



1st National Microbiological Survey 2007 (07NS1)

Microbiological Quality of Ice for Cooling Drinks

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Executive Summary

This survey examined the microbiological quality of ice used for cooling drinks (n=1092 samples). Ice samples were obtained by Environmental Health Officers (EHOs) from public houses, restaurants, take-aways, cafés, hotels and other premises serving drinks cooled by the addition of ice, between January and April 2007. Samples were analysed for *Escherichia coli*, enterococci and coliforms in the Official Food Microbiology Laboratories (OFMLs) of the Health Service Executive (HSE).

E. coli were detected in 2.0% (22/1091), enterococci in 4.5% (47/1045) and coliforms in 24.8% (271/1091) of ice samples. The incidence of *E. coli* and coliforms was lower than that recorded in a national microbiological survey carried out in 2002. The incidence of enterococci was not determined in the 2002 survey.

The survey included a questionnaire through which information was collated on the sample source, the water source used to prepare the ice, the method of preparation, the method of storage etc. There was a 75.5% (825/1092) response rate to the questionnaire. Data collated for this subset of survey samples revealed that 64.7% of samples were obtained from public houses, 83% of samples were prepared using water from a public water supply, 96.6% of samples were prepared in an ice machine and 53.8% of samples were stored in the ice bin of the machine prior to use. Some storage and handling practices were identified which had a statistically significant effect on the presence/absence of coliforms. However, further research would be required to investigate if a causal relationship existed between these practices and the presence/absence of coliforms.

Water used to prepare ice must comply with the standards specified in the drinking water legislation (Council Directive 98/83/EC which is transposed into Irish law by S.I. No. 278 of 2007), i.e. absence of *E. coli*, enterococci and coliforms/100ml. Due to the absence of specific microbiological standards[∞] or guidelines[♦] for ice, the microbiological standards for water tend to be applied as guideline criteria to ice. However some authors have suggested that these are unrealistic for ice because it undergoes a handling process (Nichols *et al.*, 2000). It has been noted from this survey that the major failure of ice with respect to these guideline criteria is for coliforms. It is important that a realistic guideline criterion is set for ice to reflect water hygiene and hygienic handling practices.

[∞] A microbiological standard is a microbiological criterion contained in law where compliance is mandatory

[♦] A microbiological guideline is a criterion which relates to the microbiological condition of the food sample that is applied at any stage of food processing and retailing. It aids in identifying situations requiring attention for food safety or quality reasons. Guidelines are not legally enforceable.

Abbreviations

CFU	Colony Forming Unit
EHO	Environmental Health Officer(s)
EPA	Environmental Protection Agency
FSAI	Food Safety Authority of Ireland
GWS	Group Water Scheme(s)
HSE	Health Service Executive
OFML	Official Food Microbiology Laboratory
RTE	Ready-to-Eat
S.I.	Statutory Instrument
WHO	World Health Organisation

1. Introduction

A national survey undertaken in Ireland in 2002 on the microbiological quality of ice for cooling drinks detected *Escherichia coli* and coliforms in 5.0% (29/580) and 29.5% (171/580) of samples respectively (FSAI, 2002). This and other international studies have shown that the microbiological quality of ice needs improvement (Moyer *et al.*, 1993; Vieira *et al.*, 1997; Wilson *et al.*, 1997; Murphy & Mepham, 1988; Nichols *et al.*, 2000). Furthermore, illness associated with the consumption of contaminated ice has been reported (Talbot *et al.*, 1987; Beller, 1992; Quick *et al.*, 1992; Khan *et al.*, 1994 and Pedalino *et al.*, 2003).

The microbiological quality of ice depends on a number of factors including the microbiological quality of the water used in its preparation and the hygienic practices undertaken during its preparation and storage.

Water used to prepare ice must not contain pathogenic microorganisms as studies have shown that although their numbers are lowered by freezing and exposure to some drinks, they are not completely eliminated (Dickens *et al.*, 1985). MacLeod & Calcott (1976) have shown that a multiplicity of factors including the rates of freezing and thawing affect cell survival.

Contamination of ice may also arise from the environment (e.g. air, equipment, etc), improper handling and cross-contamination during storage. In a survey of licensed premises in the United Kingdom, ice produced on the premises was found to have a lower microbiological quality than the water supply used to prepare it suggesting poor handling and hygiene practices. This was confirmed by the finding that in these premises little emphasis was placed on hygiene issues relating to the ice machines, the equipment which comes in contact with the ice and the training of staff (Murphy & Mepham, 1988).

There are no national microbiological guidelines[♦] or microbiological standards[∞] for ice. However, the current regulation on the hygiene of foodstuffs (Regulation 852/2004) states that '*Ice which comes into contact with food or which may contaminate food is to be made from potable water*' and '*It is to be made, handled and stored under conditions that protect it from contamination*'. Potable water is defined in Regulation 852/2004 as '*water meeting the minimum requirements laid down in Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption*'^{*}. These requirements include microbiological parameters for *E. coli* and enterococci (absence per 100ml) and an indicator parameter for coliforms (absence per 100mls). Due to the absence of specific microbiological guidelines and standards for ice the microbiological

[♦] A microbiological guideline is a criterion which relates to the microbiological condition of the food sample that is applied at any stage of food processing and retailing. It aids in identifying situations requiring attention for food safety or quality reasons. Guidelines are not legally enforceable.

[∞] A microbiological standard is a microbiological criterion contained in law where compliance is mandatory.

^{*} At the time of commencement of this survey, Council Directive 98/83/EC was transposed into Irish law by S.I. No. 439 of 2000. This was revoked on 13/03/07 by S.I. No. 106 of 2007. This was then revoked on 15/06/07 by S.I. No. 278 of 2007.

standards for water tend to be applied as guideline criteria to ice. However, the authors of a survey undertaken in the UK by LACOTS/PHLS (Local Authorities Coordinating Body on Food and Trading Standards/Public Health Laboratory Service) (Nichols *et al.*, 2000) suggest that these are unrealistic for ice because it undergoes a handling process.

