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Fish freshness at retail level

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A study was conducted in the UCD Institute of Food and Health (September 2015 - March 2016 inclusive) on the freshness of fish on sale at retail level. The objectives were fourfold: (i) conduct mini survey on temperatures prevailing in ice counters and retail chill cabinets in 12 retail stores; (ii) assess effect of temperature abuse (severe and mild) on TVBN values of ice counter fish; (iii) assess freshness of a range of fish species (ice counter and pre-packs) from eight retail stores; (iv) disseminate outcomes to end-users.

Test procedure: The total volatile base nitrogen (TVBN) test was used to estimate freshness of fish purchased from ice counters and as chilled pre-packs in eight retail stores in Dublin. TVBN measures the nitrogenous compounds (includes ammonia, dimethylamine, trimethylene) formed as fish spoil (Fagan et al. 2003). A review by Etienne (2005) of the TVBN and related tests is available at file:///C:/Users/PC/Documents/LAURA%20Tobin/TVBN%20REVIEW%20SeaFoodPlus.pdf

Samples (100g) were blended (1min) with trichloroacetic acid (200ml; 7.5% v/v), centrifuged (1210G; 5min), filtered, and 25ml of the filtrate was basicified (5ml 2.5M NaOH), and steam distilled into 15ml of 4% aqueous boric acid (w/v) (Tashiros indicator). Samples were titrated (0.02M H_2SO_4) and TVBN (mgN/100g fish) calculated as n x 16.8 (n = ml H_2SO_4). Commission Regulation (EC) No. 1022/2008 specifies a TVBN limit of <35mgN/100g fish for a number of species while industry opinion is that <15mgN/100g represents fresh fish and >35mgN/100g stale fish. A colour coding system was used for different TVBN ranges (mgN/100g fish) to improve ease of reading of the results tables as follows:

0-15 = blue (very fresh)
16-25 = dark green (fresh)
26-35 = black (still OK)
>35 = red (stale)

It is important to note when reading Tables 3-11 that TVBN values may vary to an extent for different species, e.g. a value circa 20 for some species may equate to a similar level of freshness in other species with a TVBN value circa 30mgN/100gfish.

RESULTS AND OUTCOMES

1. Ice counters and chilled retail cabinets

Ice counters were well maintained with ample ice thereby ensuring fish at 0ºC. Fish appearance was satisfactory except in two stores where fish appeared tired/desiccated. Skin packs were by far the most used form of packing followed by modified atmosphere air packs. Temperature displays in retail chill cabinets ranged 1.5 to 2.5ºC which is ideal for fish pre-packs. Shelf lives on some fish pre-packs were too long; this was confirmed by TVBN values (see below).

2. Number of fish samples tested

In excess of 100 fish samples were tested in nine trials. Twenty seven samples were purchased from ice-counters in different stores (Table 1) and 22 samples were pre-packs. Forty eight samples were tested in nine trials. In the case of three of these trials, which included two 5-day trials (Trials 2 and 3) an additional 51 sub-samples were also tested. Over 20 samples were tested in preliminary trials when addressing teething issues in the test method. A breakdown of samples by store/species including origin i.e. ice counter or pre-packs (skin pack, modified atmosphere, air) is presented in Tables 1 and 2

Table 1: Breakdown of sample numbers[1] tested by store & by ice counter/pre-packs

		Type of pack			
Store	**Ice counter**	**Skin**	**MAP**	**Air**	**Total**
A	4	4	1	0	**9**
B	2	9	0	0	**11**
C	0	0	0	4	**4**
D	3	0	0	0	**3**
E	4	1	0	0	**5**
F	0	2	1	0	**3**
G	1	0	0	0	**1**
H	13	0	0	0	**13**
Total	**27**	**16**	**2**	**4**	**49**

[1]13 of the ice counter samples were bulk samples and 51 additional sub-samples were tested arising from these

Skin packs were by far the most used form of pre-packing followed by modified atmosphere (MA) (used mostly for salmon darnes) and packing in air on trays covered with cling film (Table 1). A total of

12 species was tested with salmon, cod and hake predominating (Table 2).

