

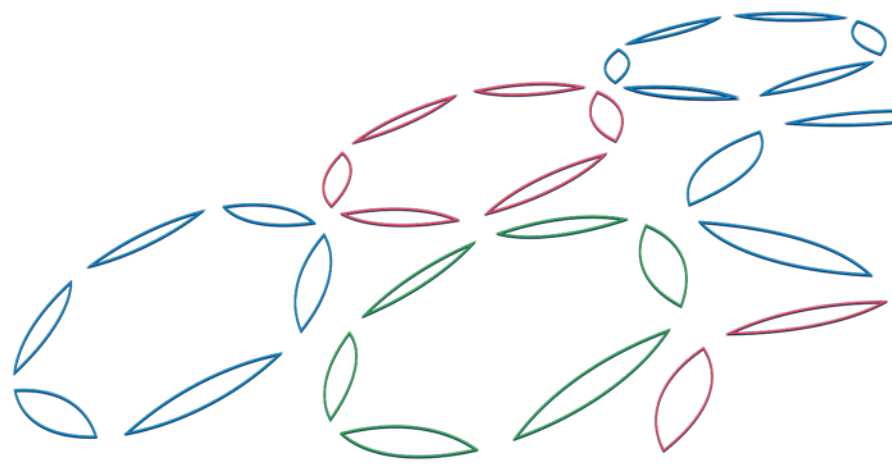


Styrene migration from expanded polystyrene boxes into fresh cod and redfish at chilled and superchilled temperatures

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Titill / Title	Styrene migration from expanded polystyrene boxes into fresh cod and redfish at chilled and superchilled temperatures		
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Ágrip á íslensku:	<p>Markmið tilraunarinnar var að rannsaka mögulegt flæði stýrens úr frauðplastkössum í fersk þorsk- og karfaflök, sem geymd eru við dæmigert hitastig í sjóflutningi á ferskum flökum frá Íslandi til Evrópu eða Ameríku. Amerískir kaupendur óska eftir því að fiskflökum sé pakkað í plastpoka fyrir þökkun í frauðplastkassa vegna mögulegrar stýrenmengunar úr frauði í fisk. Því var í þessu verkefni mælt stýren í fiski, sem geymdur hafði verið án plastpoka í frauðkössum, og magn stýrens borið saman við viðmið bandaríska matvæla- og lyfjaeftirlitsins (FDA).</p> <p>Í heildina voru 12 frauðkassar, sem innihéldu þorsk- eða karfaflök, geymdir í 4, 7 eða 13 daga við annaðhvort -1 °C eða 2 °C, sem samsvarar annars vegar ákjósanlegasta og hins vegar hæsta líklega hitastigi í sjóflutningi með fersk flök. Eitt 10-50 g sýni var tekið úr neðsta hluta neðsta fiskflaks í hverjum kassa og hafði þar með verið í beinni snertingu við frauðplast og því komið fyrir í glerflösku. Því næst voru sýnin 12 send til greiningar hjá Eurofins, alþjóðlegri rannsóknastofu í Þýskalandi.</p> <p>Niðurstöðurnar sýna að magn stýrens, sem og annarra óæskilegra efna líkt og bensens og tólúens, var undir 0,01 mg/kg fisks í öllum tólf fisksýnunum. Viðmið (hámark) FDA er 90 mg af stýreni í hverju kg af fiski á einstakling á dag, sem jafngildir skv. niðurstöðum þessarar tilraunar er að neytandi þarf að neyta daglega 9000 kg af fiski til að nálgast viðmið FDA sem er mjög óraunhæft magn. Meginniðurstaða þessarar tilraunar er því að ekki er nauðsynlegt að pakka ferskum fiskflökum í plastpoka fyrir þökkun í frauðplastkassa, sem geyma og flytja á við kældar og ofurkældar aðstæður.</p>		
Lykilorð á íslensku:	Stýrenflæði, frauðplast, ferskur fiskur, þorskur, karfi		