2. Specific Objectives

The specific objectives of this survey were as follows:

- To examine the microbiological quality of ice used to cool drinks
- To examine the factors which relate to the microbiological quality of ice
- To compare the findings with those of the 2002 national microbiological survey
- To determine the need for specific microbiological guidelines for ice.

3. Method

3.1 Sample Source

Environmental Health Officers (EHO) were requested to obtain samples from any premises serving drinks cooled by the addition of ice such as public houses, restaurants, take-away food premises, cafes, hotels etc.

3.2 Sample Period

Sampling took place between January and April 2007 inclusive.

3.3 Sample Description

All ice used to cool drinks were included in this survey. Flavoured ice drinks (*e.g. slush puppies*) and ices used to cool ready-to-eat (RTE) food were excluded.

3.4 Sample Collection

Environmental Health Officers (EHOs) from the Health Service Executive (HSE) collected one sample of ice (minimum 500ml) from each premises. Where ice was made in an ice machine and then stored in an ice bucket, the sample was taken from the ice bucket. Where a utensil (*e.g. scoop*) was present, the EHO used it to fill the sample container. The EHO completed the relevant sections of the accompanying questionnaire (Appendix 1) at the time of sampling. All samples were transported to the laboratory in a cool box. Samples requiring overnight storage were stored under refrigerated conditions (*i.e.* $\leq 5^{\circ}\text{C}$).

3.5 Sample Analysis

Analysis was undertaken in the Official Food Microbiology Laboratories (OFML) of the Health Service Executive (HSE). Samples were analysed for *E. coli* and coliforms using the MPN (colilert) method. Samples were analysed for enterococci using membrane filtration (method based on ISO 7899-2:2000).

3.6 Reporting of Results

Laboratory reports were forwarded to EHOs and the FSAI using the normal reporting channels. Laboratory reports were requested to be forwarded to the FSAI within 1 month of the survey completion date.

Laboratory reports of follow-up samples were not included in this report as this type of sampling is not random and hence would bias the original data set.

3.7 Assessment of Results

Potable water must be used in the preparation of ice used to cool drinks. This water must comply with the microbiological standards specified in the drinking water regulations (Council Directive 98/83/EC). These standards are summarised in Table 1. For the purpose of this survey these standards were applied as guideline criteria for the assessment of the microbiological quality of ice.

Table 1: Microbiological standards for drinking water which were used in this study as guideline criteria for the assessment of ice[∞]

Parameter	Parametric Value (number/100ml)
<i>Escherichia coli</i>	0
Enterococci	0
Coliforms	0

[∞] These standards are specified in the drinking water regulations (Council Directive 98/83/EC). For the purpose of this survey, they were used as guideline criteria for the assessment of the microbiological quality of ice.

3.8 Follow-up Action

Where *E. coli*, enterococci or coliforms were present a follow-up sample of the water typically used to prepare the ice was obtained. Other appropriate follow-up action was determined by the EHO.

3.9 Questionnaire Data

Upon receipt of the laboratory results, the EHO completed the questionnaire (Appendix 1) and returned it to the FSAI within 6 weeks of the survey completion date.

3.10 Statistical Analysis

Chi square and Fisher's Exact Test analysis was performed using SPSS version 14.0 (alpha = 0.05 significance level).

4. Results & Discussion

4.1 General Microbiological Results

A total of 1092 ice samples collected from the various HSE areas were analysed by the seven OFMLs (Appendices 2-3).

Coliforms, enterococci and *E. coli* were detected in 24.8% (271/1091), 4.5% (47/1045) and 2.0% (22/1091) of samples respectively (Table 2). Thus, 24.8% of samples failed the guideline criteria for coliforms, 4.5% of samples failed the guideline criteria for enterococci and 2.0% of samples failed the guideline criteria for *E. coli* (guideline criteria are specified in section 3.7 of this report).

Table 2: Microbiological results (*n*=1092 ice samples)

Microorganism	No. of Samples Analysed	Number of samples (% of samples)		
		Not detected/100mls*	Detected but <100 cfu or MPN/100ml**, *	≥ 100 cfu or MPN/100ml***, *
Coliforms	1091 [∅]	820 (75.2%)*	200 (18.3%)	71 (6.5%)
Enterococci	1045 [⊗]	998 (95.5%)	46 (4.4%)	1 (0.1%)
<i>E. coli</i>	1091 [∅]	1069 (98.0%)*	18 (1.6%)	4 (0.4%)

* i) Coliform and *E. coli* results reported by OFMLs as either 0 cfu/100mls or <1 MPN /100mls and ii) Enterococci results reported by OFMLs as 0cfu/100mls, were included in this category.

** i) Coliform and *E. coli* results reported by OFMLs as either >0 - <100 cfu/100ml or 1-<100 MPN/100ml and ii) Enterococci results reported by OFMLs as >0 - <100 cfu/100ml, were included in this category.

*** i) Coliform and *E. coli* results reported by OFMLs as either ≥100 cfu/100ml or ≥100 MPN/100ml and ii) Enterococci results reported by OFMLs as ≥100 cfu/100ml, were included in this category.

* 100 cfu or MPN/100ml was chosen as an arbitrary value to demonstrate the distribution of results.

[∅] 1 sample was not tested for *E. coli* and coliforms.

[⊗] 47 samples were not tested for enterococci.