Table 2: Breakdown of sample numbers tested by species

Species	**Number of samples**
Salmon	12
Cod	8
Hake	7
Haddock	5
Mackerel	4
Whiting	3
Ray wing	2
Pangasius	2
Bass	2
Plaice	2
Monk	1
Sea trout	1
Total	**49**

3. Severe temperature abuse (Trial 1)

This was conducted to see how the TVBN test responded to different levels of fish abuse. Severe abuse was achieved by storing hake samples at 4-5ºC for 0, 24 and 72h followed by 96, 72 and 24h at plus 20ºC i.e. all samples were stored for 96h. A frozen (-20ºC) sample was used as control. The results showed that the TVBN test responded well to the different regimes (Table 3).

Table 3: TVBN (mgN/100g fish) values for samples of hake from the ice counter in store H subjected to different temperature storage conditions **(TRIAL 1)**

Sub-sample	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**TVBN**
1	20°C	20°C	20°C	20°C	**75.6**
2	4-5ºC	20ºC	20ºC	20ºC	**72.2**
3	4-5ºC	4-5ºC	4-5ºC	20ºC	**43.7**
4	-20ºC	-20ºC	-20ºC	-20ºC	**19.3**

4. Mild temperature abuse (Trials 2 and 3)

Two trials were conducted on fish (8 species) purchased from retailer ice counters on a Monday and stored at 4-5ºC for 0, 24, 48, 72 and 96h with TVBN testing each day. This equated to mild temperature abuse and mimicked consumers who bought fish from the ice counter on Monday and held it in the household fridge until

cooking and consuming on Friday (day 4). The TVBN results showed that fish should be cooked/eaten on day of purchase (day 0) or the day after (day 1) (Tables 4 and 5). If not, the fish should be frozen until required. Salmon darnes performed differently from a salmon side (Table 4). TVBN values for haddock samples fell during the storage period from a high of 42.0 (day 0) to 29.4mgN/100g fish (day 4) (Table 4). A possible reason for this unexpected finding is that bacterial action may have reduced the content of nitrogenous compounds. TVBN values for pangasius fillets remained consistently low over the test period indicating that this species may not produce nitrogenous compounds to the same extent as other species during storage (Table 4). Ray wing samples had low TVBN values for 24h but soared thereafter in both trials (Tables 4 and 5). TVBN values for mackerel remained low for 48h but rose dramatically thereafter (Table 5). This was as expected as mackerel is a short shelf life species.

Table 4: TVBN (mg N/100g fish) values for fish samples from stores E&D ice counters tested on day of purchase & daily thereafter for 4 days during storage at 4-5ºC **(Trial 2)**

Sample/store	Day 0	Day 1	Day 2	Day 3	Day 4
Cod loins/E	11.8	11.8	15.1	42	56.3
Salmon darnes/E	22.7	23.5	23.5	27.7	33.6
Haddock fillets/E	42.0	33.6	31.1	32.8	29.4
Ray wing/D	10.1	13.4	33.6	50.4	107.5
Pangasius fillets/D	9.2	9.2	10.9	13.4	13.4
Salmon side/D	21.8	21.8	21.8	22.7	23.5

Table 5:TVBN (mg N/100g fish) values for fish samples from stores H&A ice counters tested on day of purchase & daily thereafter for 4 days during storage at 4-5ºC **(Trial 3)**

Sample/store	Day 0	Day 1	Day 2	Day 3	Day 4
Salmon fillet/H	20.2	21.8	22.7	31.1	53.8
Cod fillet/H	12.6	15.9	15.1	37.0	87.4
Hake fillet/H	12.6	15.1	19.3	38.6	84
Bass fillets/A	21.0	23.5	24.4	30.2	62.1
Mackerel fillets/A	12.1	16	21.0	38.6	85.7
Ray wing/A	15.1	16.8	40.3	57.1	198.2

5. Tests on a range of pre-packed and ice-counter samples (Trials 4-9)

Table 6: TVBN values (mgN/100g fish) for fish samples tested on their use-by-date (UBD) **(Trial 4)**

Sample	Store	Pack	Days at 4-5ºC	Tested	TVBN
Salmon fillet	B	SP[1]	5	UBD	**21.8**
Salmon darne	A	SP	5	UBD	**31.9**
Salmon darne	C	AIR	3	UBD	**32.8**
Hake fillet	B	SP	3	UBD	**20.2**
Hake fillet	C	AIR	2	UBD	**23.5**
Plaice fillet	E	SP	3	UBD	**37.8**
Comment: Salmon and hake fillets had low TVBN values but values for salmon darnes suggested they were near the end of their shelf life. The plaice fillet was stale based on the TVBN value. All samples were tested on their UBD having been stored at 4-5ºC in a household fridge for 2-5 days.					