Report summary

<p><i>Summary in English:</i></p>	<p>The aim of the study was to investigate possible styrene migration from expanded polystyrene into fresh cod and redfish, two important export fish species in Iceland, while stored under conditions mimicking transport by ship from Iceland to America and Europe. American buyers wish to have a plastic bag between EPS boxes and fish during transport as a safety measure due to possible styrene migration. Thus, this project was conducted to investigate if adding a plastic bag is necessary with regards to safety limits for styrene migration from packaging to food set by the FDA (US Food and Drug Administration).</p> <p>A total of twelve samples of cod and redfish were stored in EPS boxes manufactured by Temptra Ltd. for 4, 7 and 13 days at two temperatures (-1 °C, 2 °C) which represent optimal and expected maximum storage temperatures during sea transport of fresh fish. A sample of 10-50 grams of fish, which had been in direct contact with the packaging, was taken from the bottom of each box, as it is considered the most hazardous place regarding styrene migration, and put in a glass bottle before analysis. Finally, the twelve samples of fish were sent to Eurofins, an international laboratory in Germany, for analysis.</p> <p>The results show that styrene content, and other solvent residues like benzene or toluene, were below 0.01 mg/kg in all twelve samples of fish. The FDA's daily intake limit of styrene is 90 mg/kg per person per day, which means that in this study an unrealistic intake of at least 9000 kg of fish would be necessary to exceed this FDA's limit. The main conclusion from this study is therefore that a plastic bag is not needed to safely pack cod and redfish fillets into EPS boxes to be stored under chilled and superchilled temperatures.</p>
<p><i>English keywords:</i></p>	<p><i>Styrene migration, expanded polystyrene, fresh fish, cod, redfish</i></p>

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INTRODUCTION

Tempra is a plastic manufacturer of EPS (expanded polystyrene) boxes, used mainly for food packaging in Iceland and throughout the world. Traditional EPS boxes (Figure 1) are widely used for the transport of fish by truck, plane or ship. EPS is manufactured with styrene beads which are heated in high pressure steam and bound to each other. The final packaging is comprised of 98% air and 2% polystyrene. During the production process, styrene monomer can be obstructed in the EPS product and can possibly migrate out of the packaging into the food.



Figure 1. Traditional EPS box used for fish transport

The project was to elaborate and monitor a plan for studying the possible migration of styrene from expanded polystyrene boxes to fresh fish. The most important factors controlling the transport are temperature, storage time of fish and fish species. It has been shown that fat content of the food can also affect the migration of styrene into food (Lickly et al., 1995, Tawfik, 2014), thus both cod and redfish are considered in this current study. Nowadays, American buyers wish to have the fish packed in a plastic bag inside the EPS box, contrary to the Europeans who allow it without the plastic bag. In this study, we tried to determine if possible migration of styrene into the fish could occur, which would bring possible impact on human health and whether adding a plastic bag between the fish and the EPS box is necessary with regards to safety limits on styrene migration from packaging to food set by the FDA (US Food and Drug Administration).

MATERIALS & METHODS

Fish fillets from a fish store were put in EPS boxes (Figure 2) and placed in controllable air climate chambers, manufactured by Celsius (Reykjavík, Iceland) at Matís in Reykjavík, Iceland.



Figure 2. EPS boxes with fish before placing them in air climate chambers

Cod and redfish (Figure 3), two species which are commonly fished around Iceland and important export species, were tested at two different storage temperatures: $-1\text{ }^{\circ}\text{C}$ and $2\text{ }^{\circ}\text{C}$, which corresponds to realistic optimum and maximum temperatures for the present sea transport of fresh fish to other countries. The two fish species were also of interest for their different fatty level (cod with about 0.7% and redfish with 1-3%), with a higher rate for the redfish, which could play a role for the styrene migration into food. Some of the fish were placed in EPS boxes with drain holes, iced on top in the traditional way, and stored at $2\text{ }^{\circ}\text{C}$. The rest was placed in EPS boxes without drain holes and stored at $-1\text{ }^{\circ}\text{C}$. Onset temperature loggers (Figure 4), type UTBU-001, were placed inside each box and in the air climate chambers to monitor the temperature during the test. This logger has an accuracy of $\pm 0.2\text{ }^{\circ}\text{C}$, a resolution of $0.02\text{ }^{\circ}\text{C}$ and an operating range of $-20\text{ }^{\circ}\text{C}$ to $+70\text{ }^{\circ}\text{C}$. The diameter is 30 mm and the thickness is 17 mm.

