# SESSION 5. NUTRITION

## 5 : 1

### EFFECT OF COOKING ON FAT CONTENT OF BEEF AND PORK

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SUMMARY

Retail cuts with fat content of 2 to 40% were studied. The results show a linear relationship between the amount of fat (expressed in g/100 g raw meat) in cooked meat of beef and pork (y) and the amount of fat in raw meat (x) for each of three cooking methods investigated: pan-broiling, roasting in an oven and boiling in water. Only small differences in fat losses between the different cooking methods were obtained. Consequently an overall equation, $y = 0.197 + 0.854x$ ($r = 0.986$) may be used to calculate the fat content after cooking, irrespective of the cooking method. The major part (85-90%) of the fat content was retained in the meat after cooking. However, most of the cooked retail cuts of pork and beef could be trimmed of visible fat to a fat content of only 2-3 g/100 g raw meat, irrespective of the original fat content.

INTRODUCTION

Dietary recommendations to the general public in Sweden include the reduction of dietary fat intake. This requires knowledge of the fat content of foods and dishes and of what people actually consume. So far, calculations of fat consumption originating from meat have been based only on data concerning raw products.

In order to calculate dietary fat intake, knowledge of the fat content of different retail cuts from common animal species and the fat retention after cooking by different methods, and also after trimming off visible fat, is necessary. Previous studies on fat retention after cooking have been concentrated on the effect of different cooking methods (Woolsey and Paul, 1969; Moss et al, 1983; Unklesbay et al, 1983; Berg et al, 1985; Renk et al, 1985) or different fat content such as different marbling classes (Berg et al, 1985; Jones 1985) or different types of fat distribution (Woolsey and Paul, 1969; Jones, 1985; Renk et al, 1985).

The purpose of the present study is to provide general information on the fat retention in different retail cuts of beef and pork after cooking using common cooking methods and also after trimming off visible fat. Factors that may influence the fat retention are fat content, fat distribution and cooking method. Thus, samples of varying fat content were chosen on the basis of fatty tissue distribution and cooked using three different methods.

MATERIALS AND METHODS

Raw meat samples. Retail cuts of pork and beef were chosen according to their fat distribution with fat content in raw tissue ranging from 2 to 40%: (1) intramuscular fat: boneless top loin of pork without backfat, (2) subcutaneous fat: boneless top loin of pork with 8 to 16 mm backfat, (3) intermuscular fat as small depots: boneless rib steak/roast of beef and (4) intermuscular fat as layers of fat: fresh side pork.

Cooking methods. In an initial study, rib steak of beef and pork cutlets (1.5 cm thick) were cooked both with and without frying-fat for 3 min on each side at 165°C: (1) Pan-broiling on a teflon pan without frying fat. (2) Pan-frying on a teflon pan with 3 g of frying fat per steak/cutlet. (3) Pan-frying on a cast-iron pan with 5 g of frying fat per steak/cutlet.

In the main study, all retail cuts were cooked in three different ways: (a) pan-broiling on a teflon pan (without any frying fat ) of 1.5 cm thick steaks, for 3 min on each side at 165°C (final internal temperature 75-86°C), (b) roasting in an oven of roasts of about 1 kg, at 175°C to a final internal temperature of 85°C and (c) boiling in water (with 10 g NaCl/l water) of roasts of about 1 kg to a final internal temperature of 85°C.

A special study was performed on fresh side pork of different slice thicknesses (3, 6, 10 and 15 mm) with a fat content of about 39%. The slices were pan-broiled on a teflon pan (without frying fat), for 3 min on each side at 165°C.

Sample treatment. Pan-broiling: each retail cut was divided into 1.5 cm thick slices where every other slice was analysed raw and every other cooked. Roasting and boiling: retail cuts from one side of the carcass were cooked and the anatomically matched cuts from the opposite side of the carcass were analysed raw. Both raw and cooked samples were weighed and dissected into fatty tissue and lean meat. Each component was then weighed and analysed for fat content.

Analyses. Fat content was determined using the SBR method (Nordic Committee on Food Analysis, 1955). Total weight loss during cooking was determined as the weight difference before and after cooking.

Calculations. The total amount of fat after cooking was calculated as g of fat remaining in the meat after cooking of 100 g of raw meat. The amount of fat after trimming off visible fat was also calculated on the basis of 100 g of raw meat.

Fat retention was calculated as true retention according to Murphy et al. (1975).