1044 ice samples were analysed for all three microbiological parameters. 27.1% (283/1044) of these ice samples failed one or more guideline criteria (Table 3). For example, 20.9% (219/1044) of ice samples failed the guideline criteria for coliforms alone; while, 0.4% (4/1044) of ice samples failed the guideline criteria for *E. coli*, coliforms and enterococci.

Table 3: Samples which failed the guideline criteria for *E. coli*, enterococci and/or coliforms (*total number of ice samples = 1044*)*

Reason for failure of guideline criteria	Number of samples (% of samples)
Coliforms alone	219 (20.9%)
Enterococci alone	21 (2.0%)
<i>E. coli</i> & coliforms	17 (1.6%)
Coliforms & enterococci	22 (2.1%)
<i>E. coli</i> , coliforms & enterococci	4 (0.4%)
Total number of positive samples	283 (27.1%)

* 1044 samples were tested for all three microbiological parameters

4.2 *Escherichia coli*

E. coli is a coliform bacterium which occurs in the faeces of all mammals and is regarded as the primary indicator of faecal contamination in water (Schindler *et al.*, 1995; Environment Agency, 2002 and WHO, 2006). Its presence in ice is either due to faecal contamination of the water used in its production and/or due to poor hygiene practices during production, handling and storage.

Of the 1091 ice samples analysed in this survey, *E. coli* were detected in 2% (22/1091) of samples. The breakdown of results by HSE Region is outlined in Table 4.

Table 4: *Escherichia coli* Results by HSE Region (*n=1091 ice samples*)

HSE Region	HSE Area	Number of samples			Grand Total
		Not detected	Detected		
		<1 MPN/ 100ml or 0 cfu/100ml	1-<100 MPN/ 100ml or >0 - <100 cfu/100ml	≥ 100 MPN/100ml or ≥ 100 cfu/100ml	
Dublin Mid- Leinster	East Coast	53	2	0	55
	Midlands	83	2	0	85
	South Western	78	2	1	81
Dublin North East	North Eastern	66	1	0	67
	Northern	35	1	1	37
Southern Region	South Eastern	416	2	2	420
	Southern	116	4	0	120
Western Region	Mid-Western	85	1	0	86
	North Western	67	0	0	67
	Western	70	3	0	73
Grand Total (%)		1069 (98.0)	18 (1.6)	4 * (0.4)	1091 ** (100.0)

* These 4 ice samples were prepared from water sourced from public water supplies.

** 1092 samples were submitted for analysis but 1 sample from the South Western Area was not tested for *E. coli* because there was insufficient sample.

In the 2002 national microbiological survey (FSAI, 2002) *E. coli* were detected in 5% (29/580) of samples. A United Kingdom survey detected *E. coli* in 6.9% (243/3498) of ice samples used to cool drinks (Nichols *et al.*, 2000).

4.3 Enterococci

Enterococci include a number of species which occur in faeces of humans and warm blooded animals (Environment Agency, 2002). They are generally more resistant than *E. coli* and coliforms to environmental stress and generally survive longer in water environments (Environment Agency, 2002 and WHO, 2006). Enterococci indicate faecal contamination of water (WHO, 2006). Their presence in ice is either due to faecal contamination of the water used in its production and/or due to poor hygiene practices during production, handling and storage.

Of the 1045 ice samples analysed, enterococci were detected in 4.5% (47/1045) of samples. The breakdown of results by HSE Region is outlined in Table 5.

Table 5: Enterococci Results by HSE Region (*n=1045 ice samples*)

HSE Region	HSE Area	Number of samples			
		Not detected	Detected		Grand Total
		0 cfu/100mls	>0 - <100 cfu/100ml	≥ 100 cfu/100ml	
Dublin Mid-Leinster	East Coast	50	4	1	55
	Midlands	82	3	0	85
	South Western	76	6	0	82
Dublin North East	North Eastern	65	2	0	67
	Northern	34	3	0	37
Southern Region	South Eastern	362	18	0	380
	Southern	118	1	0	119
Western Region	Mid-Western	76	5	0	81
	North Western	63	3	0	66
	Western	72	1	0	73
Grand Total (%)		998 (95.5)	46 (4.4)	1* (0.1)	1045 ** (100.0)

* This sample was prepared from water sourced from a public water supply.

** 1092 samples were submitted for analysis but 47 samples not tested for enterococci (40 south eastern area, 1 southern area, 5 mid western area, 1 north western area) because there was insufficient sample.

The incidence of enterococci in ice was not tested as part of the 2002 national microbiological survey (FSAI, 2002). A United Kingdom survey detected enterococci in 12.3% (426/3467) of ice samples used to cool drinks (Nichols *et al.*, 2000).

4.4 Coliforms

Coliform bacteria belong to the family Enterobacteriaceae. Typical genera belonging to the coliform group found in water include *Citrobacter*, *Enterobacter*, *Escherichia*, *Hafnia*, *Klebsiella*, *Serratia* and *Yersinia* (Environment Agency, 2002). The presence of coliforms is not necessarily indicative of faecal contamination of the water (WHO, 2006). Coliform bacteria also originate in the environment and can form biofilms on surfaces of equipment. Therefore, coliforms may indicate a problem with the quality of the water source or indicate possible contamination during the handling of ice or poor hygiene of equipment. The public health significance of coliforms in ice needs to be treated with caution in the absence of bacteria like *E.coli* and *enterococci* that are considered an index of faecal pollution. The presence of coliform bacteria in isolation is not in itself a strong indication of potential presence of enteric pathogens.

Of the 1091 samples analysed, coliforms were detected in 24.8% (271/1091) of ice samples. The breakdown of results by HSE Region is outlined in Table 6.

