Abstract:
The invention provides a method of post mortem treatment of units offish flesh, which method comprises injecting into said units from 50 to 250 mL/kg of an aqueous solution of a physiologically tolerable base and sodium chloride, the concentration of said base being 0.05 to 0.35N and that of sodium chloride being 5 to 30% by weight.
Method of salting fish

This invention relates to improvements in and relating to the salting offish, and to fish meat prepared thereby and cooked meals prepared therefrom.

Salting, i.e. treatment with sodium chloride, is one of the oldest known ways of preserving fish or the meat of other animals for subsequent consumption. Typically this is done by embedding whole fish or meat taken from fish, e.g. fillets, in salt or by injecting aqueous solutions of salt into the flesh.

In general, salting of fish by injection must be done after the flesh has passed through the stage of rigor mortis, i.e. a delay which may be inconvenient or expensive is required. Saline solution if injected before rigor has passed is inadequately retained by the flesh.

Besides serving to preserve the flesh, salting can increase the yield, that is to say the weight of the flesh after storage. More specifically, salting reduces weight loss and may even achieve a weight increase. Clearly yield enhancement is of interest to the producer of fish products for consumption.

We have now surprisingly found that yield may be further enhanced by injection of the flesh with a base in conjunction with salting. Moreover we have surprisingly found that treatment with a base enhances the colour of the flesh and its sensory properties on cooking. Still more surprisingly we have found that if a base is injected, the flesh may be salted by injection before rigor has passed, e.g. pre-rigor or during rigor. Yet more surprisingly we have found that different sections of the fish benefit from different such treatments.

Thus viewed from one aspect the invention provides a method of post mortem treatment of units of fish flesh, which method comprises injecting into said units from 50 to 250 mL/kg of an aqueous solution of a physiologically tolerable base and
sodium chloride, the concentration of said base being 0.05 to 0.35 N and that of sodium chloride being 5 to 30% by weight.

Base and salt injection may be sequential or simultaneous. Simultaneous injection using a solution containing both the base and the sodium chloride is preferred. If injection is separate then the specified base and sodium chloride concentrations and injection volumes are for the combined dose.

The injection solution used is preferably essentially free of organic compounds, for example thickeners, proteins, protein hydrolysates, and amino acids. Moreover it is also preferably essentially free of phosphates.

By physiologically tolerable, it is meant that the base is not toxic to humans or animals that may subsequently consume the flesh units, optionally after cooking or other preparation. While many bases may be used, particular mention may be made of sodium and potassium hydroxides, bicarbonates and carbonates, especially bicarbonates and carbonates, particularly bicarbonates. The use of hydroxides alone is not preferred. The use of bases with sodium counterions is particularly preferred.

The base will preferably be at a concentration sufficiently low as to avoid the necessity of soaking the flesh to remove the base before consumption and indeed the flesh units prepared according to the invention will generally be consumed with little or no soaking, e.g. with less than 15 minutes soaking, in any aqueous liquid which is discarded before cooking. In general, the base solution is preferably less than 0.7 N, especially less than 0.65 N, particularly less than 0.5 N, especially 0.05 to 0.35 N, for example 0.10 to 0.33 N, more especially 0.15 to 0.33 N, more particularly 0.2 to 0.3 N. If the base used is sodium bicarbonate, the concentration in the injection solution is preferably 5 to 30 g/L, especially 10 to 27 g/L, particularly 15 to 26 g/L, more particularly 20 to 25 g/L.
Salt (sodium chloride) will preferably be injected at a concentration of 5 to 30% wt, more especially 10 to 30% wt, particularly 15 to 25% wt. Salt may additionally be applied topically in solid form.

The total sodium concentration in the injection solution is preferably up to about 4 M, e.g. 0.5 to 3.5 M, particularly 2 to 3 M.

Quite surprisingly, treatment by injection was found to be more effective with skin-bearing fillets if injection was through the skin rather than through the exposed flesh.

Thus viewed from a further aspect the invention provides a method of treatment of skin-bearing fish fillets, by injection of an aqueous treatment solution at a dosage of from 50 to 250 mL/kg, wherein said solution is injected through the skin on said skin-bearing fillets and wherein said aqueous solution contains sodium chloride at from 15 to 30% by weight and a physiologically tolerable base in dissolved form at a concentration of 0.05 to 0.35N.

If desired, the added sodium content in the treated products may be reduced by partial replacement, e.g. 1 to 20 mole % replacement, of sodium by potassium. Thus for example the injection solution might contain: NaCl and NaHCO₃; NaCl and KHCO₃; NaCl, KCl and NaHCO₃; or NaCl, KCl and KHCO₃. In general however, sodium replacement by potassium is not generally preferred in the method of the invention.

