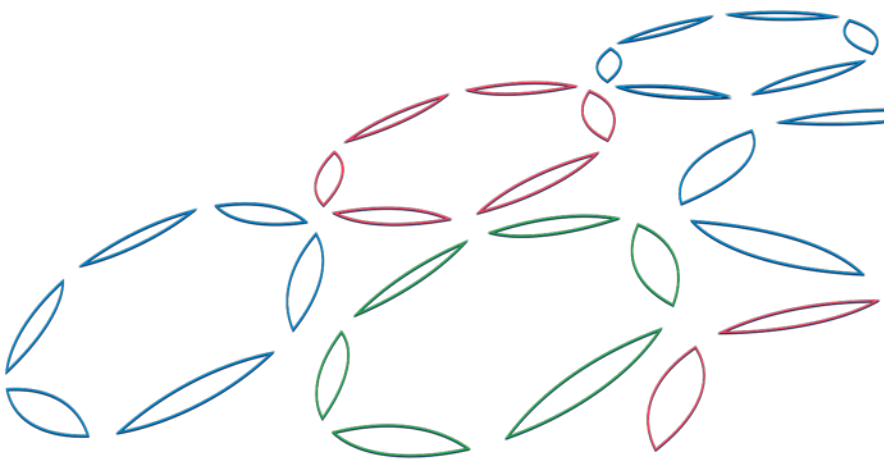
The keeping quality of chilled sea urchin roe and whole urchins

Guðmundur Stefánsson
Aðalheiður Ólafsdóttir

Skýrsla Matís 08-17
September 2017

ISSN 1670-7192



Skýrsluágrip Matís ohf
Icelandic Food and Biotech R&D

Report summary

ISSN: 1670-7192

Titill / Title	**The keeping quality of chilled sea urchin roe and whole urchins**		
Höfundar / Authors	Guðmundur Stefánsson and Aðalheiður Ólafsdóttir		
Skýrsla / Report no.	08-17	*Útgáfudagur / Date:*	20th of Sept 2017
Verknr. / Project no.	20012358		
Styrktaraðilar /Funding:	Northern Periphery and Arctic Programme 2014-2020		
Ágrip á íslensku:	Ígulker (*Strongylocentrotus droebachiensis*) eru algeng við strendur Íslands og eru veidd í litlu magni og flutt út einkum sem heil ker. Aflinn árið 2015 var 280 tonn. Markaðir eru til staðar í Evrópu og Asíu fyrir ígulkerahrogn fersk, frosin eða unnin á annan hátt. Í þessari rannsókn var lagt mat á geymsluþol ferskra og gerilsneyddra hrogna sem geymd voru við 0-2°C. Áhrif frystingar, bæði hægfrystingar (blástursfrysting við -24°C) og hraðfrystingar (frysting í köfnunarefni) voru könnuð sem og meðhöndlun með dextríni og alúmi. Einnig var lagt mat á það hversu lengi ker héldust lifandi sem geymd voru við 3-4°C. Ígulkerin voru veidd í Breiðafirði með plóg og þeim landað hjá Þórishólma í Stykkishólmi þar sem þau voru unnin. Hluti af ígulkerunum var opnaður, hrognin fjarlægð, hreinsuð og notuð í tilraunirnar. Heilum ígulkerum var pakkað í plastkassa á sambærilegan máta og við útflutning. Ferskleikaeinkenni ferskra ígulkerahrogna eru sjávarlykt og bragð, eggjarauðulykt og bragð og sætubragð. Bragð gerilsneyddra hrogna var svipað bragði ferskra hrogn en mildara. Almennt má segja að með tíma dofnaði sætu, sjávar- og eggjarauðubragðið en málmkennd, þara og efnabragðeinkenni jukust. Geymsluþol ferskra ígulkerahrogna er takmarkað af áferðarbreytingum – hrogn leysast upp og verða ólystileg – og má gera ráð fyrir um eins til fjögurra daga geymsluþoli við 0-2°C. Gerilsneydd hrogn héldu ferksleikaeinkennum sínum í a.m.k. 14 daga og höfðu 22 daga geymsluþol eða meira við 0-2°C án þess að fram kæmu breytingar á áferð. Frysting ferskra ígulkerahrogna leiddi til þess að þau urðu grautarleg við þýðingu og ekki virtist vera munur á milli hægfrystingar eða hraðfrystingar. Eftir þriggja mánaða geymslu við -24°C var komið sterkt óbragð í þídd hrogn sem gerðu þau óhæf til neyslu. Frysting gerilsneyddra hrogna hafði lítil sem engin áhrif á áferð eða bragð þeirra; hins vegar eftir sex mánaða frystigeymslu fannst vottur af óbragði. Meðhöndlun með alúmi leiddi til sterks óbragðs sem gerði hrognin óhæf til neyslu. Rotvarnarefnin sorbat og bensóat leiddu til sterks bragðs í hrognunum og málmkennds eftirbragðs en meðhöndlun með dextríni virtust ekki have mikil áhrif á skynmatseiginileika. Öll heil ígulker voru lifandi eftir 5 daga frá veiði en á degi 9 var eitt ker af 18 dautt en engin skemmdarlykt fannst. Það má ætla að heil ígulker haldist lifandi við 3-4°C á milli fimm til níu daga frá veiði.		
Lykilorð á íslensku:	*Ígulker, heil ker, fersk og unnin hrogn, geymsluþol*		

Skýrsluágrip Matís ohf
Icelandic Food and Biotech R&D

Report summary

ISSN: 1670-7192

Summary in English:	The green sea urchin (*Strongylocentrotus droebachiensis*) is commonly found in Iceland and is currently fished and exported mainly as whole urchins. The catch in 2015 was 280 tons. There are markets both in Europe and Asia for urchin roe, fresh, frozen or processed. In this study the shelf-life of fresh and pasteurised sea urchin roe, stored at 0-2°C was evaluated. The effect of freezing (blast freezing and freezing in liquid nitrogen), treatment with dextrin and alum was evaluated on both fresh and pasteurised roe. Further, the keeping quality of whole (live) sea urchins at 3-4°C was evaluated. The sea urchins were caught in the Breidafjordur area using a modified dredge, landed at Thorisholmi in Stykkishólmur, cleaned and the whole live sea urchin were packed in the same manner as that for export. Part of the sea urchins was opened up and the roe removed, cleaned and used for the experimental trial. The freshness characteristics of fresh sea urchin roe were found to be sea odour & flavour, egg yolk odour & flavour and sweet flavour. The flavour was similar but milder in pasteurised roe. In general, with time the sweet, egg yolk and sea flavours seemed to decrease but metallic, seaweed and chemical flavours increased. The shelf-life of fresh roe is limited by changes in texture – the roe liquefies - as indicated by sensory evaluation and can be expected to be between one and four days at 0-2°C. Pasteurised roe had a freshness period of at least 14 days and a shelf life of 22 days or more at 0-2°C, with no detectable changes in appearance or texture during that time. Freezing of fresh roe resulted in a porridge like texture at thawing and no difference was seen between freezing methods, blast freezing and liquid nitrogen freezing. After three months storage at -24°C frozen roe had developed a strong off-flavour and were considered unfit for consumption by the panellists. Freezing of pasteurised roe did not change the texture or flavour of the roe; however, after 6 months freezer storage, the roe had a trace of an off-flavour. Treatment with alum gave all samples a strong off-flavour which made them unfit for consumption. Preservatives (a mix of sorbate and benzoate) gave a strong flavour and a metallic aftertaste but treatments with dextrin did not have a considerable effect on sensory characteristics. All whole sea urchins were alive after 5 days from catch, but on day 9 from catch, one urchin out of 18 had an open mouth but no spoilage odour was detected. It is estimated that the shelf life of live sea urchins is between five and nine days from catch at 3-4°C.
English keywords:	*Sea urchin, fresh and processed roe, whole urchins, shelf-life*

Contents

Introduction 1
Materials and methods 2
Sea urchin and roe 2
Procedure 2
Methods 3
Sensory evaluation 3
Microbial evaluation 4
Results 5
Fresh roe 5
Pasteurised roe 8
Frozen roe 16
Frozen - Fresh roe 16
Frozen - Pasteurised roe, blast frozen 20
Whole (live) sea urchins 21
Conclusion 23
Acknowledgements 24
References 25

Introduction

The green sea urchin (*Strongylocentrotus droebachiensis*) is commonly found in Iceland; it can be found all around the island except possibly at the south coast. It is commonly associated with luminaria kelp which it feeds on. Currently, the only area used for fishing sea urchins in Iceland is in the inner part of Breidafjordur.

