Quality of vacuum-thawed middles and hams

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Introduction

Experimental work on middles and hams has been carried out using an APV-Torry thawing plant (pilot scale). The aim of the work described in this paper is to determine the quality of vacuum-thawed meat compared to fresh meat and for that reason the following has been studied:
Combined freezing and thawing loss, bacteriological quality, capability of absorbing brine, salt/water ratio, yield, colour and general appearance. Furthermore, the thawing time has been determined. The work on middles includes 10 identical experiments using 2 x 12 middles (total capacity of the pilot plant) and the work on hams includes five identical experiments using 2 x 5 hams.

Methods

One day after slaughter the meat was placed either in a blast freezer or in a chilling room (5°C). Left and right side of the same pig were treated differently. If the left side was frozen, the right side was placed at 5°C as a reference and vice versa. After freezing the core temperature of the middles was approx. -22°C and the core temperature of the hams approx. -28°C (two different freezers were used). Storage time before thawing and processing was three days for middles and five days for hams. After thawing at 10°C the middles were placed in the same chilling room as the references and approx. six hours later they were deboned, cured (19° Be brine) and after approx. one to two weeks' draining sliced as back and streaky bacon and vacuum-packed.

The hams were deboned 1 1/2 hours after thawing. The pure ham muscles were cured with brine (18° Be), massaged for 18 hours, stuffed into casings and cooked as ham rolls. The trimmings of the thawed hams were frozen once more and after re-thawing used for production of a comminuted meat batter with and without phosphate, both types with a reference based on chilled meat. The temperature at thawing was measured using copper/constantan electrodes connected to either a Solartron compact logger 3430 or a Philips multi channel recorder PR 3500. Bacterial counts on middles were made using the swab technique on PCA. The results were read after three days at an incubation temperature of approx. 20°C. Protein analyses were made on Kjel-Foss. Salt/water ratios of bacon were determined one to two months after curing. For the comminuted meat batter the salt/water ratios were determined one to two months after production.

Colour determinations of the vacuum-packed bacon were made using the Elrepho 535 and DMC 25 instruments one to two months after curing. Colour determinations of the ham rolls were made using Elrepho 535 three to eight weeks after production. For the comminuted meat batter this was made using the Hunter L,a,b-method one to two months after production.
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Determination of pigment was made using the modified Hornsey-method (carried out on a few samples, only).

Results and discussion

Thawing time

The thawing time for middles has been found to be approx. eight hours (Table 1). For practical reasons the middles were deboned after six hours but they are ready for deboning after only one to two hours at 5°C.

Table 1 Temperatures during thawing of middles and hams at approx. 10°C

	Temperature °C - middles			Temperature °C - hams		
Thawing time hours	Surface (rind side)	Surface (meat side)	Core	Surface (rind side)	Surface (meat side)	Core
0	-13.5	-16.0	22.0	-18.5	-22.0	-28.3
1	6.0	0.0	- 6.7	6.0	- 0.2	-15.0
2	8.5	3.7	- 3.2	7.8	2.5	- 8.7
3	9.4	6.2	- 2.0	8.5	4.5	- 6.0
4	9.4	8.0	- 1.5	9.0	6.2	- 4.7
5	9.5	8.7	- 1.3	9.1	7.5	- 4.0
6	9.6	9.3	- 1.0	9.3	8.3	- 3.2
7	9.7	9.5	- 0.8	9.5	9.0	- 3.0
8	9.9	9.5	- 0.4	9.6	9.3	- 2.5
9	9.9	9.5	0.5	9.7	9.5	- 2.4
10				9.8	9.7	- 2.3
20				10.1	9.9	- 1.2
21				10.2	10.0	- 1.1
22				10.2	10.0	- 1.0
23				10.5	10.2	- 0.9
24				10.6	10.5	- 0.8
25				10.8	10.8	- 0.5
26				10.8	10.8	- 0.1
27				10.8	10.8	1.5
28				10.8	10.8	3.3

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For hams the thawing time is approx. 25 hours (Table 1). Practical reasons have made it necessary to debone the hams after only 1 1/2 hours at 5°C but in the industry one must calculate with 4-5 hours before deboning can be carried out.

Thawing loss/protein loss

The average of the combined freezing and thawing losses (drip) as well as the protein loss is tabulated in Table 2.

Table 2 Combined freezing and thawing loss/protein loss

	Drip (thawed meat) %	Drip (chilled meat) %	Protein loss (thawed meat) g/kg
Middles	2.3 (s = 0.73)	0.4 (s = 0.35)	4.0 (s = 0.31)
Hams	3.3 (s = 1.21)	1.1 (s = 0.78)	5.5 (s = 0.66)
Ham trimmings (frozen and thawed twice)	6.9 (s = 1.67)		4.1 (s = 0.66)

Weighing of the different cuts after deboning of the hams has shown that the "drip" is not 3.3% for all cuts. The value of 3.3% must be considered as the average of both weight gain and weight loss. Using two assumptions, calculations were made to estimate the distribution of weight gain and/or loss on hams (without bones).

