TRANSPORT OF CHILLED AND SUPERCHILLED RAINBOW TROUT IN INSULATED CONTAINERS AND EXPANDED POLYSTYRENE BOXES

- Trial shipment from Westfjords, Iceland to Slupsk, Poland

Figure 1. Fresh rainbow trout traditionally packed with ice in a 40 L EPS box with drain holes.

Figure 2. Superchilled rainbow trout packed without ice in an EPS box measured at -1.2 °C after 8-day transport from Iceland to Poland.

Figure 3. Fresh, superchilled rainbow trout packed without ice in 460 (left) and 250 (right) L tubs.

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Introduction

Farmed fish is traditionally packed whole, gutted and fresh in ice in expanded polystyrene (EPS) boxes before containerized sea transport from Iceland. Normally around 21-22 kg of whole fish is packed in around 4-5 kg of ice in each box with volume capacity of around 40-48 L. The EPS boxes used for sea transport are usually equipped with drain holes, which allow both melting water and drip from the fish to leak out of the boxes and prevent fish from lying in water or blood. Due to thermal load during processing and packing of the fish, its temperature can easily rise to 1–6 °C when packed. As noted by Anyadiegwu and Archer (2002) and Margeirsson (2011), EPS boxes are very good thermal insulators and have, in conjunction with ice, been recommended for years to preserve fish quality under challenging temperature conditions (Seafish, 1996).

Reusable, insulated fish containers (often called fish tubs) have up until now mainly been used in Iceland for whole whitefish on board fishing vessels, for transport and storage within processing plants and transport to foreign markets by sea containers. Farmed fish like salmon and trout can be harmed from iced storage in fish tubs, but superchilling it before packing makes ice unnecessary and tubs an option with regard to fish quality, transport costs and environmental aspects (Þórðarson, 2017).

The aim of this study was to compare the quality of rainbow trout traditionally chilled and packed in ice in EPS, superchilled and packed in EPS and finally superchilled and packed in tubs of different sizes. Different covers and a drain grid were applied to the tubs in order to examine the effect of different add-ons to tubs on the fish quality.

Figure 4. Different packaging used for transporting fresh rainbow trout from Iceland to Poland. The yellow tubs to the left are the 460-L tubs (only the top one with lid), the 250 L tubs are covered with a single, blue plastic cover (pallet cover) and the white EPS boxes at the bottom right.

Figure 5. Superchilled rainbow trout in 460 L tub without a lid (top) and with a lid (bottom) after delivery in processing plant in Poland.

Figure 6. Almost no blood was found on top of or below the drain grid after 8-day storage in the 460 L tub containing 299 kg of fish. Around 10-20 kg of fish could have been packed into the container.

Materials and Methods

Rainbow trout was slaughtered, bled, gutted and transported in slurry ice between -1 and 0 °C on 30 May 2017 to a fish processing plant in Flateyri. The fish was packed on the following day. The fish were either traditionally packed (Trad) in around 3-4 kg of ice in EPS boxes (Figure 1) or superchilled (SC) in slurry ice to around -1.5 to -1.0 °C before packing without ice into either EPS boxes (manufactured by Tempra, Iceland, Figure 2) or 250/460 L tubs (manufactured by Sæplast, Iceland, Figures 3-6). The different packaging, their weights and fish weights are presented in Table 1. The depths of the EPS box, 250 L tub and 460 L tub are 17, 29 and 40 cm, respectively. Drain plugs were loosely fastened into drain holes of the tubs in order to facilitate drainage. Fish and ambient temperatures were monitored with Ibutton temperature loggers (type DS1922L) from Maxim Integrated Products (Sunnyvale, CA, USA) and Tidbit v2 temperature loggers from Onset Computer Corporation (Bourne, MA, USA). The Ibutton and Tidbit loggers had a resolution of 0.0625 and 0.02 °C, measurement range of -40 to 85 °C and -20 to 70 °C and accuracy of ±0.5 °C and ±0.2 °C, respectively.

Table 1. Weights of fish and different packaging used for transport of rainbow trout from Iceland to Poland. SC: Superchilled fish, Trad: Traditionally chilled fish in ice.