Table 6: Coliform Results by HSE Region (*n*=1091 ice samples)

HSE Region	HSE Area	Number of samples			Grand Total
		Not detected	Detected		
		<1 MPN/ 100ml or 0 cfu/100ml	1-<100 MPN/ 100ml or >0 - <100 cfu/100ml	≥100 MPN/100ml or ≥100 cfu/100ml	
Dublin Mid-Leinster	East Coast	35	15	5	55
	Midlands	73	8	4	85
	South Western	42	27	12	81
Dublin North East	North Eastern	44	18	5	67
	Northern	10	22	5	37
Southern Region	South Eastern	335	66	19	420
	Southern	94	15	11	120
Western Region	Mid-Western	65	14	7	86
	North Western	59	7	1	67
	Western	63	8	2	73
Grand Total (%)		820 (75.2)	200 (18.3)	71 * (6.5)	1091 ** (100.0)

* Information about the water source used to prepare the ice was provided for 43 of these ice samples: public water supply (n=38 ice samples); small private supplies (n=3 ice samples) and private group water schemes (n=2 ice samples).

** 1092 samples were submitted for analysis but 1 sample from the South Western Area was not tested for coliforms because there was insufficient sample.

In the 2002 national microbiological survey (FSAI, 2002) coliforms were detected in 29.5% (171/580) of ice samples. A United Kingdom survey detected coliforms in 36.9% (1297/3511) of ice samples used to cool drinks (Nichols *et al.*, 2000).

Although the water used to prepare the ice was not tested as part of this survey, it is worth noting that the Environmental Protection Agency (EPA) has indicated that compliance of the drinking water supply with the coliform parametric value specified in the drinking water legislation has been problematic in the past in Ireland. The EPA found that a large number of water supplies tested positive for the presence of coliform bacteria, particularly private group water schemes (EPA, 2007).

4.5 Survey Questionnaire

This survey included a questionnaire through which information was provided by the EHO on the sample source, source of water, method of ice preparation and associated practices. A total of 825 questionnaires were returned within the specified time period (*i.e.* there was a 75.5% (825/1092) response rate) and these questionnaires were matched with the corresponding laboratory reports. The microbiological results of this subset of 825 samples are presented in Table 7.

Table 7: Microbiological Quality of Ice Samples with accompanying questionnaire (*n=825 ice samples*)

Microorganism	No. of Samples Analysed	Number of samples (% of samples)		
		Not detected / 100mls*	Detected but <100 cfu or MPN/100ml**	≥ 100 cfu or MPN/100ml***
Coliforms [⊕]	824	631 (76.6%) *	147 (17.8%)	46 (5.6%)
Enterococci [♦]	790	758 (95.9%)	31 (3.9%)	1 (0.1%)
<i>E. coli</i> [⊕]	824	807 (97.9%) *	13 (1.6%)	4 (0.5%)

* i) Coliform and *E. coli* results reported by OFMLs as either 0 cfu/100mls or <1 MPN /100mls and ii) Enterococci results reported by OFMLs as 0cfu/100mls, were included in this category.

** i) Coliform and *E. coli* results reported by OFMLs as either >0 - <100 cfu/100ml or 1-<100 MPN/100ml and ii) Enterococci results reported by OFMLs as >0 - <100 cfu/100ml, were included in this category.

*** i) Coliform and *E. coli* results reported by OFMLs as either ≥100 cfu/100ml or ≥100 MPN/100ml and ii) Enterococci results reported by OFMLs as ≥100 cfu/100ml, were included in this category.

* 100 cfu or MPN/100ml was chosen as an arbitrary value to demonstrate the distribution of results.

⊕ 1 sample was not tested for coliforms and *E. coli*

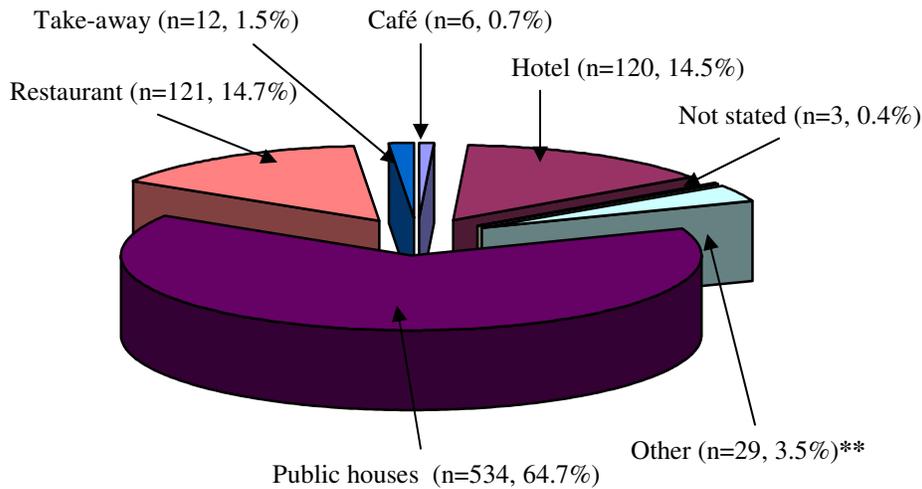
♦ 35 samples were not tested for enterococci

The microbiological results of these 825 samples are similar[⊕] to the microbiological results of the 1092 samples presented in Table 2; therefore, in terms of microbiology these 825 samples are representative of the total sample population.

4.5.1 Sample source

The majority of samples (64.7%, 534/825) were reported to have been obtained from public houses. Other sample sources were reported as restaurants (14.7%, 121/825), hotels (14.5%, 120/825), etc. (Figure 1).