[1]Skin pack (vacuum)

Table 7: TVBN values (mgN/100g fish) for fish samples tested on or before their use-by-date (UBD) **(Trial 5)**

Sample	Store	Pack/IC	Days at 4-5ºC	Tested	TVBN
Salmon darne	A	MAP[1]	4	UBD	**58.8**
Cod fillet	A	SP[2]	4	UBD	**228.5**
Hake portion	C	AIR	3	UBD	**40.3**
Haddock fillet	H	IC[3]	2	---	**37.0**
Whiting fillet	H	IC	2	---	**41.2**
Sea trout fillet	H	IC	2	---	**44.5**
Comment: All samples were stale and the cod fillet had a very high TVBN value. The high values suggest that fish supply may have been minimal due to bad weather and that fish may have been sourced from abroad resulting in a longer time in refrigeration. All pre-packed fish were tested on their UBD and the ice counter samples after 2 days at 4-5ºC in a household fridge.					

[1]Modified atmosphere pack
[2]Skin pack (vacuum)
[3]Ice counter

Table 8: TVBN values (mgN/100g fish) for fish samples tested on or before their use-by-date (UBD) **(Trial 6)**

Sample	Store	Pack/IC	Days at 4-5ºC	Tested	TVBN
Salmon darne	A	SP[1]	5	UBD	**75.6**
Hake fillet	B	SP	5	UBD	**28.6**
Mackerel fillet	B	SP	3	UBD	**102.5**
Cod fillet	B	SP	1	-6d	**23.5**
Salmon fillet	F	SP	5	-2d	**58.8**
Cod fillet	E	IC[2]	1	---	**26.9**
Comment: Only 3 samples were in the fresh category. The others were stale or very stale. This even applied to the salmon fillet which was tested 2 days (-2d) before its UBD. The salmon darne had a high TVBN value suggesting it may have been re-introduced to the ice counter (due to not selling) on successive days. The very high TVBN value for the mackerel fillet suggested that the shelf life on the skin pack was too long for this short shelf life species. All samples were held in a household fridge at 4-5ºC for 1-5 days.					

[1]Skin pack (vacuum)
[2]Ice counter

Table 9: TVBN values (mgN/100g fish) for fish samples tested on or before their use-by-date (UBD) **(Trial 7)**

Sample	Store	Pack/IC	Days at 4-5ºC	Tested	TVBN
Cod fillet	A	SP[1]	3	UBD	**268.8**
Plaice fillet	B	SP	3	-1d	**15.1**
Salmon darne	C	AIR	2	UBD	**40.3**
Mackerel fillet	B	SP	1	-5d	**38.6**
Haddock fillet	F	SP	0	-3d	**23.5**
Haddock fillet	G	IC[2]	0	---	**33.6**
Comment: Only the plaice and haddock fillet skin pack samples were in the fresh category while the cod sample was virtually rotten. The TVBN value for the mackerel sample was very high considering the sample was tested 5 days (-5d) before its USB and suggests that the on-pack shelf life was much too long. The haddock sample from the ice counter was nearing the end of its shelf life even though it was tested on day of purchase.					

[1]Skin pack (vacuum)
[2]Ice counter

Table 10: TVBN values (mgN/100g fish) for fish samples tested on day of purchase **(Trial 8)**

Sample	Store	Ice counter	Days at 4-5°C	TVBN
Monk fillet	H	IC	0	**21.8**
Salmon darne	H	IC	0	**37.0**
Cod fillet	H	IC	0	**40.3**
Bass fillet	H	IC	0	**25.2**
Whiting fillet	H	IC	0	**55.4**
Haddock fillet	H	IC	0	**30.2**
Comment: Monk and bass fillets were in the fresh category while the haddock was nearing the end of its shelf life. The other three samples were stale which is surprising in view of the fact that they were tested on day of purchase and suggests that they may have been re-introduced to the ice counter on successive days.				

Table 11**:** TVBN values (mgN/100g fish) for fish samples tested on or before their use-by-date (UBD) **(Trial 9)**

Sample	Store	Pack/IC	Days at 4-5°C	Tested	TVBN
Hake fillet	B	SP[1]	2	-5d	**11.8**
Mackerel fillet	B	SP	2	-3d	**25.2**
Salmon darne	F	MAP[2]	0	-3d	**20.2**
Cod fillet	B	IC[3]	1	---	**21.8**
Pangasius fillet	A	IC	2	---	**11.8**
Whiting fillet	B	IC	1	---	**14.3**
Comment: This was the best sample set tested in that all samples were in the very fresh or fresh categories. This was as expected for the pre-packed samples were as they were tested before their UBD. The ice counter samples were tested after 1-2 days at 4-5ºC. The pangasius sample had the lowest TVBN value suggesting again that this species may produce only small amounts of volatile amines (see Trial 2; Table 4).					