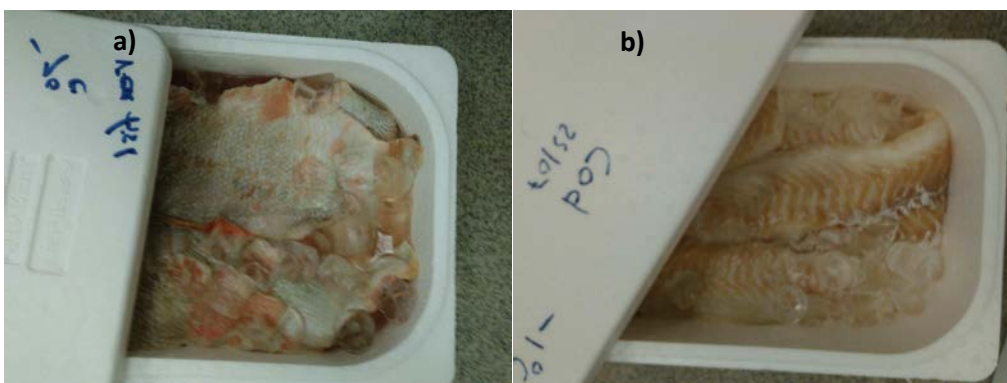


Figure 3. a) redfish fillets and b) cod fillets in EPS boxes



Figure 4. Onset temperature logger

Fresh fish fillets were collected from a fish store and packed in 3-kg EPS boxes manufactured by Tempra Ltd. (Hafnarfjörður, Iceland) on the 19th, 25th and the 28th of July 2017. The fish fillets were either with or without skin. In case of skin on, the bottom fillets had the non-skin side in direct contact with the EPS box. Following packing, the fish was stored in the EPS boxes at either -1 °C or 2 °C for 4, 7 or 13 days, i.e. until the experimental samples were taken on the 1st of August 2017. A sample of 10-50 grams of fish was taken from the bottom of each box in contact with the packaging (Figure 5), as it is considered the most hazardous place regarding styrene migration, and put in a glass bottle before analysis.

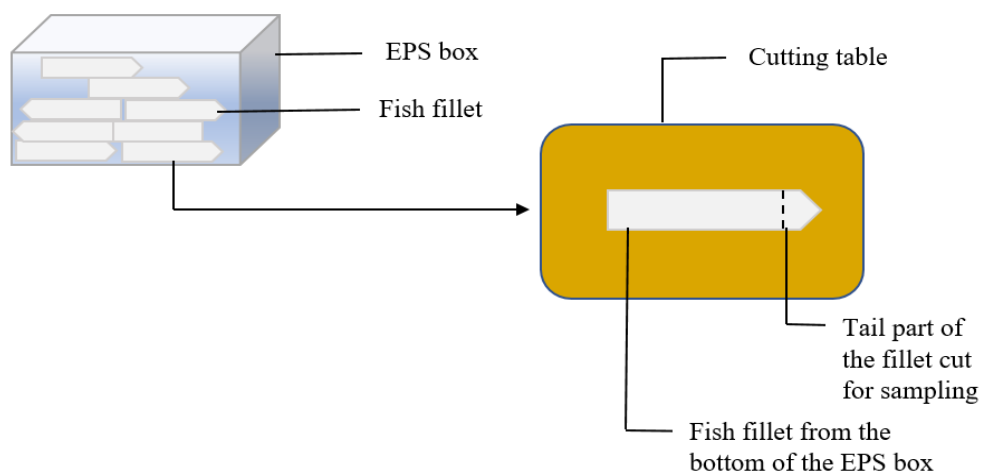


Figure 5. Sampling procedure before analysis

Samples were prepared at Matís (Figure 6), placed in a box filled with ice, and transferred by plane to Eurofins (Figure 7), an international laboratory specialized in bioanalysis located in Germany, for analysis by Gas Chromatography/Mass Spectrometry. The samples were measured by Eurofins between 7th and 9th of August, i.e. at least 10, 13, and 19 days after the fish was packed in the EPS boxes.