Packaging	Packaging weight (kg)	Fish weight (kg)	SC/Trad
460 L tub, no lid (no. 30647)	50	318,5	SC
460 L tub, no lid (no. 30651)	50	300	SC
460 L tub, with lid (no. 30328)	63	326	SC
460 L tub, with drain grid (no. 30692)	52	299	SC
250 L tub, with plastic cover (G1)	36	183	SC
250 L tub, with plastic cover (G2)	36	179	SC
250 L tub, with plastic cover (G3)	36	177	SC
250 L tub, with plastic cover (B1)	36	179	SC
250 L tub, with plastic cover (B2)	36	175	SC
40 L EPS box, no drain holes	0.75	21	SC
40 L EPS box with drain holes	0.75	21	Trad

The fish was trucked in Iceland, transported by sea in refrigerated containers to Rotterdam and trucked from Rotterdam to Slupsk, Poland. The set point temperature of the refrigerated container and the truck used for transport was -1.0 °C. The shipment was delivered in Poland 8 days post-packaging, i.e. on 8 June 2017. At the time of arrival, fish temperature was around 0.0 °C in the Trad fish packed in EPS with some ice left in all the boxes. Temperature of the SC fish packed in both EPS and the reusable 250/460 L tubs was around -1.2 °C. The fish, which was 9-day old from slaughtering, was removed from the packaging, filleted and quality inspected and temperature loggers retrieved.

Quality assessment included evaluation of elasticity, softness and gaping of fillets according to FHF (2010). Whole fish samples were taken from the EPS groups, the top and bottom of most of the tubs, the whole fish filleted, and thereby creating eleven experimental groups with 20–25 fillets in each group. One swabbing test on *Listeria Monocytogenes* was conducted by the buyer of the fish, the sample was taken from the bottom of one of the 250 L tubs after it was unloaded.

Figure 7. Superchilled rainbow trout fillets ready for quality assessment.

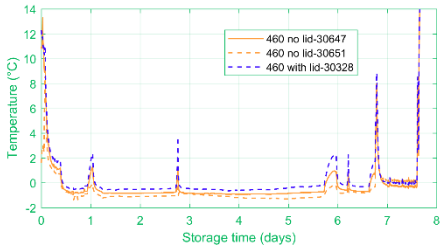

Figure 8. Ambient temperature during storage and transport of fresh rainbow trout from Iceland to Poland.

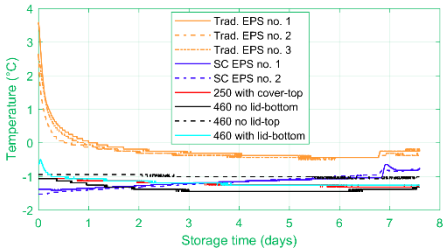

Figure 9. Fish temperature in different packaging during storage and transport from Iceland to Poland. Trad: Traditionally chilled and packed fish in ice. EPS: Expanded polystyrene.

Results and Discussion

The evolution of the ambient air temperature during storage and transport of the fish is shown in Figure 8. In general, the temperature control in the refrigerated container and trucks is good; ambient air was around 1–2 °C in the first truck, close to -1 °C in the container and around 0 °C in the truck during the last day of transport. The short thermal load periods seen in the figure should not have a big effect on the fish temperature inside the insulated packaging. The fish temperature results presented in Figure 9 confirm this, especially in case of the 250 and 460 L tubs containing relatively large amount of superchilled fish. The EPS boxes do not seem to offer as good thermal protection to the fish judging from small fish temperature increases obtained on the 7th day (both for Trad and SC) and a, slow and steady temperature rise in the SC fish in the EPS boxes throughout the storage time. This difference between the tubs and the EPS boxes could, however, be explained by the fact that only a few EPS boxes were stacked on a pallet and the fish temperature in the tubs was not measured very close to the corners of the tubs. Temperature distribution in a stack of loaded EPS boxes or insulated fish tub under thermal load can easily be heterogeneous as noted by Margeirsson (2012) and Snorrason (2014), respectively.

The elasticity, softness and gaping of the trout fillets in the eleven experimental groups are presented in Figures 10–12, respectively. The results for the softness and gaping are, in general, very good for all groups (grade 0), except 16% (4 out of 25) of the fillets from the traditionally chilled fish in EPS got a grade of 1 in the softness test.

The SC fish in both the EPS boxes and all tubs, both at top and bottom, got the best grade for both softness and gaping, except the fish from the top of the 460 L tub without any lid or cover, where 5% (1 out of 20) fillets got a grade of 1 for softness. This fact indicates that some kind of lid or cover seems to be needed for the tubs to optimize the fish quality stored in them. The need for tub cover or lid is strengthened by the results on the elasticity (Figure 10) because as high ratio as 45% (9 out of 20) of the fillets from the top of the 460 L tub without a lid only got a grade of 1 and only 55% of them got the best grade. It is an interesting fact that the fillet quality from the bottom of this particular tub was better than at the top. This may indicate that limiting access to oxygen could be more important than limiting pressure due to tub depth for the fish quality. The quality specialist and production manager from the buyer of the fish were more satisfied with the colour and odour off the SC fish gills taken from top of tubs with lid or cover as compared to the ones without lid or cover. Lids on insulated tubs not only limit air flow to the fish but can also improve the thermal insulation of the tub by as much as 30-80% (Margeirsson, 2017).