Utilisation of sea urchins in Iceland started in 1983 by divers. Diving turned out to be too labour intensive and not economically viable. Harvesting by mainly dredges started in 1993 with maximum landings in 1994 (approx. 1,500 tonnes) with export mostly to Japan. The Japanese market closed temporarily in 1996 due to an outbreak of *E.coli*. In 1997 only 20 tons of sea urchins were harvested and it is likely that the stock in the Breidafjordur area was overfished at that time (James *et al*, 2016). No or minor landings of sea urchins were reported during the period 1998 until 2003 when one small company, Thorisholmi in Stykkisholmur, started harvesting sea urchins. From 2007 until 2013 the harvest of sea urchins was about 140 tons, annually. From 2014 onwards the catch in Iceland has been increasing, reaching 280 tons in 2015 just about the maximum catch advised by the MFRI (Marine and Freshwater Research Institute) for the area.

The main export from Iceland has been whole urchins – the average volume was 110 tons annually, during the period 2011-2015 - but there is interest both in Europe and Asia in fresh urchin roe. However, the export of fresh roe from Iceland is difficult due to the (relatively) long distances to markets in Europe and especially to Asia and the perishability of the roe. There may be means of preserving the shelf-life of urchin roe, by e.g. the use of preservatives, heat preservation and/or freezing. Markets both in Europe and Asia accept such products (Stefansson *et al*., 2017). In this report the shelf-life of fresh, frozen and preserved roe is evaluated. Additionally, the shelf-life of whole live urchins was evaluated.

The work described here is part of the URCHIN project – *Utilisation of the Arctic Sea Urchin Resource* – which is funded by the Northern Periphery and Arctic Programme 2014-2020. The project is a co-operation between Nofima (Norway), Matís (Iceland), Galway Mayo Institute of Technology (Ireland), Marine and Freshwater Research Institute (Iceland), Arctic Caviar AS (Norway), Thorisholmi (Iceland) and Royal Greenland (Greenland). The project started in 2015 and will be completed in 2018.

The URCHIN project aims to utilise the sea urchin resource present in the northern periphery and arctic (NPA) regions. This report fulfils Activity 6.3.1 from the URCHIN project.

Materials and methods

Sea urchin and roe

The sea urchins were caught in the Breidafjordur area using a modified dredge on the 23rd of November 2016 by Fjola SH-7 (Thorisholmi, Stykkisholmur). On landing, broken and small sea urchins were removed; the remaining urchins were cleaned (using sea water) and packed into polystyrene boxes. Roe was removed from whole urchins, cleaned in sea water and packed in a plastic bag. Part of the cleaned roe was pasteurised using a steam oven. After pasteurisation and chilling, the roe was packed in plastic containers (approx. 50 g of roe in each). The live urchin, fresh and pasteurised roe was kept in a chiller overnight and transported to Matís, Reykjavík, on the 24th of November 2016 (1 day from catch).

Procedure

Whole sea urchin. On arrival at Matís the whole urchins were stored in a chiller at 3-4°C in the polystyrene boxes.

Fresh sea urchin roe. On arrival to Matís the roe was drained and washed with salt brine (3.5%), then packed in glass jars (100 ml) and treated as follows:

Fresh roe (control) – untreated
Fresh roe with dextrin
Fresh roe with alum

Figure 1. Fresh sea urchin roe, 1 day from catch.

The dextrin solution was 5% in 3.5% salt brine. The alum solution was 2% in 3.5% salt brine. The preservatives were sodium benzoate and potassium sorbate at 1,000 ppm (each) in 3.5% brine

solution. To prepare the different groups approximately 50 g of roe was weighed into the jars, filled up with the appropriate solution (1:1 wt/wt) and the jar closed. All groups were kept in a chiller at 0-2°C.

Pasteurised sea urchin roe. On arrival to Matís the pasteurised roe was kept in the original plastic boxes but were treated in the following way:

Pasteurised roe (control) - untreated
Pasteurised roe in brine
Pasteurised roe with preservatives
Pasteurised roe with dextrin & preservatives
Pasteurised roe with alum & preservatives

The brine was 3.5% salt (NaCl) solution and the other solutions (preservatives, dextrin and alum) as described in the section on fresh roe. The amount of roe vs. brine was adjusted to give approx. 2-2.5% salt (1 part roe: 1 part brine with and without the other ingredients). All groups were kept in a chiller at 0-2°C.

Frozen sea urchin roe. Additionally, part of the fresh and pasteurised roe was frozen in liquid nitrogen or blast frozen (-24°C) after treating as follows:

Fresh roe frozen in N2 (untreated)
Fresh roe, blast frozen (-24°C) (untreated)
Fresh roe with dextrin, frozen in N2
Fresh roe with dextrin, blast frozen (-24°C)
Fresh roe with alum frozen in N2
Fresh roe with alum, blast frozen (-24°C)
Pasteurised roe blast frozen (-24°C)

The solutions for treating the roe are described in the section on fresh roe. The fresh roe was vacuum packed before freezing. When freezing in liquid nitrogen, the vacuum bags were placed in a container, the liquid nitrogen poured over the bags and the products kept in the N2 until frozen (approx. 30 minutes). After freezing, all the products were kept at -24°C until evaluated.

Methods

Sensory evaluation

Sensory evaluation was carried out on samples of sea urchin roe during the period November 2016 to June 2017. The fresh roe was evaluated on the processing day (D1) and then after 2, 5, and 7 days from catch; the group with dextrin was evaluated on day 8. Six panellists which all were trained in sensory evaluation participated in the trial (ISO, 2008). One sample was roe from one jar, poured onto a white plate. Excess liquid was drained from the roe if stored in brine. Each sample was evaluated independently. The sample was passed between the panellists who evaluated it in silence before

discussing the sensory characteristics of the sample within the panel to come to a consensus. One sample was evaluated of each group on the sampling dates except on day 1 where two jars of the fresh roe (control) were used.

The pasteurised roe was evaluated in the same way after 8, 14, 22 and 28 days from catch. Additionally, the control (pasteurised, untreated roe) was evaluated on day 1, and the groups; pasteurised roe with preservatives and with dextrin, 43 days from catch.

All frozen samples were evaluated 3 months from catch; additionally, the fresh roe samples were evaluated 1 month from catch. The frozen roe was taken out of the freezer before evaluation and defrosted at room temperature (for approx. 2-3 hours).

Photos were taken of all roe samples prior to the evaluation.

The status of live sea urchins was evaluated by opening a (new) polystyrene box on each sampling day and checking the colour of the urchins; whether they were open, had lost some liquid or for foul odour. The sea urchins were evaluated on days 2, 5, 9 and 13 from catch. Photos were taken of whole urchins before and during evaluation.

Microbial evaluation

Total viable count of bacteria was determined by pour plating into an agar medium under aerobic conditions at 22°C for 3 days (NMKL, 2013). The sampling dates were the same as described in the sensory evaluation section and the same samples; fresh roe and pasteurised. Before sensory evaluation, microbial sampling was carried out and the remainder of the samples used for the sensory evaluation.

Results

Fresh roe

Day 1 from catch

Fresh roe, control

Appearance: Much liquid. Colour of the roe is very diverse: red, brown and yellow. Colour of liquid is light brown. The roe is easily split with a fork.
Odour: Fresh cucumber, mild, fresh sea
Flavour: Very rich in flavour, sweet, salty, slightly bitter, egg yolks, sea aftertaste
Texture: Very soft, like soft boiled eggs.

Day 2 from catch

Fresh roe, control

Appearance: Very little liquid but still wet and shiny. Bright and variant colours.
Odour: Cucumber, mild, fresh sea odour.
Flavour: Very rich in flavour, sweet, egg yolks, salty, metallic, sea aftertaste.
Texture: Like egg yolks, soft, slimy and slightly grainy (difference between individual roe sacks).

Fresh roe with dextrin

Appearance: Bright and variant colours.
Odour: Cucumber, weaker sea odour than that of the fresh roe sample.
Flavour: Rich in flavour, similar flavour as of the fresh roe sample, sweet, egg yolks, strong sea flavour (seaweed), metallic flavour. The liquid is very salty.
Texture: Soft, slightly gelatinous, slightly slimy.