Typical fish that can be treated according to the invention include: salmon (and other salmonids such as trout); cod; coalfish; monk fish; mackerel; and herring. The treatment is especially suited to fish the meat of which is not white, especially coalfish, as treatment results in a more attractive or lighter colour. Surprisingly, for fish with pink flesh such as salmon, the treatment appears to enhance the colour, albeit only to a minor extent. The treatment is also particularly suitable for fish the
meat of which is tough when cooked or overcooked, e.g. monkfish, as a softer texture is obtained on cooking.

The softer texture on cooking, and a reduced loss in volume, is especially noticeable when the base is a carbonate or more especially a bicarbonate.

The volume of solution injected into flesh in the methods of the invention is 50 to 250 mL/kg, preferably 65 to 200, particularly 70 to 160.

Quite surprisingly, for fish, the preferred base for use according to the invention varies according to the origin within the fish of the meat being treated, with hydroxide bases being preferred for tougher belly fillets and bicarbonate bases being preferred for tail fillets, in both cases due to the reduction of volume and weight losses on cooking. If a single treatment solution is being used for all fish fillets, it will preferably contain both hydroxide and bicarbonate bases.

Moreover, while it is generally preferred to use concentrations of sodium bicarbonate towards the higher end of the ranges specified herein for salmonids and towards the middle of the range for fish with white or off-white flesh (e.g. cod and coalfish), it is preferred to use salt (sodium chloride) concentrations towards the higher end of the ranges specified for loin and towards the lower end for tail and, more especially, belly, e.g. 5 to 10% by weight.

Where salt and bicarbonate solutions are used according to the invention, it has been found that the pH of the treated tissue is generally about 6.6.

The flesh units treated according to the methods of the invention form a further aspect of the invention. Viewed from this aspect the invention provides an uncooked, optionally packaged and optionally smoked, fish flesh unit produced according to a method according to the invention. Viewed from a further aspect the invention provides a ready-prepared meal comprising an optionally cooked, optionally packaged fish flesh unit produced according to a method according to the
invention together with further food components, e.g. sauces, vegetables and the like. Packaging is preferably in air-tight plastics containers, e.g. using vacuum packaging.

The method of the invention may be effected on flesh pre-rigor, during rigor or post rigor, and pre- or post-freezing, and, if desired pre-smoking.

Embodiments of the invention will now be described with reference to the following non-limiting Examples and the accompanying drawings, in which:

Figure 1 is a graph showing weight change after 24 hours from injection;
Figure 2 is a graph showing weight change of cod fillets 12 hours after injection;
Figure 3 is a graph showing weight change after 24 hours from injection;
Figure 4 is a graph showing perceived firmness of cooked coalfish;
Figure 5 is a graph showing perceived saltiness of cooked coalfish;
Figure 6 is a graph showing perceived preference for cooked coalfish;
Figures 7a, 7b and 7c are graphs showing weight loss after cooking for treated coalfish filets from belly, loin (i.e. back), and tail respectively;
Figures 8a, 8b and 8c are graphs showing volume loss after cooking for treated coalfish filets from belly, loin (i.e. back), and tail respectively; and
Figure 9 is a graph showing weight change after injection and 24 hours storage for coalfish filets.

Example 1
Post-rigor treatment with: water; salt; sodium bicarbonate; and salt and sodium carbonate

Fillets of cod (28) and coalfish (6) were injected with solutions A to D. After injection, the fillets were placed on ice in sealed plastic bags. The mean fillet weight before injection, after injection and 24 hours after injection was set out in Table 1 below and shown in Figure 1.

Table 1

<table>
<thead>
<tr>
<th>Injection solution</th>
<th>Fish</th>
<th>Wt. before injection(g)</th>
<th>% wt. change after injection</th>
<th>% wt. change 24h after injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cod</td>
<td>603</td>
<td>7.0</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>Cod</td>
<td>584</td>
<td>8.9</td>
<td>4.9</td>
</tr>
<tr>
<td>C</td>
<td>Cod</td>
<td>551</td>
<td>9.7</td>
<td>4.2</td>
</tr>
<tr>
<td>D</td>
<td>Cod</td>
<td>544</td>
<td>8.9</td>
<td>6.2</td>
</tr>
<tr>
<td>C</td>
<td>Coalfish</td>
<td>293</td>
<td>11.9</td>
<td>6.2</td>
</tr>
</tbody>
</table>

A = spring water  
B = 5% wt NaCl in spring water  
C = 25g/L NaHCO₃ in spring water  
D = 5% wt NaCl and 25g/L NaHCO₃ in spring water

Example 2  
Treatment pre-rigor

Farmed cod of average weight 4kg was filleted within 2 hours of slaughtering and injected with solutions B and D (see Example 1). The fillets were sealed in plastic bags and stored on ice in a refrigerated room (6°C). Fillet length and weight were recorded before and after injection and 12 hours post injection. The fillets were also photographed to record their appearance. The results after 12 hours are set out in Figure 2 and Table 2.