Statistical analyses. Student's t-test and regression analysis were used for statistical evaluation of the data.

RESULTS AND DISCUSSION

Cooking with and without frying fat

To evaluate how the addition of frying fat influences the fat retention after cooking, rib steak of beef and pork cutlet were each fried with and without frying fat. The results are shown in table 1.

Results show that neither in rib steak of beef nor in pork cutlet were significant differences in the change of fat, fat retention or total weight loss during cooking with frying fat, compared to without, obtained. Meat has a compact structure and this fact is probably the explanation for the low absorption of fat during pan-broiling.

However, when pork cutlet without backfat (3% raw fat content) was fried with and without frying fat, there was a small but significant difference in the change of fat. With frying fat there was a small uptake of fat (+ 0.6 g/100 g raw meat, data not shown in the table) compared to without frying fat. This small amount of fat absorption could be due to a thin layer of fat formed on the meat surface. Thus the amount of fat after cooking is influenced very little by the addition of frying fat.

Pan-broiling

The results from pan-broiling are shown in table 2.

| Retail cut | Cooking method | N | Amount of fat in raw product (g/100 g) | Total weight loss during cooking (g/100 g raw product) | Amount of fat after cooking (g/100 g raw product) | Change of fat during cooking (g/100 g raw product) | Fat retention (%) |
|---|---|---|---|---|---|---|---|
| Boneless rib steak of beef | Broiling in a teflon pan without frying fat | 5 | $^{a}$ 8.3±3.1 | $^{a}$ 26.7±1.9 | $^{a}$ 8.6±2.3 | $^{a}$ +0.3±1.6 ns | $^{a}$ 108.3±25.1 |
| | Frying in a teflon pan with frying fat | 5 | $^{a}$ 9.0±2.9 | $^{a}$ 28.3±1.2 | $^{a}$ 9.4±3.4 | $^{a}$ +0.4±1.3 ns | $^{a}$ 104.3±11.3 |
| | Frying in a cast-iron pan with frying fat | 5 | $^{a}$ 8.8±2.7 | $^{a}$ 28.4±1.7 | $^{a}$ 8.3±2.0 | $^{a}$ -0.5±1.3 ns | $^{ab}$ 97.3±16.8 |
| Pork cutlet of boneless top loin with approx. 10 mm backfat | Broiling in a teflon pan without frying fat | 23 | $^{b}$ 17.3±4.0 | $^{b}$ 21.8±4.8 | $^{b}$ 15.5±3.6 | $^{b}$ -1.8±2.1*** | $^{b}$ 90.5±12.2 |
| | Frying in a teflon pan with frying fat | 24 | $^{b}$ 18.0±3.7 | $^{b}$ 24.0±2.7 | $^{b}$ 15.9±3.0 | $^{b}$ -2.1±1.9*** | $^{b}$ 89.2±9.2 |

ns = not significant, *** $P < 0.001$
Means in the same column with common superscript letter are not different ($P > 0.05$).

Table 1. Amount of fat and fat retention during cooking with and without frying fat (mean ± standard deviation).

The amount of fat in both raw meat (ranging from 2.7 to 35.2 g/100 g) and cooked meat differed significantly between the various retail cuts. Significant losses of fat during cooking were obtained for all retail cuts except rib steak of beef. For pork there was a higher fat loss with higher fat content in the raw product.

A linear relationship was found between the amount of fat (expressed in g/100 g raw meat) in broiled meat (y) and the amount of fat in raw meat (x). The equation for pan-broiling was $y = 0.295 + 0.859x$ ($r = 0.991$).

The fat losses during pan-broiling were rather small. Most of the fat still remained in the meat after cooking. If, however, all visible fat was trimmed off, the amount of fat in the lean meat was found to be between 1.5 and 2.2 g/100 g raw product, irrespective of the original amount of fat.

Roasting in an oven

The results from roasting in an oven are shown in table 3.

Among the cuts roasted in an oven, rib roast of beef and top loin of pork with 10 mm backfat had the same amount of fat, both raw and after cooking. Top loin of pork without external fat had significantly smaller amounts of fat, and fresh side pork significantly higher than these, both raw and after cooking.

Losses of fat during cooking were obtained for all cuts, although significant only for rib roast of beef. The fat loss of pork loin without external fat was very small. More fat was lost from the other three cuts, with no significant differences between them.

A linear relationship was found between the amount of fat (expressed in g/100 g raw meat) in roasted meat (y) and the amount of fat in raw meat (x). The equation for roasting was $y = -0.188 + 0.841x$ ($r = 0.976$).