Fresh roe with alum

Appearance: White precipitations on roe and in liquid. Roe more formed, separate and seem bigger than fresh roe or roe with dextrin. The eggs are well visible.
Odour: Weak sour odour (whey, skyr), egg yolk.
Flavour: Salty, trace of sour and bitter. Weaker sweet flavour than that of fresh roe and roe with dextrin, sea shore, egg yolk at the end and metallic aftertaste. The brine is salty and sour.
Texture: Slightly firmer than fresh roe and roe with dextrin.
Comments: The flavour of the roe is like of fresh roe and roe with dextrin, but the liquid has a big effect on the flavour. The white precipitations could have a negative influence on the appearance.

Day 5 from catch

Fresh roe, control

Appearance: The roe is more dissolved than on previous sampling dates. They are not separate and they leak thick liquid. It looks as the eggs burst more easily than before.
Odour: Cucumber, sea odour, no off odour.
Flavour: Very rich in flavour, very sweet, salty, egg yolks, seaweed, bitter aftertaste of some roe, sea flavour.
Texture: Like egg yolks, thicker than before.

Fresh roe with dextrin

Appearance: Like the fresh roe sample, seem rather dissolved, the roe leak brown thick liquid (not from brine) and the eggs seem to burst easily.
Odour: Cucumber (less than the fresh roe), more egg yolks than in fresh roe, sea odour.

Flavour: Rich in flavour but less than in the fresh roe. Very sweet, salty, seaweed, egg yolks, sea flavour.
Texture: Different between individual roe sacks, perhaps more gelatinous than the fresh roe.

Fresh roe with alum

Appearance: Much less liquid than in fresh roe and roe with dextrin. The liquid is lighter in colour and a lot thinner. The roe is well formed and separated. The eggs do not burst when touched but there is quite much of white precipitations on the roe and in the liquid.
Odour: Sour, iodine or metallic. Reminds of canned mussels. No odour of cucumber or egg yolks but a trace of sea odour.
Flavour: A strong seaweed flavour, bitter, sour, prickling, chemical (iodine / metallic). No sweet flavour, sea flavour or egg yolk flavour. Not a characteristic flavour of sea urchin roe.
Texture: Difficult to evaluate because of off-flavour.
Comments: Not suitable for consumption.

Day 7 from catch

Fresh roe, control

Appearance: Quite dissolved, thick brown mud.
Odour: Spoilage odour, slight cucumber odour, sea, heavy rotting odour, fish intestines.
Flavour: Not tasted.
Texture: Not tasted.
Comments: Spoiled.

Fresh roe with dextrin

Appearance: Not as dissolved as the fresh roe, but dissolves when touched.
Odour: Cucumber, sweet, egg yolks, sea odour, not as fresh as before but not spoiled, a trace of heavy odour (sea shore with seaweed).
Flavour: Rich in flavour, salty, sweet, egg yolks, sea flavour, no spoilage flavour but a trace of heavy flavour, not fresh.
Texture: astringent and rather slimy.
Comments: Not spoiled but has lost freshness characteristics.

Day 8 from catch

Fresh roe with dextrin

Appearance: Very wet, thick brown liquid, rather dissolved, very variable colours.
Odour: cucumber, sweet, trace of egg yolks.
Flavour: Sweet and salty, sea shore, egg yolk, strong seaweed flavour, sea flavour, chemical or iodine flavour as aftertaste, bitter, no off-flavour.
Texture: Slimy, individual eggs not detected.

Photos of the fresh roe samples before sensory evaluation can be seen in Figure 2.

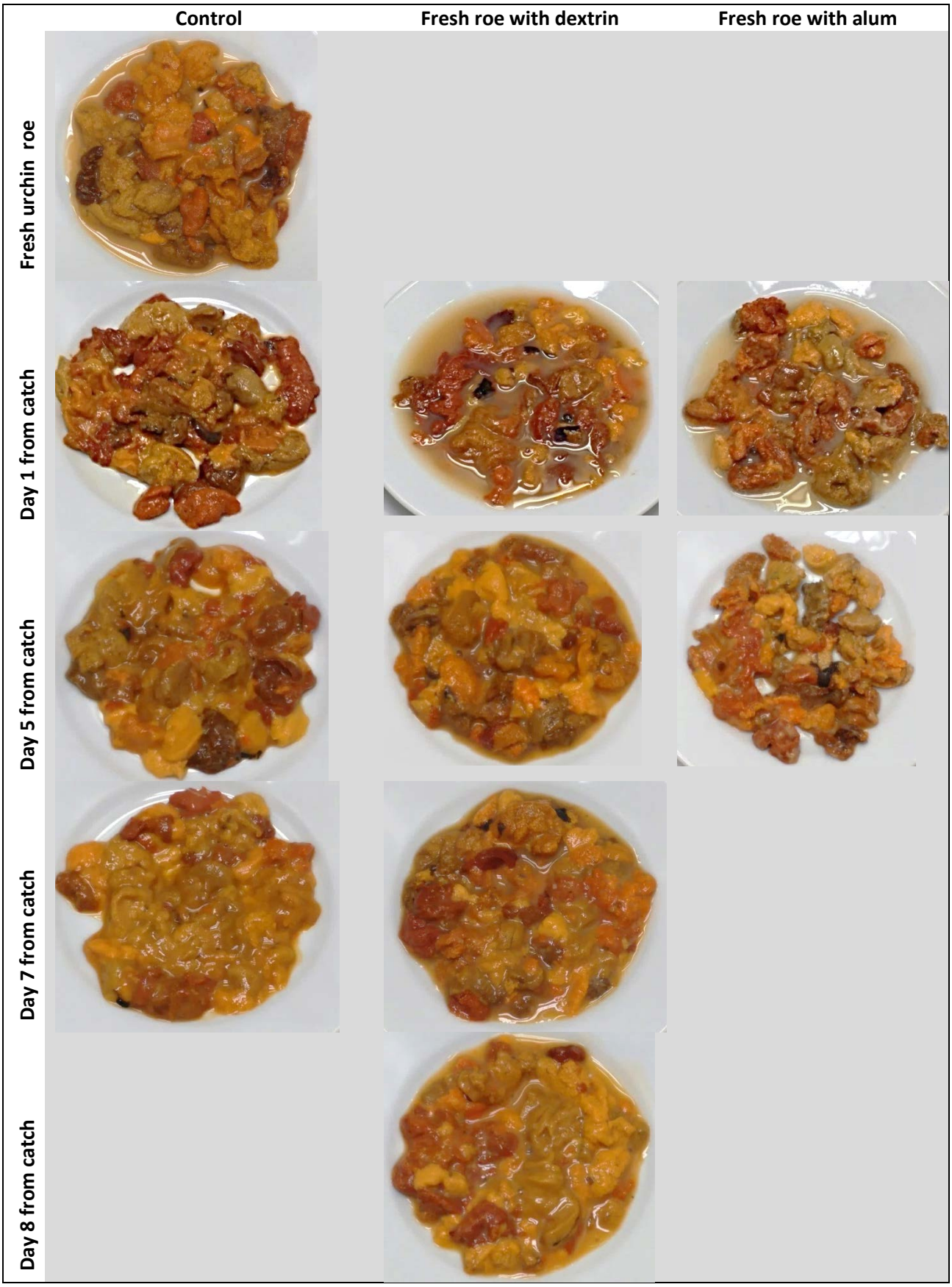


Figure 2. Appearance of fresh sea urchin roe (control) and roe treated with dextrin (5%) or alum (2%) stored at 0-2°C.