Apart from this, the Trad EPS group still gets the worst average grade for elasticity (as for softness and gaping), which underlines the advantage of superchilling the fish before packing it. The SC groups were all of top-quality, except from the tub without lid or cover, suggesting that using 29-40 cm is as good for the fish quality as using the traditional 17 cm deep EPS boxes.

The drain grid at the bottom of one 460 L tub yielded good results with regard to elasticity, softness and gaping. The quality specialist and production manager from the buyer of the fish were satisfied with how the grid prevents fish from lying in blood at the bottom of tub. The main disadvantage of the grid is the volume it takes from the fish inside the tub, thereby decreasing the volume exploitation during transport.

Finally, no traces of *Listeria Monocytogenes* were found at the bottom of one of the 250 L tubs after unloading.

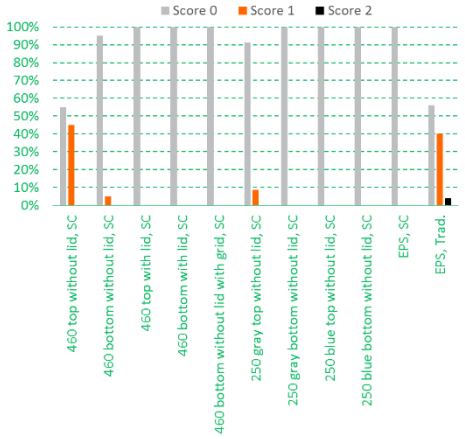

Figure 10. Elasticity of rainbow trout transported in different packaging. SC: Superchilled fish. Trad: Traditionally chilled and packed fish in ice. EPS: Expanded polystyrene.

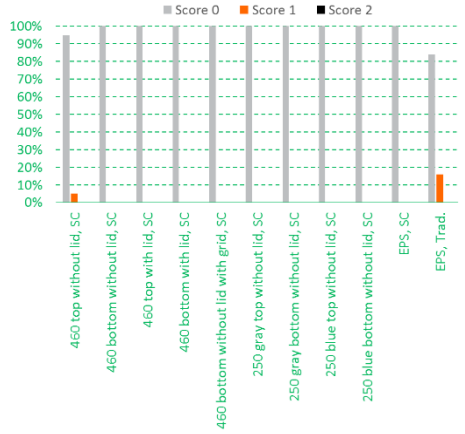

Figure 11. Softness of rainbow trout transported in different packaging. SC: Superchilled fish. Trad: Traditionally chilled and packed fish in ice. EPS: Expanded polystyrene.

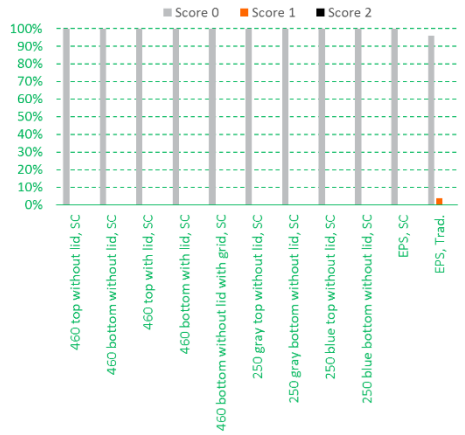

Figure 12. Gaping of rainbow trout transported in different packaging. SC: Superchilled fish. Trad: Traditionally chilled and packed fish in ice. EPS: Expanded polystyrene.

Conclusions

The results from the current study have shown that superchilling whole rainbow trout before packing and 8-day refrigerated transport unarguably results in better fish fillet quality than the traditional packing in ice in expanded polystyrene boxes. Furthermore, the superchilling increases the choice of packaging types and seems to make 29-40 cm deep insulated tubs a viable option for transport of whole rainbow trout without any ice in the tubs. This can be stated because the superchilled fish from most tubs was of similar quality as the superchilled fish from the EPS boxes.

However, judging from the worse elasticity of the superchilled fish stored at the top of the 460 L tub without a lid as compared to the 460 L tub with a lid and the 250 L tub covered with a large plastic bag, some kind of cover seems to be needed for the tubs.

Future studies should include storage of superchilled fish in even deeper tubs than used in the current study, i.e. deeper than 40 cm. Deeper tubs offer the possibility of further increasing the volume exploitation of refrigerated containers and trucks, which is important for transport costs. Future studies should also focus on finding out if a lid is actually needed to close each tub or if a thin plastic bag yields the same quality and finally if the drain grid is necessary to optimize the quality of superchilled rainbow trout during transport.

Acknowledgements

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