Figure 6. Twelve samples of fish in Iceland ready for transport to Eurofins in Germany

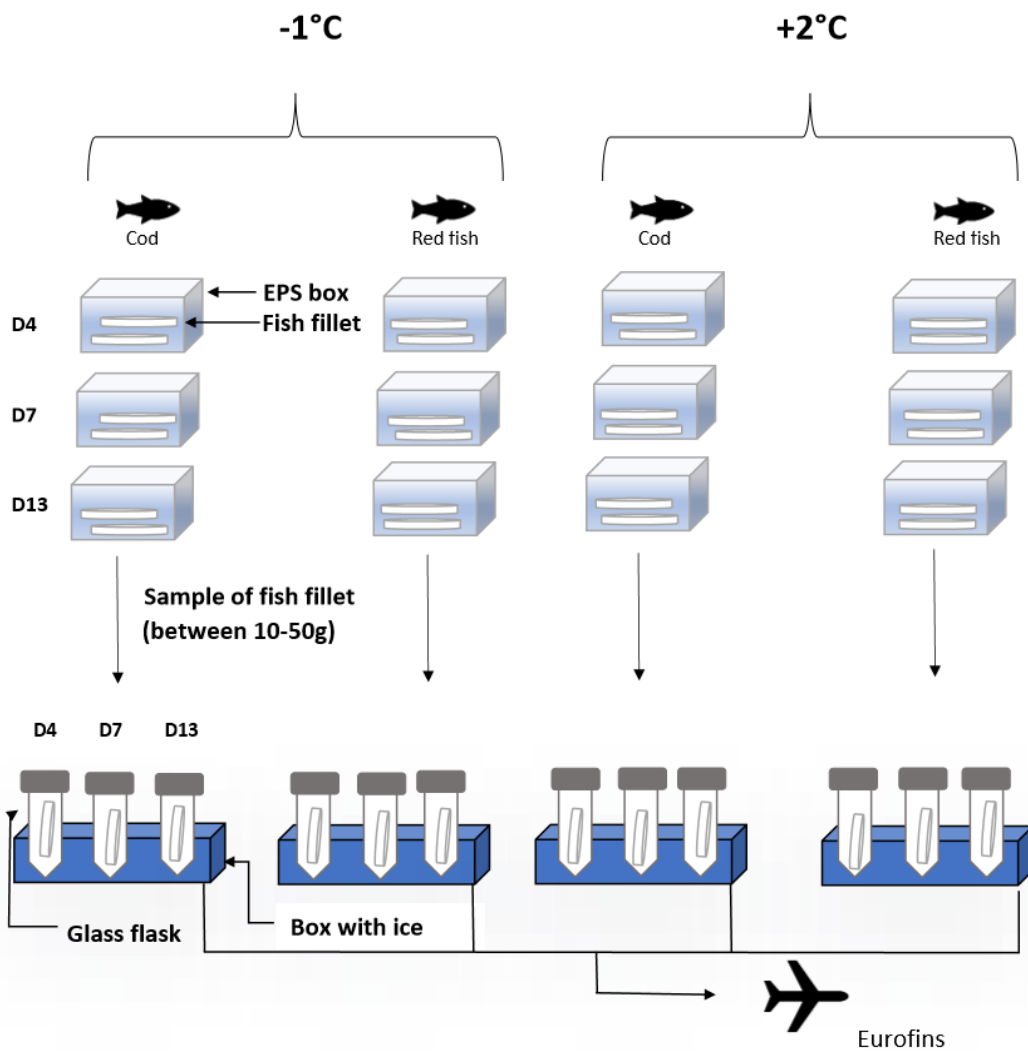


Figure 7. Experimental plan for styrene migration

RESULTS

Temperature

Monitoring the temperature throughout this project was realized by Onset temperature loggers. Two loggers were placed in the air climate chamber (Figure 8), whereas one was placed in each EPS box filled with fish (see Figure 9).