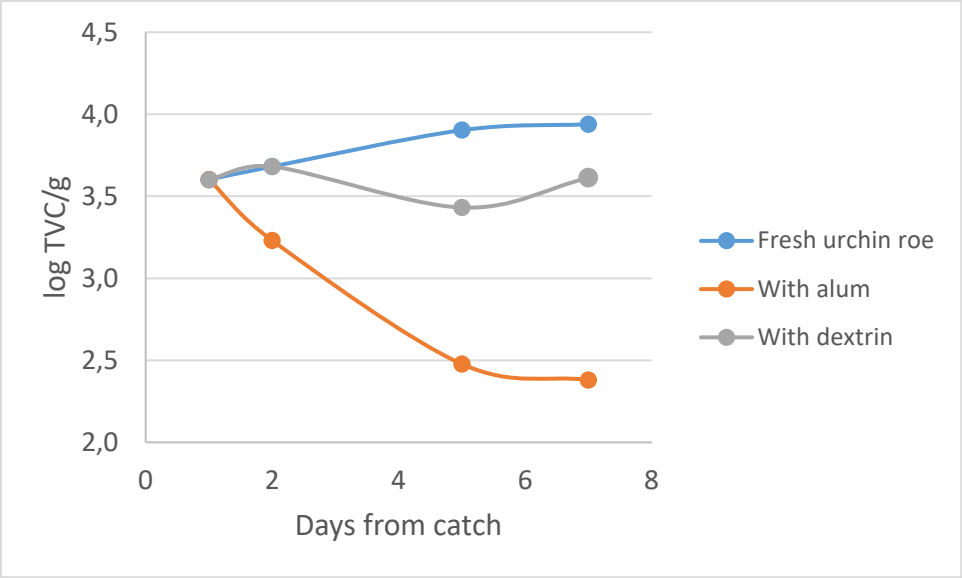


Figure 3. Total viable count in fresh sea urchin roe and roe treated with alum and dextrin at 0-2°C

The sensory evaluation shows that the control and fresh roe with dextrin had a characteristic odour and flavour typical for sea urchin roe on days 1 and 2 from catch, but the roe with dextrin was evaluated saltier, probably due to the salt brine used. On day five the roe was more dissolved but no off-odour or off-flavour was detected. It is likely that roe treated with dextrin may give a slightly more gelatinous texture. On day 7 both the control and fresh roe treated with dextrin were quite dissolved but slightly less in the roe treated with dextrin. The untreated fresh roe had a spoilage odour and was not tasted. The dextrin treated roe had lost its freshness characteristics but had not developed spoilage odour or flavour. On day 8 from catch the dextrin treated roe was rather dissolved but still had not developed spoilage odour or flavour. However, the roe was not fresh and had chemical or iodine flavour as an aftertaste.

Alum gave a strong off-flavour described as metallic, sour and bitter. The sensory panel found the alum treated roe not suitable for consumption.

The microbial results show that at day one from catch the fresh roe had about 4.000 colony forming units/g (CFU). On day 7 the number of CFUs was still low in the fresh untreated roe or about 8.700 CFU/g. The level of CFUs in the roe treated with dextrin remained low during the storage period whereas in the roe treated with alum the CFUs decreased rapidly with only 240 CFU/g on day 7 from catch.

Pasteurised roe

Day 1 from catch

Pasteurised roe, control

Appearance: Very little liquid (compared with fresh roe). The colours are paler than that of the fresh roe. The roe looks drier and firmer than the fresh roe and is more difficult to split with a fork.
Odour: Much stronger odour than of the fresh roe. Boiled roe, sea or sea shore.
Flavour: Sweet, egg yolk, sea flavour, no bitter taste.
Texture: Drier, firmer and more like the texture of caviar than fresh roe. Melts less in mouth.
Comments: In general, paler colours in the pasteurised roe than in that of the fresh roe.

Day 8 from catch

Pasteurised roe, control

Appearance: Very little liquid, slight precipitations on one roe sack. Roe very well separated, pale colours, mat, individual eggs well visible.
Odour: Mild sea odour (seaweed, sea shore), egg yolks.
Flavour: Not as rich in flavour as the fresh roe, salty, sweet (sweeter than pasteurised roe and pasteurised roe with preservatives), egg yolks, mild cod roe caviar in tubes, sea flavour (sea shore).
Texture: Firm, the form of the eggs felt while chewing, not astringent, not slimy.
Comments: Panellists felt that they rather preferred the orange coloured roe over the brown roe. This should be kept in mind when the results are interpreted.

Pasteurised roe with brine

Appearance: Slight precipitations, very little liquid, roe well separated, brighter colours than that of the control and shinier, individual eggs well visible.
Odour: Mild sea odour, boiled shrimp, less seaweed or sea shore than of the control, trace of egg yolks but less than that of the control.
Flavour: Richer in flavour, saltier (not too salty) and less sweet compared with the control. Shrimp, trace of egg yolks, very little sea flavour.
Texture: Similar to the texture of the control.

Pasteurised roe with preservatives

Appearance: Slightly more liquid than on the control and pasteurised roe in brine. Liquid brown in colour. Roe are brown and pale, individual eggs not well visible, no precipitations.
Odour: Boiled meat, trace of sea shore.
Flavour: Stronger flavour than that of the control and pasteurised roe in brine, sweet and salty (less salty than that in brine and much less sweet than the control). Egg yolks, sea shore, metallic, trace of bitter, some off-flavour (perhaps metallic) that sits as an aftertaste at the back of the mouth, slightly prickling or numbing for some time.
Texture: Slightly softer and melts more than the control and pasteurised roe in brine.

Pasteurised roe with dextrin and preservatives

Appearance: Very little liquid, looks wet, individual eggs are well visible. The colours are variable, individual roe sacks well separated and slight white precipitations are seen in some roe.
Odour: Egg yolks, sea odour (sea, sea shore).
Flavour: Sweet, shrimp flavour, not very salty, egg yolks, aftertaste of sea flavour (sea shore).
Texture: Similar to the texture of the control, roe in brine and roe with preservatives.
Comments: The brown roe have often stronger flavour and seem to be more bitter than roe of other colours.

Pasteurised roe with alum and preservatives

Appearance: Slightly more liquid than on the roe treated with dextrin and preservatives, the roe still seems drier and more mat. More precipitations (on some roe), individual roe well separated, rather bright colours.
Odour: Boiled meet, slightly sour or acidic (vinegar), off–odour (spices?) a trace of cooked eggs, no sea odour.

Flavour: off-flavour, chemical flavour, iodine, bitter, trace of sea shore (more metallic) as aftertaste. Little or no characteristic flavour of sea urchin roe.
Texture: Similar as the texture of other samples.
Comments: Difficult to evaluate flavour and texture due to off-flavour.

Day 14 from catch

Appearance, all samples:
The control has the least liquid and most homogeneous colour but otherwise there is little difference between samples. They are all rather shiny, some roe has slight precipitations. Roe is well separated and has little or no liquid. Individual eggs are well visible. Pale colours.

Pasteurised roe, control

Odour: Weak egg yolk odour, sea shore, no spoilage or off-odours.
Flavour: Very sweet, slightly salty, strong metallic flavour, sea flavour, egg yolks, bitter, characteristic flavour of sea urchin roe, no spoilage- or off-flavour.
Texture: As before, firm, eggs well detectable.

Pasteurised roe with brine

Odour: Weak odour of canned meat, egg yolks, very little sea odour, no spoilage- or off-odour.
Flavour: Salty, less sweet than the control, boiled shrimp, little sea flavour, a trace of metallic as aftertaste, no spoilage- or off-flavour.
Texture: As before.

Pasteurised roe with preservatives

Appearance: More precipitations than that of the control and pasteurised roe in brine.
Odour: Meat, slightly sour (not spoilage), a trace of egg yolks, no spoilage odour.
Flavour: Salty, strong flavour (flavour richness), flavour sensed at the back of the mouth (like umami or MSG) and lingers for a long time, not sweet, a trace of egg yolks, strong aftertaste of sea and metal, no spoilage flavour.
Texture: As before.

Pasteurised roe with dextrin and preservatives

Odour: Weak odour, egg yolks, stock odour, no spoilage- or off-odours.
Flavour: Strong flavour, salty, sweet, slightly acidic, strong seaweed flavour (iodine, metal, sea), egg yolks, no spoilage- or off flavours.
Texture: As before.

Pasteurised roe with alum and preservatives

Odour: Sour odour (acidic), boiled meat, canned tuna, no spoilage- or off-odour.
Flavour: Bitter, sour, not characteristic flavour of sea urchin roe, off-flavour but not spoiled.
Texture: As before.

Day 22 from catch

Pasteurised, control

Appearance: Almost no liquid, a lot of precipitations, individual eggs well visible, rather mat.

Odour: Egg yolks, rather heavy, sea, sea shore, slightly sour, characteristic odour of sea urchin roe, no off-odour or spoilage odour.
Flavour: Rather sweet, not salty, egg yolks, sea shore, some off-flavour in the beginning, seaweed aftertaste, slightly bitter.
Texture: As before.

Pasteurised with brine

Appearance: A little of thin clear liquid, rather bright colours, some precipitations, individual eggs well visible.
Odour: Canned meat, metallic.
Flavour: Quite salty, weak sweet flavour, a trace of egg yolks, strong metallic flavour, strong seaweed and iodine aftertaste, a trace of bitter flavour.
Texture: As before.