The amount fat after trimming off visible fat ranged from 1.6 to 5.4 g/100 g raw product, where rib roast of beef showed the highest fat content.

Boiling in water

The results from boiling in water are shown in table 4.

The amount of fat in both raw meat (ranging from 1.7 to 35.3 g/100 g) and cooked meat differed significantly between the various retail cuts. There was a significant loss of fat during boiling for rib roast of beef and fresh side pork, significantly highest for fresh side pork with the highest amount of fat in raw meat.

A linear relationship was found between the amount of fat (expressed in g/100 g raw meat) in boiled meat (y) and the amount of fat in raw meat (x). The equation for boiling was $y = 0.435 + 0.859x$ ($r = 0.993$).

The amount of fat after trimming off visible fat was very small (1.2-3.4 g/100 g raw product), somewhat higher in rib roast of beef and fresh side pork than in the other two cuts.

All cooking methods

The calculation of % fat retention is a way of making comparisons, irrespective of the fat content of the meat. Fat retentions for all retail cuts and cooking methods are presented in table 5.

Fat retentions ranged from 71.0 to 108.3% with an overall mean of 87.7±14.4%. Regression analysis showed that the fat content of the raw meat (x) influenced the fat retention (y) very little. The equation was $y = 90.214 - 0.141x$ ($r = -0.120$). There was no trend of lower or higher fat retention associable with cooking method or retail cut. Nor were there any differences in fat retention between retail cuts of different fat distribution.

These results are in agreement with Renk et al (1985) who obtained fat retentions of intramuscular fat of 86-110% when broiling and roasting beef and pork from different marbling classes. However, Moss et al (1983) found fat retentions of 111-137% for braised, broiled and roasted lean from retail cuts of pork. The higher fat retentions are probably due to the different fat extraction method used. There was no fat loss from the lean of beef semitendinosus muscle but some fat loss as drip from the same muscle with an external fat cover roasted at two temperatures, 163 and 218°C (Woolsey and Paul, 1969). There was more drip at the

| Retail cut | N | Amount of fat in raw product (g/100 g) | Total weight loss during cooking (g/100 g raw product) | Amount of fat after cooking (g/100 g raw product) | Change of fat during cooking (g/100 g raw product) | Amount of fat after cooking and trimming off visible fat (g/100 g raw product) |
|---|---|---|---|---|---|---|
| Boneless top loin of pork without external fat | 5 | a 2.7±0.5 | ac 27.4±3.3 | a 1.9±0.7 | ac -0.8±0.3* | ab 1.9±0.7 |
| Boneless rib steak of beef | 5 | b 8.3±3.1 | a 26.7±1.9 | b 8.6±2.3 | a +0.3±1.6 ns | ab 2.1±0.5 |
| Boneless top loin of pork with 8 mm backfat | 5 | c 16.4±1.9 | bc 23.3±2.7 | c 13.4±1.6 | b -3.0±0.9** | a 1.5±0.3 |
| Boneless top loin of pork with 16 mm backfat | 5 | d 25.4±2.2 | b 22.1±2.7 | d 22.6±2.6 | bcd -2.8±2.2* | b 2.2±0.6 |
| Fresh side pork | 5 | e 35.2±2.5 | ab 24.1±3.3 | e 30.5±2.3 | d -4.7±1.3** | a 1.5±0.3 |

ns = not significant, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$
Means in the same column with different superscript letters are significantly different ($P < 0.05$).

Table 2. Amount of fat before and after pan-broiling, change of fat and total weight loss during pan-broiling and amount of fat after cooking and trimming off visible fat (mean ± standard deviation).

| Retail cut | N | Amount of fat in raw product (g/100 g) | Total weight loss during cooking (g/100 g raw product) | Amount of fat after cooking (g/100 g raw product) | Change of fat during cooking (g/100 g raw product) | Amount of fat after cooking and trimming off visible fat (g/100 g raw product) |
|---|---|---|---|---|---|---|
| Boneless top loin of pork without external fat | 5 | a 1.8±0.3 | a 40.1±1.7 | a 1.6±0.1 | a -0.2±0.4 ns | a 1.6±0.1 |
| Boneless rib roast of beef | 4 | b 16.6±1.7 | b 36.1±0.6 | b 12.4±1.5 | b -4.2±1.6* | b 5.4±0.3 |
| Boneless top loin of pork with approx. 10 mm backfat | 5 | b 16.8±2.4 | b 35.2±0.9 | b 14.0±1.0 | ab -2.8±2.8 ns | c 2.1±0.1 |
| Fresh side pork | 5 | c 34.6±6.1 | c 24.1±5.0 | c 29.7±5.5 | b -4.9±4.3 ns | d 3.9±0.9 |

ns = not significant, * $P < 0.05$
Means in the same column with different superscript letters are significantly different ($P < 0.05$).