Table 2
The injected fillets had a nice appearance with no unwanted tissue rupturing. After 12 hours both salt- and salt-and-NaHCCV treated fillets showed a length decrease of about 19%. As can be seen, pre-rigor injection with salt alone results in weight loss while with salt and bicarbonate a slight weight gain was recorded.

**Example 3**

Treatment post-rigor with NaHCO$_3$ and 0, 5 and 15% wt NaCl.

Coalfish was filleted and 18 fillets each were injected with solutions E, F, G, H, I, and J at 6°C. After injection the fillets were left to drip for 5 minutes on a tilted surface, packed into plastic bags and stored for 8 days on ice. The fillet weight was recorded before injection (average 614g), after injection and 24 hours after injection. The results are set out in Table 3 and Figure 3.

**Table 3**

<table>
<thead>
<tr>
<th>Solution</th>
<th>% wt. change after injection</th>
<th>% wt change after 24 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>7.7</td>
<td>0.8</td>
</tr>
<tr>
<td>F</td>
<td>7.7</td>
<td>3.0</td>
</tr>
<tr>
<td>G</td>
<td>7.5</td>
<td>3.2</td>
</tr>
<tr>
<td>H</td>
<td>8.8</td>
<td>5.2</td>
</tr>
<tr>
<td>I</td>
<td>8.9</td>
<td>5.4</td>
</tr>
<tr>
<td>J</td>
<td>7.9</td>
<td>5.8</td>
</tr>
</tbody>
</table>

E - spring water  
F - 15 g/L NaHC$_3$ in spring water  
G - 5% wt NaCl in spring water  
H - 5% wt NaCl and 15 g/L NaHCO$_3$ in spring water  
I - 15% wt NaCl in spring water  
J - 15% wt NaCl and 15 g/L NaHCO$_3$ in spring water
The fillets were cut into pieces and baked in a conventional oven at about 72°C core temperature. The fillets were weighed before and after baking. The weight loss on baking was 16% for fillets injected with NaCl and NaHCO₃ and 24% for fillets injected with NaCl alone. Colour analysis showed the cooked fillets treated with NaCl and NaHCO₃ were significantly lighter than those treated with NaCl alone.

The baked fillets were assessed by a panel of 14 consumers and rated from 1 (poor) to 5 (extremely acceptable). The fillets treated with NaCl and NaHCO₃ scored 4.0 while those treated with NaCl alone scored 2.2. Figures 4 to 6 show the ratings from the test panel for firmness and saltiness and the percentages of testers ranking fillets having particular treatments as their favourite.

The fillets treated with sodium bicarbonate were judged to have whiter colour and better texture and were generally preferred over the fillets injected only with saline.

Example 4
Treatment of salmon

Fillets of farmed salmon were injected pre-rigor with an aqueous solution containing 25 g/L sodium bicarbonate and 0, 5, 10, 15, 20 and 25 %wt. sodium chloride. A proportion of the injected fillets were subsequently dry (surface) salted. The bacterial count of the bicarbonate injected fillets was surprisingly lower than that for controls. Quite surprisingly, there was also a slight darkening, i.e. improvement, of the red flesh colour. The yield (weight gain/retention) was highest for bicarbonate plus 15-25 %wt salt. Adding 25 g/L sodium bicarbonate to NaCl solutions with concentrations > 15% increased the salt uptake in the salmon fillets by 15% for fillets injected only, and by 20-30% for fillets injected and subsequently dry salted. Hence, the results showed that sodium bicarbonate facilitates salt uptake in pre-rigor salmon fillets when the salt concentration is above a certain level.
Example 5
Treatment and cooking of belly, loin and tail filets of coalfish

Filets of coalfish from the tail, belly and loin were injected with the injection solutions set out in Table 4, stored for 24 hours and subjected to a simulated cooking treatment at 80°C. Weight was recorded before injection, after 24 hours and after cooking. Volume was recorded before and after cooking. The results are set out in Figures 7, 8 and 9. In these Figures, the columns from left to right respectively are for treatment with solutions M, N, O and, the control, P. As can be seen, the reaction on heat treatment of the treated tail and belly filets was quite different showing bicarbonate treatment of tail filet to be preferred over hydroxide treatment and the reverse for belly filet,