Pasteurised with preservatives

Appearance: A little liquid, light brown in colour. Slight precipitations in some roe but less than in other samples.
Odour: Egg yolks, sweet, sea shore, metallic.
Flavour: Quite salty, sea shore, very sweet, egg yolks, a slight metallic and bitter aftertaste, characteristic sea urchin roe, no off-flavour.
Texture: As before.

Pasteurised with dextrin and preservatives

Appearance: Very little liquid, mat, some precipitations, individual eggs well visible.
Odour: Less odour than that in the control, not the characteristic odour of sea urchin roe, a trace of egg yolk odour, off-odour reminding of chemicals but no spoilage odour.
Flavour: A strong flavour of seaweed, iodine, chemicals, sweet, not very salty, egg yolks, strong metallic flavour, off-flavour, not characteristic flavour of sea urchin roe, no spoilage flavour.
Texture: As before.

<u>Day 28 from catch</u>

Appearance all samples: Rather mat colour, a little liquid in all samples but the liquid in the brine sample is slightly milkier than other samples. Past roe with preservatives has the clearest liquid. Some precipitations in all samples, individual roe well separated and eggs well visible.

Pasteurised roe with brine

Odour: Strong seashore odour, slight odour of canned meat, not sweet, rather heavy odour.
Flavour: Strong flavour, very salty, sweet, egg yolk, seaweed aftertaste, undefined off-flavour, reminds of old boiled meat, not fresh but still not spoiled.
Texture: As earlier for pasteurised roe in brine.
Comments: Not suitable for consumption due to off-flavour.

Pasteurised roe with preservatives

Odour: Mild, sweet, sea shore.
Flavour: strong flavour, salty, strong seaweed flavour, sweet, egg yolks, no off-flavour or spoilage flavour.

Texture: As earlier for pasteurised roe with preservatives but rather soft, softer than the sample in brine.

Pasteurised roe with dextrin and preservatives.

Odour: Green odour, canned vegetable, corn, not sweet, trace of seaweed odour.
Flavour: Very salty, some off-flavour, mould, a trace of sweet and egg yolks.
Texture: As earlier for pasteurised roe.
Comments: Not suitable for consumption due to off-flavour.

Pasteurised roe with alum and preservatives
Not evaluated due to off-flavour in previous samples.

<u>Day 43 from catch</u>

Appearance both samples
The sample with the preservatives is wetter and more colourful than the one with dextrin and preservatives, has slightly more precipitations and is firmer. The samples break easily when pressed.

Pasteurised roe with preservatives

Odour: Prickling, strong sea odour, strong egg yolk odour, seaweed odour, No spoilage- or off-odours.
Flavour: Strong flavour, strong seaweed, chemical and iodine. Sweet flavour and egg yolks at the end.
Texture: As before.

Pasteurised roe with dextrin and preservatives

Odour: Rather weak, not fresh odour, seaweed and sea, slight canned odour, egg yolks.
Flavour: Rather weak flavour compared to pasteurised roe with preservatives, stale seaweed flavour, not fresh, less egg yolks and more bitter than pasteurised roe with preservatives, slightly sour, stale water.
Texture: As before but the eggs seem slightly bigger.

Figures 4 and 5 show the changes in the appearance of the pasteurised roe, treated and untreated.

Figure 4. Appearance of pasteurised roe and pasteurised roe in brine after 1, 14 and 28 days of storage at 0-2°C.

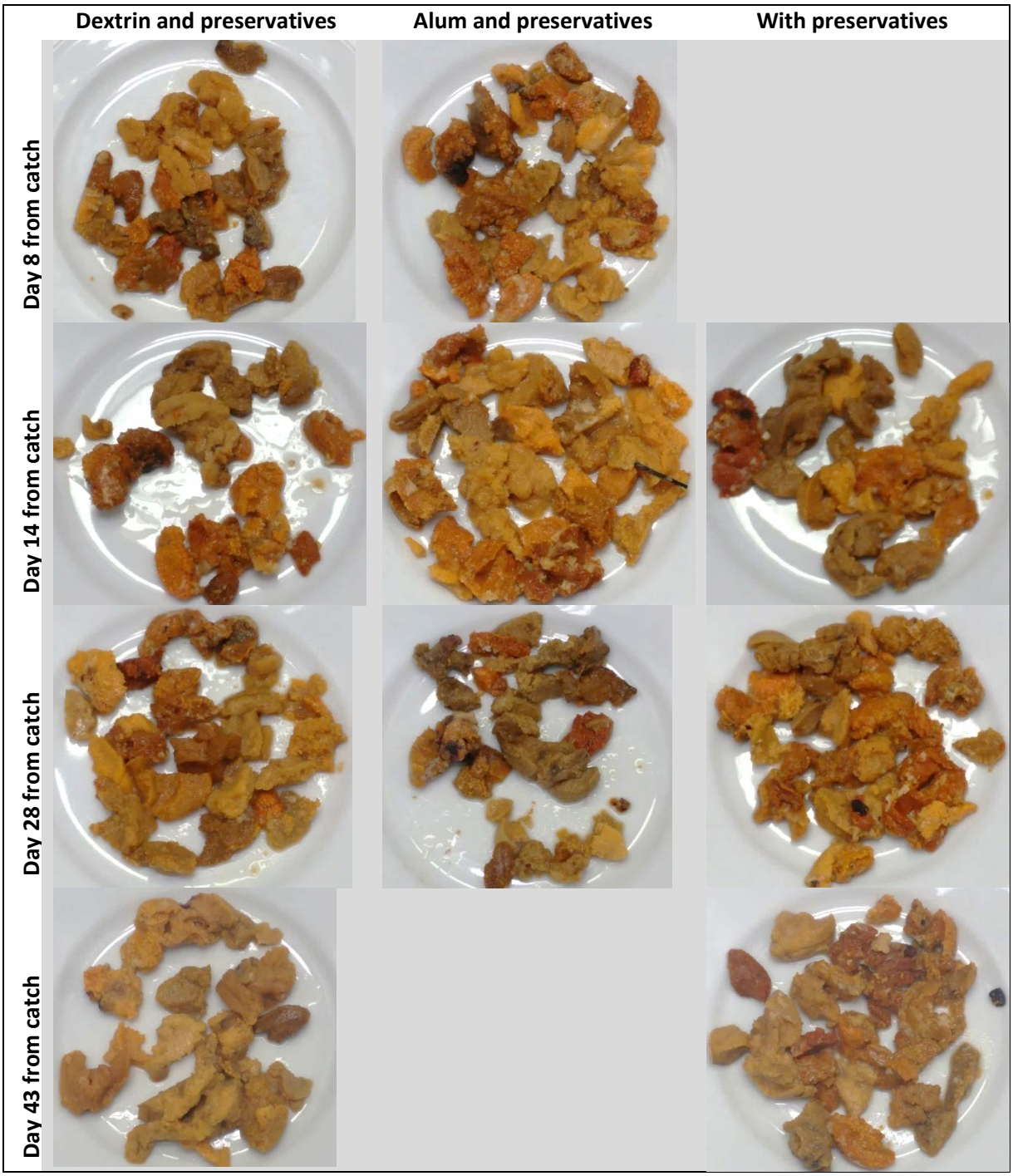


Figure 5. Appearance of pasteurised roe with dextrin & preservatives and alum & preservatives after 8, 14, 28 and 43 of storage at 0-2°C

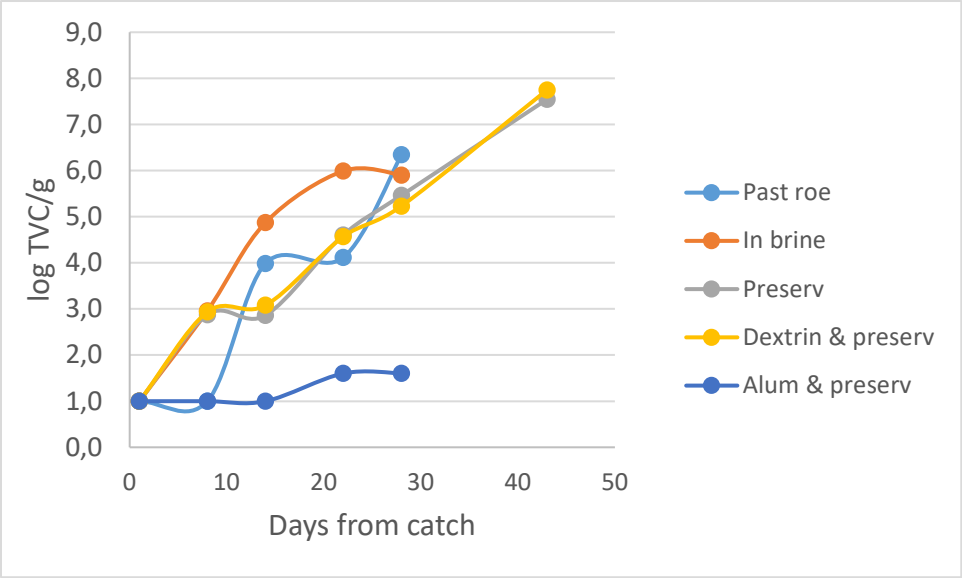


Figure 6. Total viable count in pasteurised sea urchin roe, pasteurised roe in brine, with preservatives, treated with alum and dextrin at 0-2°C.