1st assumption: 80% of the total drip of chilled hams is considered to come from the rind with fat and those parts of meat and fat tissue that are cut off as fat trimmings.

2nd assumption: The drip is distributed on these cuts with a percentage of the same magnitude as the one of which the two cuts are related to one another by weight.

From these assumptions and the weighing results it was found that:

- the rind with fat on thawing receives a weight gain of approx. 11%,
- chilled rinds with fat have a weight loss of approx. 3%,
- fat trimmings of thawed hams receive a weight gain of approx. 29%,
- fat trimmings of chilled hams have a weight loss of approx. 4%,
- the pure ham muscles of thawed hams have a weight loss of approx. 10%,
- the pure ham muscles of chilled hams have a weight loss of approx. 0.5%.

Bacteriology

Bacteriological tests on middles before freezing and after thawing have given the following results: The average gain in bacterial counts (bact./cm^2) is found to be approx. 0.63 log units (s - 0.19) on the meat side and approx. 0.04 log units (s - 0.30) on the rind side. This gain must be considered to be without importance if the bacteriological quality is satisfactory at the time of freezing.

Weight gain on curing

Middles: It has been found that thawed middles have obtained an average weight gain after curing and draining of magnitude 15.5% (s = 1.00). The corresponding value for the chilled middles is 12.9% (s = 0.96). It should be stressed that the setting of the multi-needle machine, rest period in brine (20 hours) and the draining period (45 minutes) have been identical for the two types of middles.

The thawed middles thus obtain a weight gain on curing which is 2.6% higher than the weight gain of the chilled middles. This difference may be shown by statistical analysis to be significant at 99% level (***). The draining is not finished after 45 minutes. One to two days later the accumulated weight gain of thawed and chilled middles has decreased 0-0.4%. It is unknown how this draining loss is distributed between thawed and chilled middles but no matter how it will be seen that the curing process compensates for a considerable amount of the thawing loss.

Hams: With identical setting of the multi-needle machine the pure ham muscles obtained the following weight gain:

thawed hams: 15.1% (s = 1.21) and chilled hams: 13.6% (s = 0.61)

As in the case of the middles the difference in weight gain may be shown by statistical analysis to be significant at 99% level (***).

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Yield

The yield of ham rolls based on the weight of hams before freezing or chilling is as follows:

thawed hams : 41.6% (s = 2.42), chilled hams : 46.1% (s = 2.82)

This difference is due to the weight loss of 10% on thawed ham muscles. In this production the ham muscles of both types have been given the same percentage in curing gain but it would undoubtedly be possible to compensate for the loss of water during thawing simply by increasing the percentage of added curing agents. On the other hand, the loss of protein (5.5 g/kg) will remain a problem. Technologically it is possible to add protein from different sources but this would increase the costs and in many countries it is forbidden to use additional protein without changing the name of the product because of legislation.

Colour measurements

Middles: Colour measurements were carried out on back bacon. Using the DMC 25 (CIE system) it was found that the average lightness on chilled backs is 0.45 units higher than the average on thawed backs. Using Elrepho the difference is 0.8 units. Statistically these differences may be shown to be significant at 95% and 99% levels (*) and (***), respectively. In other words, the chilled backs are lighter than the thawed backs. This difference, however, is only just about visible with the naked eye. The intensity of the colour is unaffected by the thawing process. It has been shown that chilled backs are slightly more red in colour than thawed backs (the difference between the averages in dominant wavelengths is 1.71 nm). This difference is significant at 99% level (***).

As a supplement to the colour measurements a few determinations of the pigment content have been made. Chilled backs contain 2.32 mg pigment/kg more than thawed backs which might explain the more red colour of the chilled backs. The average percentage conversion of pigment to nitrosopigment is 3.3% higher in thawed backs than in chilled backs. This is probably due to a better (more uniform) salt distribution in the thawed backs caused by a looser meat structure.

The theory that thawed backs have a looser structure seems to be confirmed by the darker colour, since lightness to a great extent is determined by the depth from which the light is reflected and not only by the content of the pigment. Approx. 8 mg pigment/kg corresponds to one reflection unit using Elrepho, and the difference in pigment content would therefore only give rise to a difference in lightness of magnitude 0.47 - in reality this is 0.8.

The more uniform salt distribution in the thawed bacon is confirmed by visual judgment resulting in the following findings:

needle marks in thawed bacon : 18.5% (s = 10.0), backs with a non-uniform salt distribution :7.4% (s = 6.5)

needle marks in chilled bacon: 49.1% (s = 20.6), backs with a non-uniform salt distribution : 57.4% (s = 24.1)

The difference in curing quality is significant at 97.5% level (**) for needle marks and at 99% level (***) for a non-uniform salt distribution.

