooked through, the fat has all but disappeared. It is only natural to think that it has been absorbed by the meat. However, chemical analyses of the fat content in meat before and after cooking show that the fat content in a pork schnitzel increases by around 0.5 g per 100 g raw meat, even when a large amount of cooking fat is used. The percentage increase in the fat content is somewhat greater, due to the cooking loss, which mostly comprises water. Most of the cooking fat that is "absorbed" by the meat forms a thin layer on the surface of the meat.

When fatty meat (for example, high-fat minced pork or fatty cuts such as bacon) is cooked, a distinct fat-melting process takes place. For minced pork patties containing 18% fat, around 2.5 g fat per 100 g raw meat melts away, irrespective of how much cooking fat is used, while for bacon, which can have a cooking loss of up to 70%, 15 g fat per 100 g bacon melts away. The fat that melts away is the intermuscular and subcutaneous fat, i.e. the fat that is not present in the muscle. The intramuscular fat does not melt away, no matter how thoroughly the meat is fried.

There is a perfectly logical explanation for this. Water accounts for around 74% of the weight of the meat muscle. Since water and fat do not readily mix, why would the fat be absorbed by the hydrophilic meat? In fact, the fat really does disappear from the pan – much of it can be wiped away from the cooking top, or it ends up in the cooker hood.

Fatty acid composition changes only in fatty cuts

The melting point of the fatty acids is dependent on their degree of unsaturation. The more unsaturated the fatty acids are, the lower their melting point will be. There is therefore a tendency to believe that the healthy unsaturated fatty acids will be the first to melt away from the meat. Fortunately, however, this is not the case. Analyses have shown that the fatty acid composition of minced pork patties containing 10% fat remains practically unchanged before and after frying, irrespective of the pan temperature. Only the amount of one fatty acid, C18:2 (linoleic acid), changed. However, in pan-fried pork belly, which is a very fatty cut with a high cooking loss, the polyunsaturated fatty acids melt to a greater extent than the monounsaturated fatty acids, while the saturated fatty acids do not change.

Choosing the right type of cooking fat

While some would opt for butter, others would recommend a mixture of butter and oil. A large number of consumers use oil or margarine. But what difference does it actually make?

Cooking fat 1	Cooking fat 2	Difference
Butter-olive oil	Olive oil	Yes
Butter	Margarine	Yes
Rapeseed oil (hot-pressed)	Rapeseed oil (cold-pressed)	Yes*
Rapeseed oil (cold-pressed)	Olive oil (cold-pressed)	No
Rapeseed oil (hot-pressed)	Grapeseed oil (hot-pressed)	No

*P=0.06

Table 1. Comparison of pork chops fried in two different types of cooking fat. The comparison was made by means of a difference test (triangle test).

A comparison of pork chops fried in different types of cooking fat showed that there was a significant difference in the flavour of pork chops fried in butter compared with margarine or a mixture of oil and butter. There was also a slight difference in the flavour of pork chops fried in hot-pressed rapeseed oil compared with cold-pressed rapeseed oil, whereas there was no difference in the flavour of pork chops fried in cold-pressed rapeseed oil compared with olive oil or pork chops fried in hot-pressed rapeseed oil compared with grapeseed oil (see Table 1).

These differences were subsequently described in a sensory profile analysis. The butter primarily imparts a butter flavour, though the meat flavour is also more intense than for the other types of cooking fat. When butter and olive oil are mixed, the butter flavour is reduced, while the meat flavour remains intense. Hot-pressed grapeseed oil imparts an oily flavour, described as "deep-fat fried flavour". Furthermore, the pork chops acquire a more sourish flavour. Margarine imparts the most neutral flavour, since all the flavour attributes are less intense than for the other fats.

Since meat does not absorb cooking fat, it is not necessary to choose the healthiest type of fat. The type of fat you choose to fry your meat in should depend on what you like best, and, in particular, on whether or not you like a butter flavour, since that is the most intense flavour. If you wish to avoid an oily flavour and yet still wish to use oil to cook with, it is recommended to choose cold-pressed oil.

Eating pork as part of a low-fat diet

You can eat pork as part of a low-fat diet. Choose your preferred cooking fat and do not be afraid to use whatever quantity you think is appropriate – very little of it will be absorbed by the meat. Just remember to discard the fat in the pan after frying.

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