Figure 1: Nature of Food Businesses Where Ice Samples Were Obtained ($n=825$ ice samples)



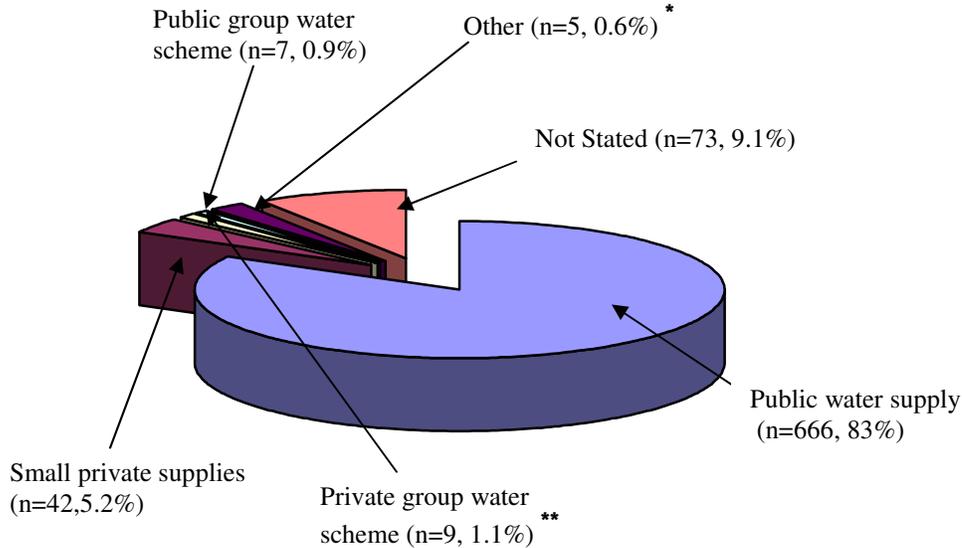
** Other (n=29) includes hospitals, army barracks, ship/ferry, juice/smoothie bar etc.

[⊕] No statistical difference (alpha = 0.05 significance level)

4.5.2 Source of Water

97.2% (802/825) of ice samples were reported to have been prepared on the premises by the food business operator (rather than being prepared by a supplier). The majority of these samples (83.0%, 666/802) were reported to have been prepared using water from a public supply. Other reported sources of water included private group water schemes (GWS), public GWS, small private supplies and wells [∅](Figure 2).

Figure 2: Source of Water used to Prepare Ice by Food Businesses (*n=802 ice samples*)



* Other includes: Lake (n=1), Ship - Ferry tank supply (n=1), Well (n=2), Not Stated (n=1)

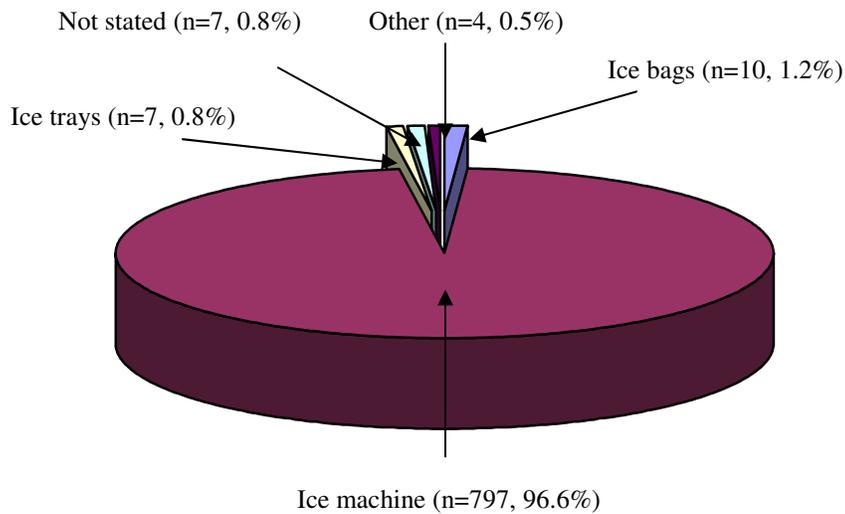
** One sample described as “Group Scheme Private with Additional In-House Water Treatment System” is included under the category of Private GWS.

[∅] **Public Water Supplies** are local authority operated schemes (though these may be run by a private contractor on behalf of the local authority). They supply water to the majority of households in Ireland. **Public Group Water Schemes** are schemes where the water is provided by the local authority but responsibility for distribution of the water rests with the group scheme. These schemes tend to be supplied off larger public water supplies. **Private Group Water Schemes** are schemes where the owners of the scheme (usually representatives of the local community) source and distribute their own water. **Small Private Supplies** are a large group of different types of supply comprising industrial water supplies (such as those used in the brewing industry) to boreholes serving single houses. The majority of these supplies are exempt from the requirements of the Regulations, except where the water is supplied as part of a public or commercial activity (EPA, 2007).

4.5.3 Method of Ice Preparation

Ice machines, ice bags and ice trays were reported to be used for the preparation of ice. The majority (96.6%, 797/825) of ice sampled in this survey were reported to have been prepared using ice machines (Figure 3).

Figure 3: Method of Ice Preparation ($n=825$ ice samples)