The sensory evaluation of untreated pasteurised roe shows that initially (1 day from catch) the freshness characteristics was sea odour, egg yolk odour, sweet flavour, egg yolk flavour and sea flavour. On day 14 from catch, a strong metallic flavour had developed but the roe was still fresh, very sweet and had characteristic flavour of sea urchin roe. On day 22 a trace of off-flavour and seaweed aftertaste was detected, and the sweet flavour had decreased. The untreated pasteurised roe was however not considered spoiled at that point.

The pasteurised roe in brine had less sweet egg yolk flavour than the control (day 8 from catch) and, as for the untreated roe, the freshness characteristics decreased with storage, a strong metallic taste and a strong seaweed and iodine aftertaste had developed. However, the roe was not considered spoiled after 22 days from catch. On day 28 from catch a trace of undefined off-flavour was detected in the pasteurised roe in brine, which reminded panellists of old boiled meat. The off-flavour was not described as normal spoilage flavour but the roe was evaluated unfit for consumption.

The pasteurised roe with preservatives had at the beginning of the storage a flavour that reminded the panellists of boiled meat and sea shore. The meaty odour seemed to disappear with storage. The flavour was very strong throughout the storage time, and the panellists described a metallic aftertaste lingering at the back of the mouth for a long time. The flavour was salty and sweet (but less sweet than that of the control), metallic and reminding of seaweed. No spoilage characteristics were detected on the last sampling day, 43 days from catch but a strong seaweed flavour was detected and the sweet flavour had decreased.

The pasteurised roe with dextrin & preservatives had at the beginning of storage an odour reminding the panellists of egg yolks and sea; the flavour was sweet, not very salty but similar to the flavour of egg yolks and shrimp. On day 14 from catch, a strong seaweed flavour was detected (iodine, metal, sea) but the flavour was still sweet and reminded of egg yolks. On day 22 an off-odour reminding of chemicals was detected, but the flavour was still sweet and reminded panellists of egg yolks and no spoilage characteristics were detected. On day 28 from catch some off-flavour or mouldy flavour was detected and the panel considered the sample unfit for consumption.

The pasteurised roe with alum & preservatives had a strong off-flavour and little or no characteristic flavour of sea urchin roe. It was not considered fit for consumption.

The appearance of pasteurised roe was more mat and had paler colours than the fresh roe but some white precipitations were observed. The texture of the roe was firmer than that of the fresh roe and more like the texture of caviar. The appearance and texture of the pasteurised roe changed little during the storage period.

The microbial results of pasteurised roe initially showed very low counts of CFUs or <10/g. With storage, TVC increased in all groups except in the pasteurised roe with alum & preservatives. On day 28 from catch, it only had 40 CFU/g. At the end of the storage test (day 43 from catch) the CFU in the pasteurised roe with preservatives and roe with preservatives & dextrin had reached 7.5-7.7 log TVC/g. The untreated pasteurised roe had low counts on day 22 from catch (13,000 CFUs/g) but on day 28 the counts had reached 2,200,000 CFUs/g.

Frozen roe

Frozen - Fresh roe

1 month of storage

Appearance, all samples:

Fresh roe blast frozen and fresh roe with dextrin frozen in nitrogen, are very similar. They are very wet, porridge like, and blend together like a thick sauce. Fresh roe with alum also frozen in nitrogen, has less liquid, is slightly more separated but still quite blended. Roe with alum is slightly darker than roe with dextrin and the control.

Fresh roe, blast frozen (untreated)

Odour: Similar but slightly stronger than of roe with dextrin.
Flavour: Very strong flavour, sweet, characteristic, strong seaweed flavour, some off-flavour (starch?).
Texture: Thick and slimy texture, a little grainy, tiny gelatinous grains, reminds of potato starch which has not dissolved completely. The grains are visible in the liquid.

Fresh roe with dextrin, frozen in nitrogen

Odour: Cold, cucumber, sea or sea shore.
Flavour: Very rich in flavour, sweet, egg yolks, seaweed and bitter as aftertaste, characteristic sea urchin roe flavour.
Texture: Roe not separated, sauce like, thick and mucous.
Comments: Appearance is unappealing since the roe is very sauce like.

Fresh roe with alum, frozen in nitrogen

Odour: Mild odour, cucumber, not as fresh as the control and roe with dextrin, more sea shore odour.
Flavour: Off-flavour, strong seaweed flavour, mouldy, sour.
Texture: Thick and slimy.
Comments: Not suitable for consumption due to off-flavour.

3 months of storage

Appearance, all samples:

The appearance of all samples is wet and shiny, porridge like, slimy and dissolved. Fresh roe with dextrin blast frozen, is a little thicker than other samples.

Fresh roe, frozen in nitrogen

Odour: Cucumber, sea odour, slightly heavy odour.
Flavour: Very strong off flavour, strong chemical flavour, iodine, bitter.
Texture: As before.
Comments: Not suitable for consumption due to off-flavour.

Fresh roe, blast frozen

Odour: Cucumber, sea odour, metallic, not as heavy odour as of the fresh roe frozen in nitrogen.
Flavour: Very strong off-flavour, very bitter, less chemical flavour than that of the fresh roe, frozen in nitrogen.
Texture: As before.
Comments: Not suitable for consumption due to off-flavour.

Fresh roe with dextrin, frozen in nitrogen

Odour: Cucumber, sea odour.
Flavour: First slightly sweet and salty, aftertaste of seaweed and mould, bitter.
Texture: As before.
Comments: Not suitable for consumption due to off-flavour.

Fresh roe with dextrin, blast frozen

Odour: Cucumber, sea odour.
Flavour: First sweet and salty flavour, then chemical flavour and very bitter aftertaste.
Texture: As before.
Comments: Not suitable for consumption due to off-flavour.

Fresh roe with alum, frozen in nitrogen

Comments: Not evaluated due to strong off-flavour of alum.

Fresh roe with alum, blast frozen

Comments: Not evaluated due to strong off-flavour of alum.

6 months of storage

Fresh roe, frozen in nitrogen (untreated)

Appearance: Very wet and porridge like, slimy, yellow and brown colours (reminds of old fashioned fruit compote).
Odour: Cucumber, fresh, cold, a trace of egg yolk odour.
Flavour: Very strong flavour, very bitter, egg yolk flavour, sea shore, metallic, strong chemical flavour, not fresh. The odour is fresh but not the flavour.
Texture: Like a thick lumpy sauce.
Comments: Not fit for consumption due to a strong bitter, chemical and metallic flavour.

Fresh roe with dextrin, blast frozen

Appearance: A lot less liquid than in the untreated roe, a little bit of thick liquid, darker colour than of the untreated roe and not as dissolved.
Odour: Not as fresh as of the untreated roe, a trace of cucumber odour, heavier odour and more sea shore odour than of the untreated roe, trace of egg yolk odour.
Flavour: Stronger flavour than of the control, first a trace of egg yolks and sweet but then extremely strong bitter and chemical flavour.
Texture: As before.
Comments: Not fit for consumption due to a strong bitter and chemical flavour.

Figure 7 shows the appearance of defrosted roe, both blast frozen and frozen in nitrogen; untreated, treated with dextrin and treated with alum, compared to fresh, unfrozen and untreated roe.