Table 3. Amount of fat before and after roasting in an oven, change of fat and total weight loss during roasting and amount of fat after cooking and trimming off visible fat (mean ± standard deviation).

higher temperature, although the final internal temperature was 58°C in both cases. Pork loins processed by infrared and convective heating methods retained 73 and 69% fat respectively (Unklesbay et al, 1983).

Our data, and data in the literature, thus show that the major part of the fat content is retained in the meat after cooking. Fat exists within fat cells surrounded by connective tissue as small or large depots around or within the muscles. The fat melts and the connective tissue shrinks at these cooking temperatures. An explanation for the low fat loss may be that the fat is retained in cavities in the protein structure of the meat by capillarity. Only fat very near the surface is accessible to drain off during cooking. Then thin slices of meat would have more fat loss than thicker slices. A study of fat loss with reference to thickness of meat slices revealed that the fat loss is proportional to thickness until the slices are 15 mm thick (table 6). At 15 mm thickness the fat retention is the same as for roasts (table 5). The equation for fat retention (y) in proportion to thickness (x) was found to be: $y = 10.055 + 6.975x - 0.124x^2$ ($r = 0.996$) where x is expressed in mm.

When the various cooking methods are compared (tables 2-4) it can be seen that there were variations between 22 and 40% in total weight loss during cooking among the different retail cuts and cooking methods. The comparison of retail cuts shows that a lower fat content results in a higher weight loss during cooking, since the weight loss is mainly water loss. The comparison of cooking methods shows that roasting in an oven and boiling in water tended to give higher weight losses than pan-broiling. This difference is probably due to lower final temperatures in the pan-broiled samples, since cooking losses are known to increase with increasing final temperature of cooking (Renk et al, 1985; Seuss et al, 1986).

However, there were small differences in fat losses between the cooking methods, as can be seen when the different equations are compared. Consequently an overall equation: $y = 0.197 + 0.854x$ ($r = 0.986$) may be used for both beef and pork to calculate the fat content after cooking, irrespective of cooking method. (Figure 1.)
Most fat could be trimmed off as visible fat before eating in all retail cuts of beef and pork. Most of the trimmed meat had a fat content of only 2-3 g/100 g raw meat, irrespective of the original fat content. (Figure 2.)

| Retail cut | N | Amount of fat in raw product (g/100 g) | Total weight loss during cooking (g/100 g raw product) | Amount of fat after cooking (g/100 g raw product) | Change of fat during cooking (g/100 g raw product) | Amount of fat after cooking and trimming off visible fat (g/100 g raw product) |
|---|---|---|---|---|---|---|
| Boneless top loin of pork without external fat | 5 | $^{a}$1.7±0.3 | $^{a}$39.5±1.0 | $^{a}$1.6±0.2 | $^{a}$-0.1±0.2ns | $^{a}$1.6±0.2 |
| Boneless rib roast of beef | 5 | $^{b}$13.1±2.4 | $^{b}$29.1±1.2 | $^{b}$11.6±2.1 | $^{b}$-1.5±0.7* | $^{b}$3.4±0.5 |
| Boneless top loin of pork with approx. 10 mm backfat | 5 | $^{c}$17.1±1.5 | $^{c}$33.0±2.5 | $^{c}$15.8±3.1 | $^{ab}$-1.3±2.5ns | $^{c}$1.2±0.3 |
| Fresh side pork | 6 | $^{d}$35.3±4.4 | $^{d}$22.0±2.2 | $^{d}$30.5±4.2 | $^{c}$-4.8±1.0*** | $^{b}$2.9±0.5 |

ns = not significant, * $P < 0.05$, *** $P < 0.001$
Means in the same column with different superscript letters are significantly different ($P < 0.05$).

Table 4. Amount of fat before and after boiling in water, change of fat and total weight loss during boiling and amount of fat after cooking and trimming off visible fat (mean ± standard deviation).