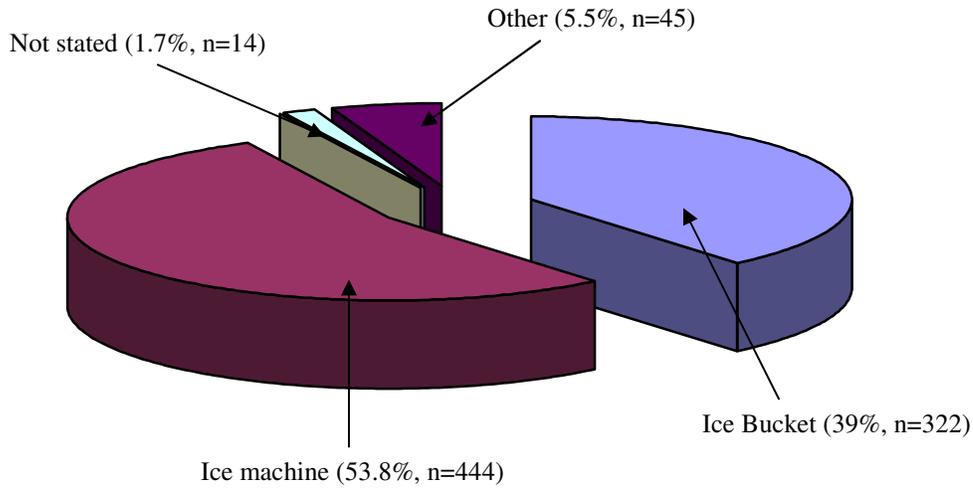


Due to the small number of ice samples prepared by methods other than the ice machine it was not possible to statistically compare preparation methods. However, other studies have noted a correlation between the method of ice preparation and microbiological quality. In a study carried out in the United Kingdom it was noted that the ice prepared in ice trays contained significantly more coliforms and enterococci than ice prepared using ice machines or ice bags (Nichols *et al.*, 2000). It was postulated in that study that unclean ice trays or improper handling techniques during or post preparation may have been responsible for the higher counts.

4.5.4 Method of Ice Storage

Immediately prior to use, the majority of ice samples were reported to have been stored in either the storage bin of the ice machine (53.8%, 444/825) or in an ice bucket (39%, 322/825) (Figure 4).

Figure 4: Method of storage immediately prior to use (*n*=825 ice samples)



As the majority of ice samples were prepared in an ice machine (*n*=797), the relationship between storage conditions and the microbiological results of these 797 ice samples was investigated (Table 8).

Table 8: Effect of storage conditions on the microbiological results of ice prepared in an ice machine (*n*=797 ice samples)

Storage conditions [∅]	Number of samples (% of samples)					
	<i>E. coli</i>		Enterococci [⊕]		Coliforms	
	Not detected /100mls *	Detected /100mls	Not detected /100mls	Detected /100mls	Not detected /100mls *	Detected /100mls
Ice bucket	310 (97.8%)	7 (2.2%)	281 (94.6%)	16 (5.4%)	208 (65.6%)	109 (34.4%)
Ice machine	430 (97.9%)	9 (2.1%)	412 (96.9%)	13 (3.1%)	374 (85.2%)	65 (14.8%)

[∅] 797 samples were prepared in an ice machine. Of these 317 were stored in an ice bucket and 439 were stored in the storage bin of the ice machine. Storage conditions were reported as 'other' or 'not stated' for 41 samples

[⊕] Enterococci test was not preformed on 34 samples

* Coliform and *E. coli* results were reported as either 0 cfu/100mls or <1 MPN /100mls.

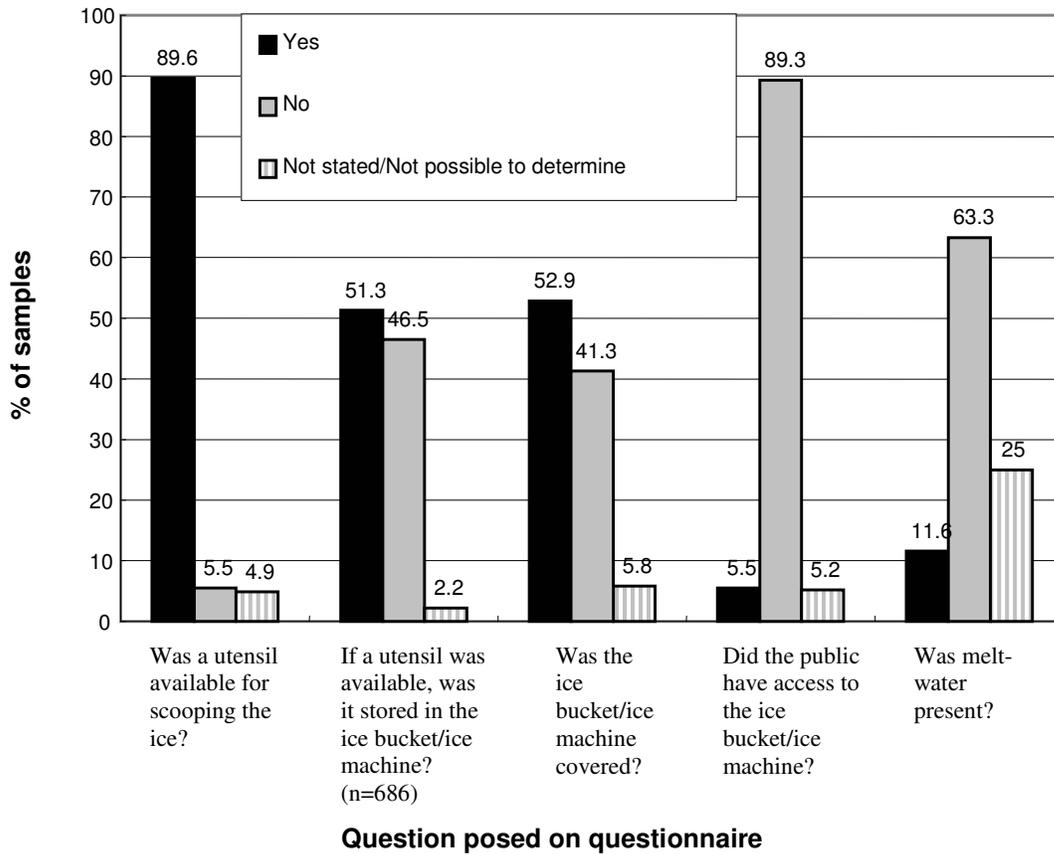
Storage conditions had no statistically significant relationship with the presence/absence of *E. coli* or enterococci; however, it had a statistically significant relationship with the presence/absence of coliforms ($p < 0.0001$). Coliforms were detected in 14.8% (65/439) of samples stored in the storage bin of the ice machine compared with 34.4% (109/317) of samples stored in an ice bucket. Similarly in the 2002 national microbiological survey, higher coliform counts were found in samples stored in an ice bucket (FSAI, 2002). However, in both surveys as the microbiological quality of the water used to prepare the ice was not investigated, a causal relationship between storage conditions and the presence/absence of coliforms in the ice could not be established. Further research would be needed to investigate if there was any basis for storage conditions to affect the coliform counts of ice.

