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Quality assessment of Atlantic cod (*Gadus morhua*) caught by longlining and trawling at the same time and location

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ABSTRACT

The quality of Atlantic cod from one trawl catch and one longline catch, caught at the same time and location, was assessed and compared. In addition, the effect of ice storage in 7 days on quality parameters was investigated. No differences between the cod from the two catches were observed on microbial activity and drip loss. Trawl caught cod had decreased pH and increased TMA compared to longlined cod. Catch Damage Index showed that trawling gave increased damages compared to longlining, where trawling resulted in poor bleeding and bruises, while longlining resulted in gaffing damages. Both color and sensory analyses confirmed the poor bleeding of trawl caught cod. In addition, the longline caught cod had increased overall sensory quality and increased lightness. Water holding capacity was decreased in trawled cod compared to longlined cod together with increased protein denaturation measured by differential scanning calorimetry. Texture analysis showed increased firmness in longlined cod. Cod loins stored on ice for 7 days encountered decreased quality attributes evaluated by sensory methods, firmness, water holding capacity and lightness, while microbial growth, pH and protein denaturation of the loin increased. In this study, the catch of Atlantic cod caught by longline had a better overall quality compared to the catch of cod caught by trawl.

1. Introduction

Atlantic cod (*Gadus morhua*) is one of the most important gadoid fish species in commercial fisheries in Norway. Over the last 60 years, average annual catch has been 660 000 metric tons in which approximately 30% has been caught by bottom trawl and 15% by longline (www.fisheries.no). Sustainability of fishing, flesh quality, effects on the environment, stock- and life cycle assessment (LCA) are gaining more and more attention and the methods for harvesting fish are eagerly debated.

The choice of fishing gear regarding cod is determined by several complex parameters, e.g. historical aspects, fuel prices, politically decided fishing quotas and prices of frozen vs. fresh raw material. However, how different fishing gears affect the quality of the catch needs more investigation and increased knowledge about this topic may have synergistic effects with political decisions (i.e. the distribution of quotas) and pricing of the fish in the market. Fishing gears have multiple impacts on fish quality (Botta et al., 1987a,b; Digre et al., 2010; Esaiassen et al., 2004; Huse et al., 2000; Larsen and Rindahl, 2008), and may result in quality downgrading of the products. A close correlation between the amount of catch defects and proportions of high value products has been found (Margeirsson et al., 2006), and lower defect rates result in significantly higher product value (Margeirsson et al., 2010). Gillnet and trap caught cod was significantly downgraded compared to handline and longline caught cod according to sensory judgment (Botta et al., 1987a), while gillnet and trawl caught cod had increased pH compared to longlined cod (Esaiassen et al., 2004; Olafsdottir et al., 2006). Longlined fish is inflicted by gaffing damages (Larsen and Rindahl, 2008) and trawl caught fish with bruises during hauling (Digre et al., 2010). In addition, different fishing gears affect length and condition factors of the catch (Huse et al., 2000). However, documentation of the severity of quality degradation on Atlantic cod due to fishing method has been requested both by Norwegian authorities and the fish processing industry.

The main objective of the present work was to study and compare several quality aspects of commercially available frozen and thawed cod during storage, caught at the same time and location, by trawl or longline.

2. Materials and methods

2.1. Raw material

It is well known that the quality of Atlantic cod is strongly affected by season (Botta et al., 1987a,b; Herland et al., 2010; Mello

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Table 1
Summary of temperature log of thawing conditions of a two-step thawing of frozen Atlantic cod, thawed in fresh water.

	First thawing step (7 h)	Second thawing step (9 h)
Top layer of water	8.1 ± 1.1 °C	0.0 ± 0.2 °C
Bottom layer of water	2.4 ± 1.4 °C	0.0 ± 0.1 °C
Ambient air	14.9 ± 0.7 °C	0.4 ± 1.2 °C

and Rose, 2005; Schwalme and Chouinard, 1999). Thus, the fish were caught at similar time of the year to ensure comparative raw materials and adequacy of the results. Atlantic cod were caught by trawl or longline north east of Finnmark, Norway (Long line N70°40′ E31°15′ and trawl N70°23′ E32°03′) on 26th May 2009. After catching, the fish were gutted and beheaded on board the fishing vessel, sorted on weight (1–2.5 kg), and directly frozen pre-rigor in blocks (25 kg) in plate freezers, and stored (−23 °C) until thawing ultimo August 2009.

The trawled cod were caught using a Selsta GR400 (Selstad AS, Måløy, Norway) in a haul that lasted for approximately 1 h and 15 min at 4 knots, and 3202 kg of cod (whole fish) was caught, while the longlined cod were caught on a longline containing 30,000 hooks with a soaking time less than 24 h (personal communication). The fishing depth for both gears was 250–350 m.