Table 5. Fat retentions for all retail cuts and cooking methods.

| Retail cut \ Cooking method | Fat retention (%) | | | | | |
|---|---|---|---|---|---|---|
| | Pan-broiling | | Roasting in oven | | Boiling in water | |
| | N | | N | | N | |
| Boneless top loin of pork without external fat | 5 | $^{a}$71.0±14.2 | 5 | $^{abc}$90.4±18.9 | 5 | $^{cdf}$97.3±8.9 |
| Boneless rib steak/roast of beef | 5 | $^{bd}$108.3±25.1 | 4 | $^{a}$75.0±8.5 | 5 | $^{bef}$88.7±4.7 |
| Boneless top loin of pork with approx. 10 mm backfat | 5 | $^{ae}$81.7±5.1 | 5 | $^{abc}$85.0±15.6 | 5 | $^{abc}$92.2±14.9 |
| Boneless top loin of pork with 16 mm backfat | 5 | $^{bef}$89.2±8.0 | - | - | - | - |
| Fresh side pork | 5 | $^{be}$86.7±3.3 | 5 | $^{abc}$86.7±13.3 | 6 | $^{be}$86.3±2.9 |

Means with different superscript letters are significantly different ($P < 0.05$).

| Thickness (mm) | Fat retention (%) | |
|---|---|---|
| | N | |
| 3 | 5 | $30.2^{a}$ ± 1.1 |
| 6 | 5 | $46.8^{b}$ ± 1.6 |
| 10 | 5 | $67.9^{c}$ ± 2.0 |
| 15 | 5 | $86.7^{d}$ ± 3.3 |

Table 6. Fat retention of fresh side pork pan-broiled in slices of different thickness (Mean ± standard deviation).

## CONCLUSIONS

From this investigation it was concluded that:

- Meat absorbs very little fat, if any, during pan-frying.
- The major part (85-90%) of the fat is retained in the meat after cooking, irrespective of cooking method (pan-broiling, roasting in an oven and boiling in water), fat content or fat distribution in raw samples as well.
- Thin slices of meat (< 15 mm) are an exception: Fat retention is proportional to the thickness of the slices. Less fat is retained in thinner slices.
- A general equation $y = 0.197 + 0.854x$ (y = cooked fat content in g/100 g raw meat; x = raw fat content in g/100 g) can be used to calculate the fat content after the cooking of whole meat (thickness of slices ≥ 15 mm) of beef and pork, irrespective of the cooking method.
- Most fat can be trimmed off as visible fat before eating. The lean meat of most retail cuts of beef and pork in Sweden, then, has a fat content of only 2-3 g/100 g raw meat.

In tables of nutritive values of meat the fat content of different retail cuts is expressed as an average. Since there are differences in raw fat content within retail cuts of beef and pork, it is not possible to calculate an exact figure of fat content either before or after cooking. The small differences in fat retention between different cooking methods and retail cuts obtained in this study, are probably less important than the differences of fat content in the raw meat. Thus a general figure of 88% for fat retention after cooking may be used, when calculating the fat consumed during a meat meal.

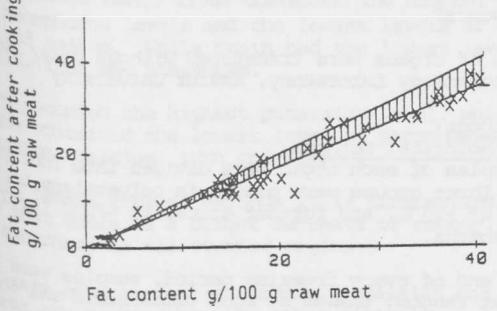


Figure 1. Fat loss during cooking (dashed area) for retail cuts of pork and beef with raw fat content from 2 to 40 g/100 g (n = 65).

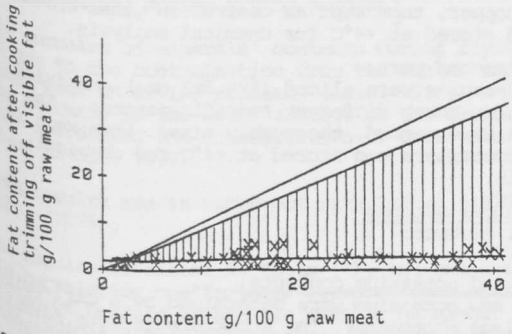


Figure 2. Visible fat (dashed area) that can be trimmed off, before eating, from retail cuts of pork and beef with raw fat content from 2 to 40 g/100 g (n = 65).

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