<table>
<thead>
<tr>
<th>Solution</th>
<th>g/L NaCl</th>
<th>g/L KCl</th>
<th>g/L NaOH</th>
<th>g/L NaHCO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>150</td>
<td>0</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>L</td>
<td>139</td>
<td>9</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>M</td>
<td>150</td>
<td>0</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>N</td>
<td>150</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Example 6
Comparison with greater volume, lower salt injection

Fresh samples of Atlantic cod were injected, then frozen at -20°C for two days, thawed and fried for 4 minutes. Frozen samples of Atlantic cod were thawed, injected, refrozen at -20°C for two days, thawed and fried for 4 minutes. Injection according to the invention involved injection of 110 - 125 mL/kg of an aqueous solution containing 10% by weight NaCl and 15g/L N-1HCO₃. Untreated frozen Atlantic cod was also thawed and cooked analogously. Injection according to the comparison involved injection of 520mL/kg of an aqueous solution containing 1.36% by weight NaCl and 7.75g/L NaHCCb. The weight increase after injection,
and the weight losses on thawing and cooking were measured and the cooked fish was sampled by a panel of consumers. The results are set out in Table 5 below. As can be seen, the fish treated according to the invention outperformed both untreated fish and fish treated with the comparison treatment.

Table 5

<table>
<thead>
<tr>
<th></th>
<th>Fresh</th>
<th>Frozen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Invention</td>
<td>Comparison</td>
</tr>
<tr>
<td>Weight increase after injection, %</td>
<td>7.2</td>
<td>9.2</td>
</tr>
<tr>
<td>Thaw loss, %*</td>
<td>1.2</td>
<td>8.4</td>
</tr>
<tr>
<td>Cooking loss, %**</td>
<td>4.0</td>
<td>8.6</td>
</tr>
<tr>
<td>Comments on thawed flesh</td>
<td>Good cohesiveness, Not wet</td>
<td>Cohesiveness OK, but a bit jelly-like</td>
</tr>
<tr>
<td>Comments on cooked flesh</td>
<td>Good cohesiveness, nice appearance</td>
<td>Adequate cohesiveness, nice appearance</td>
</tr>
<tr>
<td>Consumer response on cooked flesh regarding smell</td>
<td>Best smell</td>
<td>Adequate</td>
</tr>
</tbody>
</table>

* Calculated from weight of frozen fish
** Calculated from thawed weight
Claims

1. A method of post mortem treatment of units of fish flesh, which method comprises injecting into said units from 50 to 250 mL/kg of an aqueous solution of a physiologically tolerable base and sodium chloride, the concentration of said base being 0.05 to 0.35N and that of sodium chloride being 5 to 30% by weight.

2. A method of treatment of skin-bearing fish fillets by injection of an aqueous treatment solution, wherein said solution is injected at a dosage of from 50 to 250 mL/kg through the skin on said skin-bearing fillets and wherein said aqueous solution contains sodium chloride at from 5 to 30% by weight and a physiologically tolerable base in dissolved form at a concentration of 0.05 to 0.35N.

3. A method as claimed in either of claims 1 and 2 wherein the fish is coalfish.

4. A method as claimed in either of claims 1 and 2 wherein the fish is monkfish.

5. A method as claimed in either of claims 1 and 2 wherein the fish is a salmonid.

6. A method as claimed in any one of claims 1 to 5 wherein the base is a bicarbonate.

7. A method as claimed in claim 6 wherein said units are fish tail filets.

8. A method as claimed in any one of claims 1 to 5 wherein the base is a hydroxide.

9. A method as claimed in claim 8 wherein said units are fish belly filets.
10. A method as claimed in any one of claims 1 to 9 wherein said base comprises sodium bicarbonate and/or sodium hydroxide.

11. A method as claimed in any one of the preceding claims wherein said base is sodium bicarbonate administered at a concentration of 10 to 27g/L.

12. A method as claimed in any one of the preceding claims wherein sodium chloride is administered at a concentration of 15 to 25% by weight.

13. A method as claimed in any one of claims 1 to 11 wherein said unit is of belly and sodium chloride is administered at a concentration of 5 to 10% by weight.

14. A method as claimed in any one of the preceding claims wherein said base and sodium chloride are administered as at least two solutions of different compositions, whereby the total volume administered would if combined have a volume and composition as specified in said preceding claims.

15. An uncooked, optionally packaged and optionally smoked, fish flesh unit produced according to a method as claimed in any one of claims 1 to 14.

16. A ready-prepared meal comprising an optionally cooked, optionally packaged animal fish unit produced according to a method as claimed in any one of claims 1 to 14 together with further food components.
FIGURE 3

FIGURE 4
FIGURE 8a

Volume reduction during heat treatment

FIGURE 8b

Volume reduction during heat treatment

FIGURE 8c

Volume reduction during heat treatment
FIGURE 9