Thawing of the frozen fish was done in 600 l bins using a two-step process; 7 h in water with initial temperature of 10 °C, followed by separating the blocks to single fishes and subsequently storage in ice water (slurry) for 9 h. Temperatures in the top and bottom layer of the water were logged together with the ambient temperature. Summary of the temperature logs is shown in Table 1. The fish held approx. 0 °C when filleted.

After thawing, quality defects caused by fishing gear or improper bleeding were evaluated, before the fishes were hand filleted, skinned and the loin cut out for further storage and analysis. To be able to compare the quality at day 0 and day 7, the left loin from each fish were wrapped in aluminum foil and stored for 7 days in expanded polystyrene boxes with ice under chilled conditions (1.2 ± 1.0 °C), while the right loin were analyzed immediately.

2.2. Catch Damage Index

Quality defects caused by the fishing gear or by improper bleeding were evaluated on the thawed, gutted and beheaded fish according to the Catch Damage Index (CDI) (Akse and Joensen, 2004). This is a sensory method where five specified quality defects with significant impact on product quality or yield are evaluated by a trained person, inspecting the skin of the whole fish, and the blood vessels and color of the muscle in the belly flaps. Catch damages were evaluated according to the score in Table 2.

The evaluator used in this trial, which is the originator of the CDI method has extensive training in evaluating several thousands of cods. The evaluation was carried out, at standardized conditions at room temperature using electric light and a table provided with white covering, where a technician prepared the fish and supplied the judge with coded and randomized fish from the two groups. 18 fish from longline and 20 fish from trawl were evaluated.

Table 2
Catch Damage Index for defects caused by the catching and handling operations on wild caught Atlantic cod.

Catch damage	Score		
	Flawless	Moderate	Severe
Death in gear	0	–	2
Gear related damages	0	1	2
Bruises	0	1	2
Gaffing damages	0	1	2
Poorly bled	0	1	2

2.3. Microbiological analysis

Samples of 10 g muscle were homogenized in 90 ml of 0.9% NaCl (w/v) and 0.1% peptone (w/v) for 120 s. Aerobic plate counts (APC) were determined in aliquots from suitable dilutions using spreading technique to Long & Hammer Agar (LHA) added 1.0% NaCl to ensure growth of marine bacteria including *Photobacterium phosphoreum*, and incubated at 15 °C for 5–7 days to determine aerobic count (NMKL 184). H_2S-producing bacteria were determined on melted and tempered (44 °C) iron agar with overlay (Agar Lyngby, IA, Oxoid CM 964, Basingstoke, Hampshire, UK) supplemented with L-cysteine, and incubated at 20 ± 1 °C for 3 days (NMKL 96). Psychrotrophic bacteria (PC) were determined on plate count agar (PCA, Merck, Darmstadt, Germany) spread-plated and supplemented with 1% NaCl, in order to support growth of salt requiring and heat-labile micro-organisms, and incubated at 8 °C for 5–7 days (NMKL 74). Average results of the measurements ($n = 6$) are presented as $\log_{10}$ colony-forming units per gram muscle ($\log_{10}$ CFU g^{-1}).

2.4. Trimethylamine (TMA) and pH

TMA level at day 7 was determined by using a modified Conway micro-diffusion method (Conway and Byrne, 1933). The results are expressed as mg N 100 g^{-1} of raw material.

pH was measured with a pH meter (Orion 420 A-plus Benchtop, Thermo Electron Cooperation, Cambridgeshire, England) directly in the muscle tissue with a spear tip pH electrode (Thermo, Thermo Electron Cooperation, Cambridgeshire, England).

2.5. Drip loss

Drip loss (DL, %) during storage on ice was measured gravimetrically according to the formula

$$\mathrm{DL} = \frac{m_0 - m_1}{m_0} \times 100\% \quad (1)$$

where m_0 is the initial weight of the loin, and m_1 is the weight of the loin after 7 days. The weight after 7 days was measured after gently removing excess water on the surface with a paper towel.

2.6. Water holding capacity

WHC (%) was obtained by the method and associated equipment described by Skipnes et al. (2007). Samples of cod muscle ($n = 4$) from 11 individuals in the two catch categories (trawl caught and longlined) were analyzed. The analysis was performed both after thawing (day 0) and after 7 days. Pre-cooled samples (5 g) were placed in a sample cup and sealed before centrifugation (528 × *g*, 15 min, 4 °C). Dry matter content of fish muscle was determined gravimetrically after drying (105 °C, 16–18 h) to constant weight (NMKL, 1991). WHC was determined as the total weight of liquid expelled during centrifugation relative to the initial water content of the sample according to the formula:

$$\mathrm{WHC} = \frac{W_0 - \Delta W}{W_0} \times 100\% \quad (2)$$

where W_0 is the initial water content (%) in the sample (100 – Weight after drying × 100/Weight before drying) and ΔW is the weight loss (%) during centrifugation (Weight before centrifugation – Weight after centrifugation × 100/Weight before centrifugation).