We observed temperature around 0-4 °C of fish fillets at the start of the storage and due to the good insulation of the EPS boxes, a fish temperature stabilization was experienced finally after 8 days of storage in an air climate chamber set at 2 °C. The fish temperature in the chamber set at -1 °C was slightly higher than the set point temperature, i.e. around 0 °C.

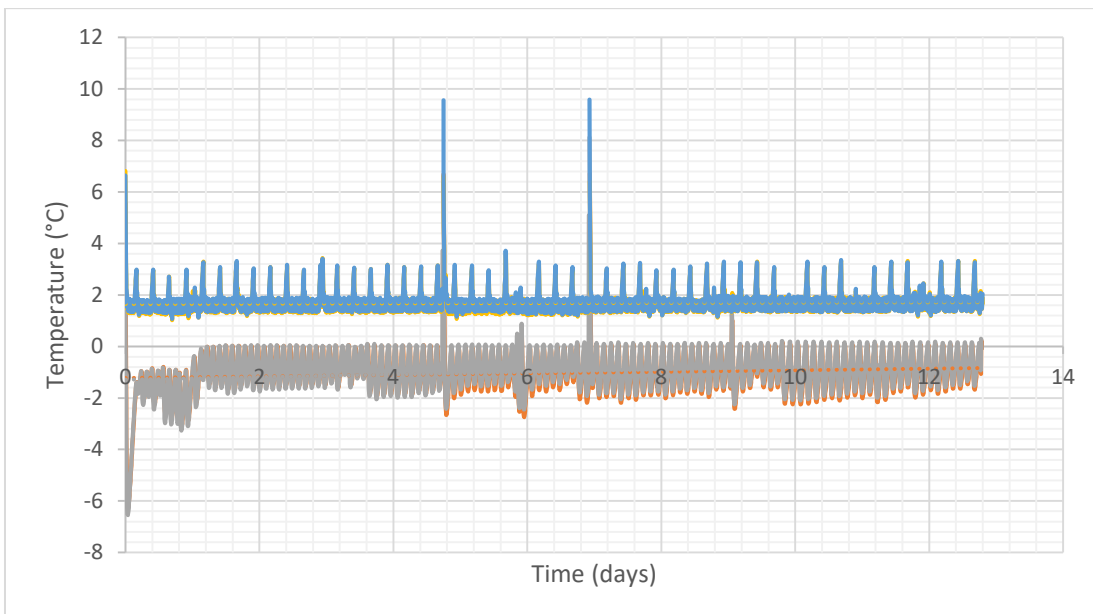


Figure 8. Ambient temperature during storage of fresh fish fillets in EPS boxes in a styrene migration study