However, similar findings have been noted in other studies. In a survey of 12 licensed premises in Leeds, ice sampled from buckets had higher coliform and TVC counts than ice sampled from ice machines (Murphy & Mepham, 1988). Similarly a LACOTS (Local Authority Co-ordinating Body on Food and Trading Standards) survey from the UK found that ice from buckets contained more coliforms than ice sampled from other sources (Nichols *et al.*, 2000).

4.5.5 Handling practices during storage

Figure 5 summarises the handling practices which were reported to be used during the storage of ice in ice buckets or the storage bins of the ice machines (n=766).

Figure 5: Handling practices during the storage of ice in ice buckets and the storage bin of the ice machine (n=766 ice samples)



A statistical analysis was undertaken to investigate if any relationship existed between handling practices and the microbiological results of the ice (data presented in Appendix 4). The microbiological quality of the ice samples with respect to *E. coli* and enterococci were similar[Ⓢ] irrespective of handling practices.

Some handling practices were identified which had a significant effect on the presence/absence of coliforms (these practices are listed below). However, as the microbiological quality of the water used to prepare the ice was not investigated, a causal relationship between these handling practices and the presence/absence of coliforms in the ice could not be established.

[Ⓢ] No statistical difference (alpha = 0.05 significance level)

- **Storage of the utensils:** Coliforms were detected in 29.8% (105/352) of ice when utensils were stored in the ice bucket/machine compared to 17.6% (56/319) of ice when utensils were not stored in the ice bucket/machine ($p=0.0002$).
- **Covering of bucket/ice machine:** Coliforms were detected in 35.1% (111/316) of ice when the ice buckets/machines were not covered compared to 15.8% (64/405) of ice samples when the ice buckets/machines were covered ($p<0.0001$).
- **Presence/absence of meltwater:** Coliforms were detected in 46.1% (41/89) of ice when meltwater was present in the ice bucket/machine compared to 20.8% (101/485) of ice when meltwater was not present ($p<0.0001$).

These findings differ to those of the LACOTS survey undertaken in the UK. That survey found little difference in the microbiological quality of ice from ice buckets with and without utensils and with or without lids. However, samples from buckets with meltwater were of significantly lower microbiological quality than those without (Nichols *et al.*, 2000).

5. Conclusions

1. Coliforms, enterococci and *E. coli* were detected in 24.8% (271/1092), 4.5% (47/1045) and 2.0% (22/1091) of ice samples respectively. Thus, 24.8% of samples did not meet the guideline criteria for coliforms, 4.5% of samples did not meet the guideline criteria for enterococci and 2.0% of samples did not meet the guideline criteria for *E. coli*. Of the 1044 samples which were analysed for all three microbiological parameters, 27.1% (283/1044) failed to meet one or more of the guideline criteria.
2. Storage and handling practices were identified which had a statistically significant relationship with the presence/absence of coliforms. These included:
 - storage conditions of the ice (coliforms were detected more often in ice stored in an ice bucket rather than the storage bin of the ice machine),
 - storage of the utensils (coliforms were detected more often in ice when the utensils were stored in the storage bin of the ice buckets/machines),
 - presence/absence of melt water (coliforms were detected more often in ice when meltwater was present in the ice buckets/machines) and
 - presence/absence of a lid/cover on the storage container (coliforms were detected more often in ice when the ice buckets/machines were not covered).However, further research would be necessary to determine if these relationships were anything more than observational (i.e. causal).
3. In this survey the microbiological standards for drinking water (i.e. absence of *E. coli*, coliforms and enterococci per 100mls) were applied as guideline criteria for the assessment of ice. However some authors have suggested that these are unrealistic for ice because it undergoes a handling process (Nichols *et al.*, 2000). It has been noted from the survey that the major failure of ice with respect to these guideline criteria is for coliforms. It is important that a realistic guideline criterion is set for ice to reflect water hygiene and hygienic handling practices.

6. Recommendations

1. An appropriate set of microbiological guidelines needs to be established for ice.
2. Managers and owners of food businesses should ensure that food workers are supervised and instructed and/or trained in food hygiene matters commensurate with their work activities, e.g. the production, storage and handling of ice. In all instances food workers should be instructed in hand washing practices. Training of staff in matters commensurate with their activities is a legal requirement.
3. Ice which comes in contact with food must be made from potable water (legal requirement); therefore, the microbiological quality of the potable water used by the food business should be regularly assessed as outlined in I.S. 340:2007 (Hygiene in the catering sector) and I.S. 341:2007 (Hygiene in food retailing and wholesaling).
4. Manufacturer's instructions relating to the positioning, maintenance, storage and cleaning of ice machines should be followed.
5. It is good practice to prepare ice in an ice machine and store it in the storage bin of the ice machine until required for use. If the use of ice buckets/containers is unavoidable they should be maintained in a hygienic condition, ice should be transferred in a hygienic manner, ice buckets/containers should be covered and melt water should not be present.
6. The preparation and storage of ice should be considered in the food businesses Hazard Analysis and Critical Control Point (HACCP) plan.