[1]Skin pack (vacuum)
[2]Modified atmosphere pack
[3]Ice counter

6. Summary of Trials 4-9

Over 40% of the fish samples tested were in the stale category (Table 12). This suggests that on-pack shelf life to use-by-dates for pre-packs is too long for some species, e.g. mackerel. The high level of staleness in ice counter samples (42.9%) may reflect fish that is being re-introduced to the ice counter for a second or third day following no sale on the previous day/days. Other contributory factors include (i) shortness of fish supply due to bad weather i.e. trawlers can't fish and fish may have to be sourced from abroad, (ii) trawlers at sea for extended periods, and (iii) poor storage practices for fish in the chill chain prior to reaching the retailer.

Table 12: Summary for Trials 4-9 (Tables 5-11): percentage of samples in different TVBN categories:

TVBN (mgN/100g fish)	Pre-packs (22 samples)[1]	Ice counter (14 samples)[2]	Overall (36 samples)
0-15	9.1	14.3	11.1
16-25	31.8	21.4	27.8
26-35	13.6	21.4	16.7
>35	45.5	42.9	44.4

[1]Samples tested on or before their use-by-date
[2]Twelve sample were tested on day of purchase; one (whiting fillet) after 24h and one (pangasius) after 48h at 2-4ºC

7. Summary of data (Trials 2-9) on a retail store basis

Twelve samples tested on day 0 from Trials 2 and 3 were included with those from Trials 4-9 (36) in order to facilitate a comparison between stores i.e. bigger number of samples (48). The data show that only three stores (A, B, H) can be compared as there are insufficient samples from the other stores for a robust comparison (Table 13).

Table 13: Data for stores: % of fish samples[1] tested with TVBN values less than 35mgN/100g fish

Store	**% of samples <35mgN/100g fish**	**No. of samples tested**
A	56	9
B	82	11
C	50	4
D	100	3
E	60	5
F	67	3
G	100	1
H	50	12
Total		**48**

[1]Pre-packs and ice counter

Store B performed much better than stores A and H based on the samples tested (Table 13). However, an even greater number of samples would be required before a definitive conclusion could be reached. Table 1 shows 49 samples tested and Table 13 shows 48. This is due to the fact that the results from the bulk sample used for the severe temperature abuse (Trial 1) were not used in the comparison between stores.

8. TVBN values and total viable count

The absence of total viable bacterial counts (TVCs) on the samples tested is a weakness in the current study, but TVCs could not be conducted in UCD for logistic reasons. However, Fagan et al. (2003) showed a positive correlation between TVBN and TVC. More strikingly, Özyurt *et al.* (2009) showed three diagrams for TVBN, TVC and sensory de-merit score (for two fish species – red mullet & Goldband goldfish) and the patterns for the three were very similar. This suggests that TVBN is a good predictor of likely TVC values and also sensory acceptability, at least for the two species in question but quite likely for other species as well.

9. Conclusions

- Ice counters were well maintained and fish appearance was generally good. Temperatures in chill cabinets ranged 1.5 to 2.5ºC (ideal for fish in pre-packs)

- Skin packs were by far the most used form of pre-packing for fish and were used for a range of species. MAP was mostly used for salmon darnes

- Consumers should cook ice counter fish on day of purchase or the day after. If not, fish should be frozen until required for cooking

- Use-by-dates on pre-packed fish may be too long for some species. The results of the current study support this observation

- Over 44% of samples tested had TVBN values >35mgN/100g fish indicating stale fish. This is a cause for concern and mandates a more in-depth study

- Of the three stores that could be compared store B performed better in terms of % of samples with TVBN values less than 35mgN/100g fish than stores A and H.

- The absence of total viable bacterial counts (TVCs) on the samples tested is a weakness in the current study but literature data suggest that TVBN is a good predictor of likely TVC values and also sensory acceptability

10. References

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11. Acknowledgements

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12. More information

A pdf copy of this document is available from ronan.gormley@ucd.ie