Hams: The lightness of the produced rolls is measured on Elrepho 535 and the rolls prepared from chilled ham muscles have an average value for lightness 1.21 units higher than the corresponding value for rolls prepared from thawed ham muscles, indicating that chilled muscles are lighter than thawed ones. This is confirmed by statistical analysis showing significance at 99% level (***). An examination of percentage conversion of pigment to nitrosopigment shows no difference between rolls prepared from thawed or chilled hams. The above mentioned difference in lightness is therefore considered to depend on a difference in meat structure, only.

Salt/water ratio - middles

The average salt/water ratio in thawed backs has been found to be 7.9 (s = 0.13) and 7.1 (s = 0.38) for chilled backs. Both values are too high (the permitted value in a normal bacon production is 5.5) due to the fact that the samples have been analysed two to three months after production (normally seven days after production) and because the sampling technique has differed from normal procedure. The results can therefore only be used to compare chilled and thawed bacon. The higher salt/water ratio in thawed backs is due to the higher weight gain on curing and is confirmed by statistical analysis of the differences - significance at 99% level (***).

Analyses of the water content show a difference of magnitude 0.3% (highest in chilled bacon). This difference was not statistically significant.

Fat and jelly cook-out

The fat and jelly cook-out from the comminuted meat batter has been studied giving the following results:

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Type		Cook -out %	s
Chilled meat	without phosphate	8.5	4.30
Chilled meat	with phosphate	7.0	3.77
Thawed meat	without phosphate	7.9	2.06
Thawed meat	with phosphate	4.8	0.92

It is noticed that the s-value of the results from the comminuted meat batter based on thawed meat is smaller than the s-value from the one based on chilled meat.

Statistical analyses of the differences in cook-out percentage between comminuted meat batter based on thawed and chilled meat show significance at 97.5% level (**) for the one without phosphate and significance at 99% level (***) for the one with phosphate.

Consequently, it is expected that the thawing process does affect the cook-out, but unfortunately it is not possible to tell whether the cook-out percentage will be higher or lower than the one for chilled meat. Statistical analyses show an interaction between experiment and type of meat used, but the meat quality factor causing this has not been found in these investigations.

Analyses of the comminuted meat batter

The average contents of salt, water, protein and fat is tabulated in Table 3.

Table 3 Analyses of the comminuted meat batter

Comminuted meat batter based on	Salt		Water		Protein		Fat	
	%	(s)	%	(s)	%	(s)	%	(s)
Thawed meat + phosphate	2.57	(0.07)	56.7	(1.40)	9.6	(0.45)	30.6	(2.77)
Thawed meat	2.52	(0.04)	56.5	(1.68)	9.7	(0.43)	31.0	(1.82)
Chilled meat + phosphate	2.50	(0.05)	54.7	(2.31)	9.3	(0.25)	33.2	(2.44)
Chilled meat	2.54	(0.04)	53.8	(1.63)	9.3	(0.43)	33.8	(2.70)

It should be noted that the water content in the comminuted meat batter based on thawed meat is higher than in the one based on chilled meat in spite of the drip loss. This is due to the fact that the fat used in the production during thawing has obtained a weight gain by absorbing water. The higher water content is altering the percentage of protein and fat, as can be seen from the Table.

Use of thawed meat and fat trimmings necessitates therefore analyses of the actual water, fat and protein contents.

Conclusion

Vacuum heat thawing is a fast thawing process giving rise to both increase and decrease of quality depending on the type of meat which is to be thawed.

Thawing time for middles (starting temperature -22°C) is approx. eight hours. The middles are ready for deboning after approx. one to two hours at 5°C. Thawing time for hams (starting temperature - 28°C) is approx. 25 hours. The hams are ready for deboning after approx. four to five hours at 5°C.

The combined freezing and thawing loss of middles is 2.3% (s = 0.73) and the protein loss is 0.4% (s = 0.31). The average loss for hams is 3.3% (s = 1.21) but this is considered to be composed of a weight gain on rind with fat of magnitude 11%, a weight gain on fat trimmings of magnitude 29% and a weight loss on the pure ham muscles of magnitude 10%. The protein loss of hams is 5.5 g/kg. Refreezing and thawing of trimmings cause a weight loss of approx. 6.9% and a protein loss of 4.1 g/kg.

In the case of middles the drip loss is not critical since it is possible to compensate during the curing process (less salt should be used in the brine) and the protein loss is of minor importance.

In the case of hams it is possible to compensate for the loss of water but here the protein loss is an important quality deteriorating factor.

In the production of comminuted meat batter based on thawed trimmings the changed water, protein and fat percentages should be taken into consideration.

The colour of thawed meat is darker than of chilled meat but the difference is of minor importance.

The thawing process in the case of middles is a quality increasing factor regarding the general appearance of the sliced bacon. This is partly due to a better salt distribution giving a more uniform colour and partly to the observation that less needle marks can be seen in the final rashers.

The bacteriological quality of meat thawed by this method has shown to be satisfactory.