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APPENDIX 1

Questionnaire 07NS1: Microbiological Quality of Ice for Cooling Drinks

General Information:

- * EHO Name: _____
- * EHO Sample Reference Number (*i.e. EHO's own personal reference number for the sample*) _____
- * Laboratory Reference Number (*upon receipt of lab report*) _____

Premises Information (See section 4 of Protocol):

- ❖ **Premises type:** Pub ; Restaurant ; Take-away ; Café ; Hotel ; Other *Please specify* _____
- ❖ **Water Supply:** Public water supply ; Public group water scheme ; Private group water scheme ; Small private supplies ; Other *Please specify* _____

Details relating to the ice:

- ❖ **Where was the ice manufactured?:** On the premises ; Other *Please specify* _____
- ❖ **How was the ice produced?:** Ice machine ; Ice bags ; Ice tray ; Other *Please specify* _____
- ❖ **Where was the ice stored immediately prior to use?:** Ice machine ; Ice bucket ; Other *Please specify* _____
- ❖ **If the ice was stored in an ice bucket or ice machine please complete the following questions:**
 - Was a utensil available for scooping the ice? Yes ; No
 - If a utensil was available to scoop the ice, was it stored in the ice bucket/ice machine? Yes ; No
 - Was the bucket/ice machine covered? Yes ; No
 - Did the public have access to the ice bucket/ice machine? Yes ; No
 - Was melt-water present? Yes ; No ; Not possible to see/determine

Microbiological results :

Microbiological parameter	Result (Count/100ml)
<i>E. coli</i>	
Enterococci	
Coliforms	

Follow-up action:

- None ;
- Repeat sample of water (Lab. ref. no. of repeat sample : _____)
- Repeat sample of ice (Lab. ref. no. of repeat sample : _____)
- Verbal warning
- Written warning
- Improved in house control required
- Other (Please specify) _____

Appendix 2

Number of Samples Submitted from each Health Service Executive (HSE) Region and Area:

HSE Region	HSE Area	Number of Samples Submitted
HSEDMLR	East Coast Area	55
	Midlands Area	85
	South Western Area	82
HSEWR	Mid-Western Area	86
	North Western Area	67
	Western Area	73
HSEDNER	North Eastern Area	67
	Northern Area	37
HSESR	South Eastern Area	420
	Southern Area	120
Total		1092

Appendix 3

Number of samples analysed in each Official Food Microbiology Laboratory (OFML):

Official Food Microbiology Laboratory	Number of Samples Analysed
Cherry Orchard	178
Cork	120
Galway	73
Limerick	86
Sligo	67
SPD	148
Waterford	420
Grand Total	1092

Appendix 4

Effect of handling practices undertaken during storage of ice in ice-buckets or in the bin of the ice machine on microbiological results

Question posed	Reply	Number of samples	Number of samples (% of samples)					
			Not detected/ 100mls [⊕]	Detected/ 100mls	Not detected/ 100mls [⊕]	Detected/ 100mls	Not detected/ 100mls	Detected/ 100mls
			<i>E. coli</i>		Coliforms		Enterococci	
1. Was a utensil available for scooping the ice? [∞]	Yes	686	671 (97.8%)	15 (2.2%)	520 (75.8%)	166 (24.2%)	631 (96.0%)	26 (4.0%)
	No	42	41 (97.6%)	1 (2.4%)	34 (81.0%)	8 (19.0%)	38 (92.7%)	3 (7.3%)
	N/S or N/A	38	38 (100%)	0 (0%)	36 (94.7%)	2 (5.3%)	34 (100%)	0 (0%)
2. If a utensil was available to scoop the ice, was it stored in the ice bucket/ice machine? [*]	Yes	352	344 (97.7%)	8 (2.3%)	247 (70.2%)	105 (29.8%)	325 (95.6%)	15 (4.4%)
	No	319	313 (98.1%)	6 (1.9%)	263 (82.4%)	56 (17.6%)	295 (97.4%)	8 (2.6%)
	N/S	15	14 (93.3%)	1 (6.7%)	10 (66.7%)	5 (33.3%)	11 (78.6%)	3 (21.4%)
3. Was the bucket/ice machine covered? [∞]	Yes	405	395 (97.5%)	10 (2.5%)	341 (84.2%)	64 (15.8%)	377 (95.9%)	16 (4.1%)
	No	316	310 (98.1%)	6 (1.9%)	205 (64.9%)	111 (35.1%)	286 (95.6%)	13 (4.4%)
	N/S	44	44 (100%)	0 (0%)	43 (97.7%)	1 (2.3%)	40 (100%)	0 (0%)
4. Did the public have access to the ice bucket/ice machine? [∞]	Yes	42	42 (100%)	0 (0%)	31 (73.8%)	11 (26.2%)	39 (95.1%)	2 (4.9%)
	No	684	668 (97.7%)	16 (2.3%)	520 (76.2%)	162 (23.8%)	628 (95.9%)	27 (4.1%)
	N/S	40	40 (100%)	0 (0%)	39 (97.5%)	1 (2.5%)	36 (100%)	0 (0%)
5. Was melt-water present? [*]	Yes	89	87 (97.8%)	2 (2.2%)	48 (53.9%)	41 (46.1%)	83 (94.3%)	5 (5.7%)
	No	485	473 (97.5%)	12 (2.5%)	384 (79.2%)	101 (20.8%)	439 (95.4%)	21 (4.6%)
	N/S	40	40 (100%)	0 (0%)	38 (95.0%)	2 (5.0%)	36 (100%)	0 (0%)

[⊕] Coliform and *E. coli* results were reported as either 0 cfu/100ml or <1 cfu/100ml by OFMLs

[∞] Enterococci results are not provided for 34 samples as the test was not preformed

^{*} Enterococci results are not provided for 29 samples as the test was not preformed

^{*} Enterococci results are not provided for 182 samples as the sampling officers were either unable to determine the answer to the question or the test was not preformed.