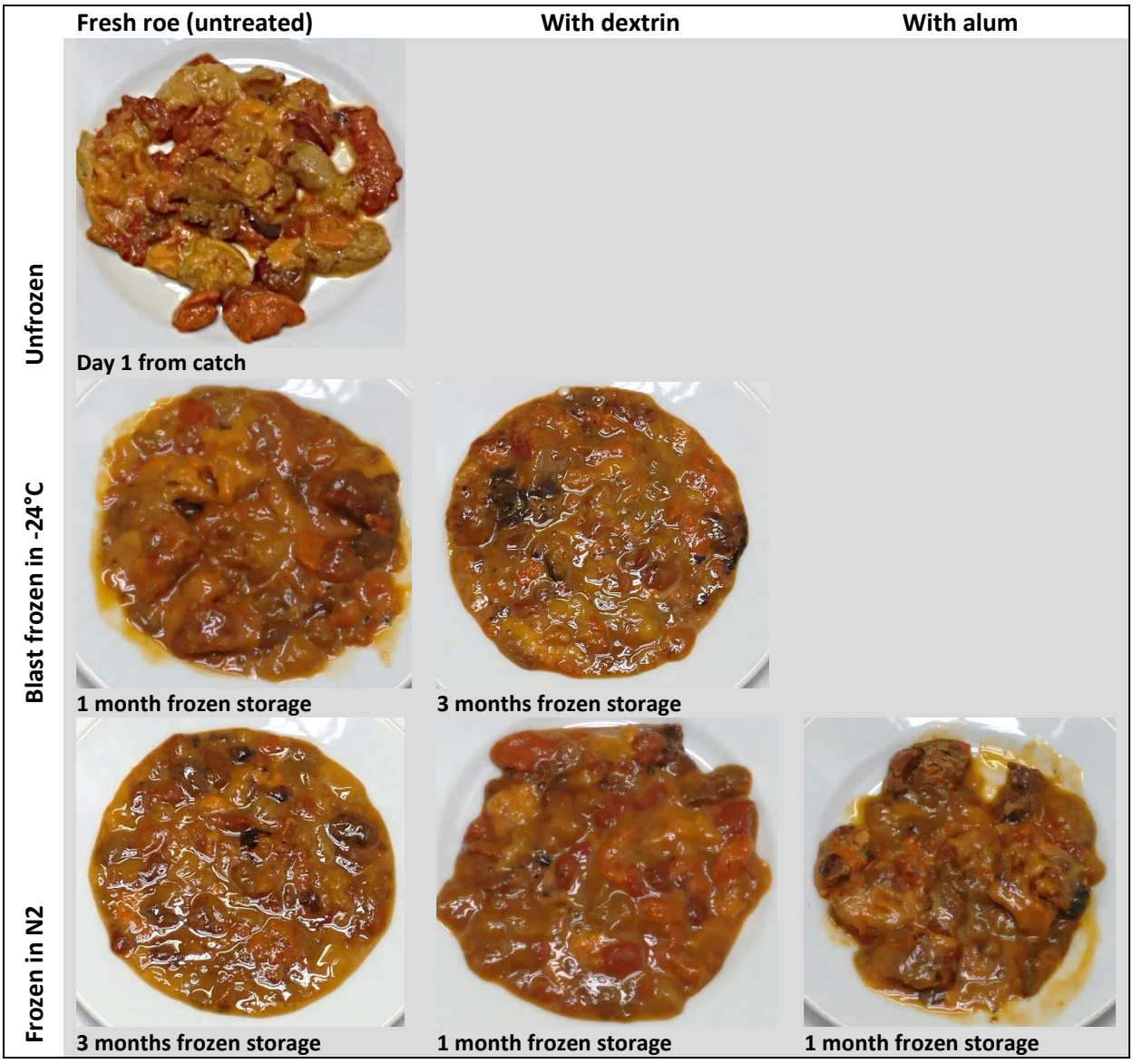


Figure 7. Appearance of fresh frozen roe (in N2 and blast frozen), untreated, treated with dextrin and treated with alum, compared with fresh, untreated and unfrozen roe.

After defrosting, all fresh frozen roe was quite dissolved and the appearance was porridge or sauce like and the roe was quite liquefied. The texture was thick and mucous. As for fresh unfrozen roe, the use of alum resulted in an off-flavour which made the roe unfit for consumption.

The odour and flavour after one month of frozen storage was quite similar to that of fresh unfrozen roe. The odour reminded of cucumber and sea shore and the flavour was sweet, reminding of sea shore and egg yolks. The panellists however detected a trace of off-flavour reminding of starch in untreated blast frozen roe. No off-odour or off-flavour was detected of roe with dextrin frozen in nitrogen.

After three months of frozen storage, all samples had developed an off-flavour. The fresh roe, both blast frozen and frozen in nitrogen, had a very strong off-flavour described as chemical, iodine and bitter. Fresh roe with dextrin frozen in nitrogen had a bitter aftertaste reminding of mould and seaweed. Blast frozen roe with dextrin also had a chemical off-flavour and very bitter aftertaste. The roe with alum was not evaluated due to a strong off-flavour detected in earlier samples.

The off-flavour was also detected after six months of frozen storage in fresh roe frozen in nitrogen, and blast frozen roe with dextrin. The off-flavour was in both cases described as chemical and very bitter.

These results indicate that the sea urchin roe lose their texture when frozen and become dissolved and mucous. The different treatments did not seem to have any considerable effect on the texture of the roe, apart from treatment with alum, which resulted in less dissolved roe. However, treatment with alum also gave a strong off-flavour which made the roe unfit for consumption. The flavour of the frozen roe was fresh after one month of frozen storage and was characteristic of fresh sea urchin roe. After three months of storage, all samples had developed an off-flavour, most often chemical, metallic and very bitter. This indicates that the shelf life of fresh frozen roe, blast frozen and frozen in nitrogen, untreated and treated with dextrin, is between one and three months at -24°C.

Frozen - Pasteurised roe, blast frozen

1 month of storage

Odour: Sweet, egg yolks, boiled meat.
Flavour: Sweet, lamb liver, egg yolk, trace of seaweed, not quite characteristic flavour of sea urchin roe.
Texture: Firm in first bite but soft when chewing. Not slimy, individual roe well separated.

3 months of storage

Appearance: Slight milky, thin liquid, roe well separated, a little bit of precipitation.
Odour: Characteristic odour of fresh sea urchin roe, egg yolks.
Flavour: Sweet, salty, sea flavour, egg yolks, metallic aftertaste, bitter.
Texture: As before.

6 months of storage

Appearance: Well separated, no liquid, pale autumn colours, slight precipitations.
Odour: Weak sweet odour of egg yolks, canned meat.
Flavour: First sweet and egg yolks, then sea shore, not fresh, a trace of off-flavour (beginning of spoilage) as aftertaste in some of the roe.
Texture: As before.

Figure 8 shows the appearance of unfrozen pasteurized roe one day from catch at 0-2°C, and blast frozen roe after 3 and 6 months of frozen storage at -24°C.

Figure 8. Pasteurised roe, unfrozen, and blast frozen after 3 and 6 months of storage at -24°C.

Changes in the appearance and texture of pasteurized roe, blast frozen at -24°C, were not detectable. The roe was well separated, had little or no liquid, slight precipitations and pale colours (compared to fresh roe). The texture was firm on first bite but soft while chewing. The roe was not slimy and individual roe was well separated. The odour was sweet and reminded of egg yolks and canned meat and the flavour was sweet, reminding of egg yolks and seashore, sometimes with metallic and bitter aftertaste. The panellists evaluated roe after one and three months of storage fresh but a trace of off-flavour or beginning of spoilage was detected in roe after six months of frozen storage.

Whole (live) sea urchins

All sea urchins were alive after 2 and 5 days from catch, the mouths were closed and the odour was fresh. On day 9 from catch, one urchin out of 18 had an open mouth but no spoilage odour was detected (Figure 9). On day 13 from catch, 3 urchins out of 17 were open, a strong spoilage odour was detected, the urchins were darker than before and dark liquid had accumulated in the box. Therefore it can be concluded that the shelf life of live sea urchins is between five and nine days at the conditions described previously.