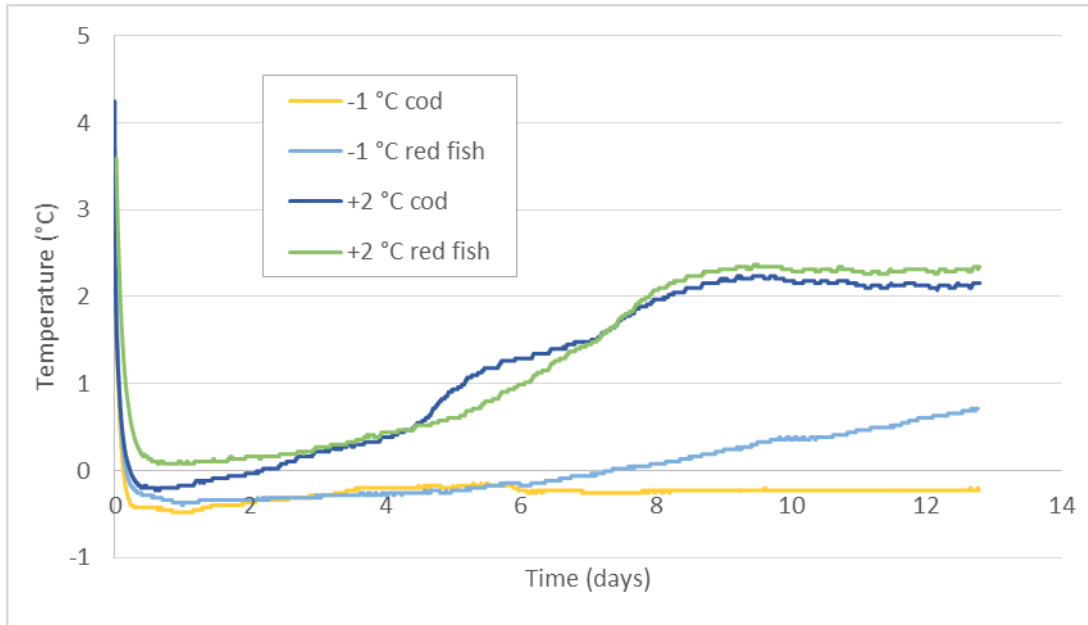


Figure 9. Fish temperature in EPS boxes during storage in a styrene migration study

Diffusion of styrene in the fish muscle

The results from the German laboratory show that all 12 samples of fish fillets presented styrene migration below 0.01 mg/kg (Table 1). It should be noted that the fish fillets were stored in the EPS boxes with direct contact between fish flesh without skin and EPS for 4, 7 and 13 days, respectively. During the analysis, not only styrene but also other components were looked for in the fish: benzene, ethylbenzene, toluene, xylene (ortho-) and m-/p-xylene. The results for these other solvent residues are <0.01 mg/kg for all the 12 samples of fish.

Table 1. Rate of styrene migration from EPS into fish (mg styrene/kg fish)

Storage temp.	-1 °C		2 °C	
	cod	redfish	cod	redfish
No. of storage days in EPS until sampling				
4	<0.01	<0.01	<0.01	<0.01
7	<0.01	<0.01	<0.01	<0.01
13	<0.01	<0.01	<0.01	<0.01

CONCLUSION

The results from the styrene migration are encouraging, all samples had styrene content below 0.01 mg/kg.

The FDA's acceptable daily intake value of styrene is 90 mg per person per day (<https://plasticfoodservicefacts.com/main/Safety/Safety-of-PS-Foodservice-Products>), which

means that one could eat at least 9000 kg per day of the fish used in the current study without reaching FDA's limit of 90 mg of styrene.

Thus, it seems that for the storage duration of fish fillets in EPS boxes (4-13 days) and temperatures (-1 °C, 2 °C) considered in this study, styrene migration is very limited and the cod and redfish fillets appear to be safe from high levels of styrene content.

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APPENDICES

Annex 1: Sampling plan for styrene migration from EPS boxes, even numbers: cod fillets, odd numbers: redfish fillets

-1 °C	Fish weight (g)	2 °C	Fish weight (g)	
A1	36.36	B1	43.72	D13
A2	48.02	B2	43	
A3	40.81	B3	28.57	D7
A4	34.52	B4	28.29	
A5	32.02	B5	26.74	D4
A6	27.85	B6	32	

Annex 2: Analytical report example on solvent residues migration

Analytical report: AR-17-JC-128125-01

Sample Code 706-2017-00124691

Reference	fish
Client Sample Code	A1
Number	1
Amount	139 g
Reception temperature	cooled
Ordered by	Ms. Heida Pálmadóttir
Submitted by	Ms. Heida Pálmadóttir
Sender	DHL
Reception date time	04.08.2017
Packaging	glass container with plastic closure
Start/end of analyses	07.08.2017 / 08.08.2017

TEST RESULTS
Physical-chemical Analysis

JCSRD	Solvent residues (BTEXS) (#)		
Method:	Internal method, CON-PV 01330, HS-GC-MS		
Benzene		<0.01	* mg/kg
Ethylbenzene		<0.01	* mg/kg
m-/p-Xylene		<0.01	* mg/kg
Styrene		<0.01	* mg/kg
Toluene		<0.01	* mg/kg
Xylene (ortho-)		<0.01	* mg/kg

* = Below indicated quantification level

(#) = Eurofins WEJ Contaminants GmbH (Hamburg) is accredited for this test.

Result +/- expanded measurement uncertainty (95%; k=2), sampling not included

Signature



Analytical Service Manager (Claudia Stehr)