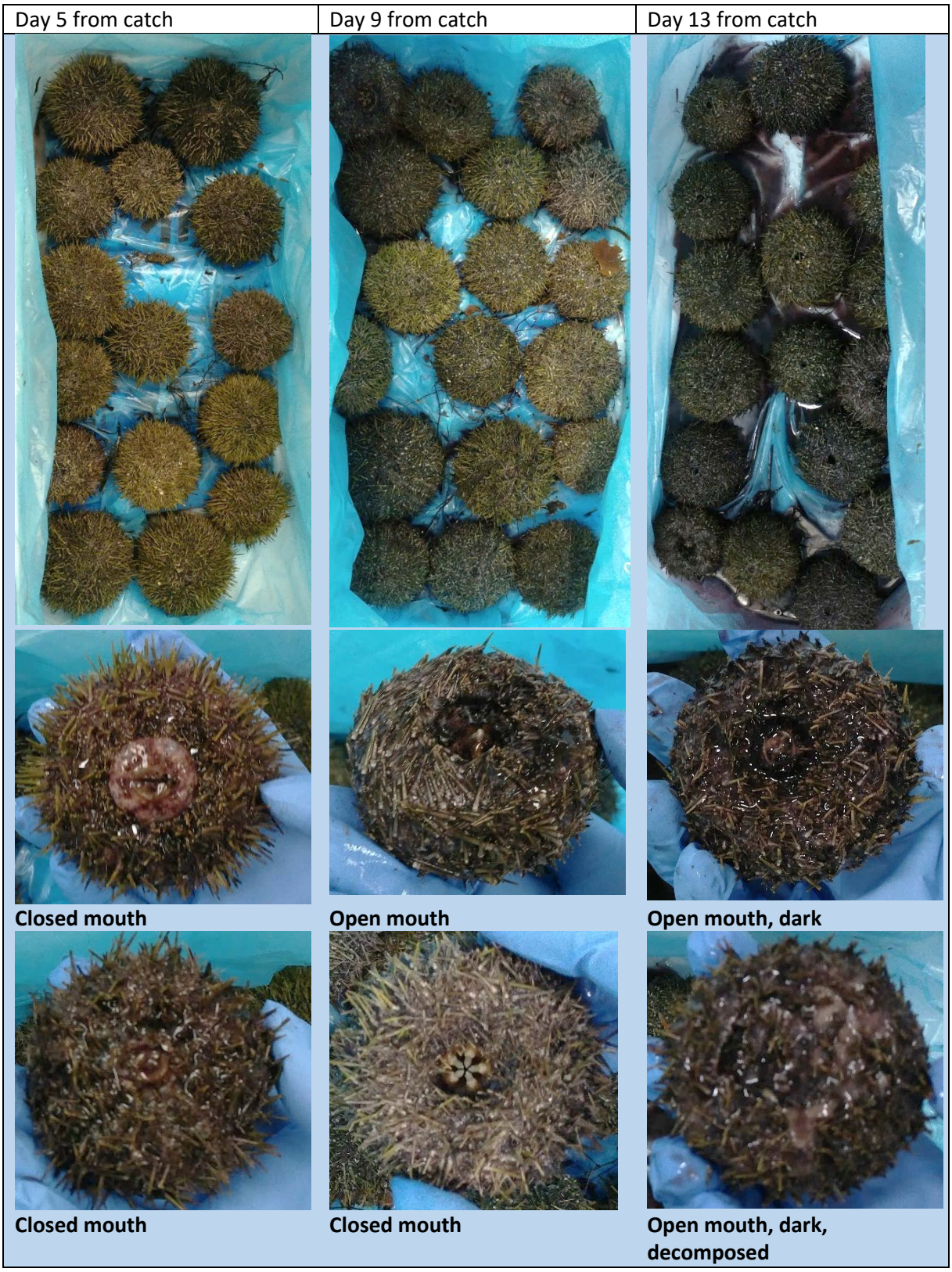


Figure 9. Changes in appearance of live sea urchins stored in polystyrene boxes at 3-4°C. Photos in the top row show the sea urchins when the boxes were opened on sampling day. Rows 2 and 3 show the oral side of two individual sea urchins on the same day.

Conclusion

Sensory characteristics

The freshness characteristics of fresh sea urchin roe were: sea odour & flavour, egg yolk odour & flavour and sweet flavour. The flavour was similar but milder in pasteurised roe. In general, with time the sweet, egg yolk and sea flavours seemed to decrease but metallic, seaweed and chemical flavours increased.

Shelf life of fresh roe

The fresh roe did not change to any large degree on storage from one to two days from catch. After five days from catch, it had begun to dissolve but was still considered fresh. After seven days of storage the roe was quite liquefied and the control group was not tasted due to spoilage odour. On day eight, roe with dextrin had lost its freshness characteristics but was still not spoiled. The dextrin at the level used did not seem to have any large effect on the texture; the roe treated with dextrin had become quite liquid and had a similar texture as the fresh untreated roe on day 5 from catch. The roe treated with alum had a better texture – less liquid and firmer - than the fresh roe on day 5 from catch but the alum left an unpleasant bitter, chemical flavour. In fact, due to the off-flavour the panellists commented that fresh roe treated with alum was not suitable for consumption.

Shelf life of pasteurized roe

All samples of pasteurised roe were considered fresh and without spoilage characteristics 14 days from catch. After 22 days from catch all groups had lost their freshness characteristics but were still not spoiled. However, the control group had a trace of off-flavour which might indicate the beginning of spoilage. After 28 days from catch, the roe in brine was considered at the threshold of shelf life, roe with dextrin was considered spoiled but roe with preservatives was still quite fresh with no spoilage characteristics. After 43 days from catch both samples evaluated, roe with dextrin and roe with preservatives, had lost their freshness but were not considered spoiled.

These results indicate that all samples of pasteurised roe had a freshness period of at least 14 days and a shelf life of 22 days or more. The freshness seems to decrease in most samples between 14 and 22 days of storage. Roe with preservatives seemed to have a longer freshness period than the other groups. Even though the two groups tested on day 43 were not considered spoiled, they had developed an off-flavour and had lost their freshness characteristics.

The texture of the pasteurised roe was firmer than that of the fresh roe and did not become liquid on storage. Dextrin and alum did not seem to affect the texture of the pasteurised roe to any significant degree. The alum however left an unpleasant off-flavour.

Shelf life of frozen roe

Thawed roe, frozen for one month had a very thick, sauce like and slimy texture. The flavour and odour were however similar to that of fresh (unfrozen) roe. After three months storage at -24°C all tested samples of fresh frozen roe had developed a strong off-flavour and were considered unfit for consumption by the panellists. However the texture and flavour of frozen pasteurised roe was similar to that of unfrozen pasteurised roe after both one and three months of storage but the frozen roe had a trace of an off-flavour after 6 months of storage.

Treatments

Different effect of treatments on the sensory characteristics of the roe was detected. Pasteurised roe with brine was evaluated less sweet and saltier than untreated roe, but was otherwise quite similar. Pasteurised roe with preservatives had a strong flavour throughout the storage time and the panellists described a metallic aftertaste lingering at the back of the mouth for a long time. Pasteurised roe with dextrin & preservatives did not have a distinct off-odour or off-flavour and the odour and flavour was quite similar to that of the control. All samples of alum treated roe were considered unfit for consumption by the panel, due to off-flavour.

Final conclusions

The results indicate that texture (and appearance) limits the keeping-life of fresh roe and the shelf-life can be expected to be between one and four days at 0-2°C. Pasteurised roe had a freshness period of at least 14 days and a shelf life of 22 days or more at 0 – 2°C, with no detectable changes in appearance or texture. Freezing of fresh roe resulted in a porridge like texture and no difference was seen between freezing methods, blast freezing and liquid nitrogen freezing. Freezing of pasteurised roe did not change the texture or flavour of the roe; however, after 6 months freezer storage, the roe had a trace of an off-flavour. Treatment with alum gave all samples a strong off-flavour which made them unfit for consumption. Preservatives gave a strong flavour and a metallic aftertaste but treatments with dextrin did not have a considerable effect on sensory characteristics.

Acknowledgements

The authors thank Ragnar Jóhannsson, physical chemist, for scientific advice and technical help and Óli Þór Hilmarsson for technical assistance.

References

ISO 8586 (2008). Sensory analysis general guidance for the selection, training and monitoring of assessors. Part 1: selected assessors. The International Organization for Standardization, Geneva, Switzerland.

James, P., Noble, C., Hannan, C., Stefánsson, G., Þórarinsdóttir, G., Sloane, R., Ziemer, Nl, Lockhead, J. (2016). Sea urchin fisheries, management and policy review. Report 18/2016 Nofima, Norway.

NMKL, Nr 86, (2013). Areobic microorganisms. Determination in foods at 37°C, 30°C, 25°C, 20°C, 17/7°C r 6.5°C by the colony count method. Nordic Committee on Food Analysis 5th edition. http://www.nmkl.org/dokumenter/sk/86sk5utg2013.pdf

Stefansson, G., Petty, H. T., Ziemer, N., Hannon, C. and James, P (2017). Markets for Sea Urchins: A Review of Global Supply and Markets. Matís report, Reykjavik, Iceland.