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Abstract

Livers of Atlantic cod (*Gadus morhua*) are traditionally used in cod liver oil production or consumed cooked or canned. Farming of cod is a relatively new industry in Norway. The aim of this study was to determine quality and shelf life of fresh liver from farmed cod during chilled storage on ice by hydrolysis and oxidation state and sensory quality and the influence on canned liver. In two experiments, livers from farmed cod were stored chilled and sampled from day 0 to 13, respectively. Quality, measured as hydrolytic and oxidation degradation, was reduced after 7 days of storage, while sensory quality was reduced after 4 days. Free fatty acids increased from day 7 in both experiments, while peroxide value and anisidine value showed no change when the livers were single wrapped. Rancid odor was the first sign of oxidation and was registered after

three to four days of storage. Canning within two days of storage prevented leakage of oil from the canned livers. Sensory analyses of oxidation are recommended as a sensitive and rapid method to detect oxidation of chilled cod liver.

Introduction

Atlantic Cod (*Gadus morhua*) is the economically most important white fish species in Norway. Farming of Atlantic cod started as a new industry in 1990 in Norway. Compared to wild caught cod, the farmed cod production is still rather insignificant with respect to volume and value, and the production has stagnated due to high production cost and increasing wild catch (Digre et al., 2011). In 2009, about 21 000 tons of farmed Atlantic cod were produced in Norway, and the first hand value of farmed cod reached almost 48 mill EURO. The market price is sensitive to the supply of wild cod and other cod species like Pacific cod (*Gadus macrocephalus),* haddock (*Melanogrammus aeglefinus)*, and saithe (*Pollachius virens)*.

Farming of Atlantic cod facilitates a broad range of fresh co-products that can directly be used for human consumption or ingredients (Rustad et al., 2011). The main co-products are liver, roe, cleaned stomach, milt, backbone, skin, viscera, and bits and pieces from filleting. Cod liver is usually consumed cooked, canned, or used for cod liver oil production and refining. Traditionally, wild cod liver is processed to cod liver oil (Heyerdal, 1895). Cod liver oil has been a commercial health care product in Northern Europe for centuries, and cod liver oil as a nutraceutical, primarily as a vitamin supplement, can be traced back to 1783 (Curtis et al., 2004). As a consumer product with long shelf life, cod livers are traditionally canned. Market

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possibilities for canned liver are highest in the Baltic, where imported fresh or frozen livers are canned before export to Russia, Poland, France, and Germany in addition to inland markets.

Quality and shelf life of different cod products are influenced both by diet, handling during transportation, and slaughtering procedure. Pre-harvesting of farmed cod includes a starvation period and crowding and transportation by a well-boat to slaughter site. Manual gutting results in intact livers, while machine gutting occasionally results in ruptures and pieces of livers. Gutting machines that allow gentle gutting have been developed by several Norwegian companies (Kjølås, 2010; Rustad, et al., 2011). To ensure high quality and extend shelf life of products, it is important to chill and process co-products as soon as possible after slaughter (Sikorski, 1990). Liver quality is evaluated by appearance and color for consumer products. For production of cod liver oil, fatty acid profile and hydrolytic and oxidation states are also valued.

Farmed cod has enlarged liver compared to wild cod (Jobling et al., 1991; Lie et al., 1986). The hepatosomatic index (HSI) of farmed cod is usually in the range of 7-13 % and has been reported up to 17 % (Eliassen and Vahl, 1982; Shahidi and Dunajski, 1994) compared to a reported HSI of 5 % in wild cod (Falch et al., 2006). Energy is stored as lipids and glycogen in liver. HSI in cod is closely related to dietary lipid level and intake (Jobling et al., 1991, 2008; Lie et al., 1988). In the wild, the fatty acid composition is influenced by seasonal temperature and photoperiod, in addition to diet composition (Levesque et al., 2005). Gadiform species store lipids primarily as triacylglycerols in the liver. The fatty acid composition in livers from farmed cod differs from wild cod and has resulted in a European Pharmacopoe standard (EP 2006) for oil refined from livers of farmed cod.

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The high amount of unsaturated fatty acids is strongly susceptible to oxidation when exposed to light, oxygen, and temperature. A study on liver reported that the relative proportions of 17 fatty acids significantly deviated between livers from farmed and wild cod (Mach, 2004). The sums of docosahexanoic acid (DHA, 22:6n-3) and eicosapentaenoic acid (EPA, 20: 5n-3) were 23 % in wild and 18 % in farmed cod, amounting to 148.8 mg/g and 118.9 mg/g, respectively.

Liver appearance, light natural color and fresh odor are important for the consumer. Greenish discoloration of farmed cod livers is occasionally observed; in the extreme, more than 50% of a batch of farmed cod have a greenish discoloration making them unsuitable for consumption. The greenish coloration is also reported from other aquaculture species like yellowtail and red sea bream, possibly caused by low taurine supplement in the diet (Mørkøre and Luten, 2009; Takagi et al., 2005, 2006, 2008). Nematodes (*anisakis)* often occur in livers of wild cod, and the advantage of farmed cod is the absence of these parasites (Heuch et al., 2011). Canned cod liver has shown that the highest content of n-3 polyunsaturated fatty acids was found in the oil (31.91±1.83/100g) compared to the solids (16.59±7.48/100g) (Kolakowska et al., 2002). Liver resistance to oxidation was found to be reduced after thermal treatment. The lipid oxidation level was, however, low after 3-8 months storage of canned livers (Kolakowska et al., 2002).

The aim of this work has been to determine quality and shelf life of chilled cod liver based on sensory evaluation and oxidation measurements. Effect of cold storage on quality and yield of canned cod liver has been evaluated.

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Material and Methods

A cold storage experiment of liver of farmed cod was carried out in the autumn of 2009 (Figure 1). Results from this experiment showed a long shelf life, and we wanted to confirm our findings with an additional study to include days not examined in the first trial and expand storage period to 13 days. The cod from two different commercial cod farms was used.

Raw material, storage, and sampling

In experiment 1, the fish were kept in a holding cage. It was crowded and landed by a scoop net; then, the fish were anaesthetized by CO_2, the gills were cut, and the fish bled in chilled water, gutted manually, and filleted. In experiment 2, the fish were first pumped by a vacuum pump from the well-boat, electrically stunned, bled for 30 minutes, and finally gutted by machine and filleted.

In experiment 1, Atlantic cod were starved at least 12 days prior to slaughter. The fish were manually gutted, and livers were collected from the slaughter line and sorted by process rinsing and color to hold quality for consumption. After manual sorting of high quality livers, livers were wrapped in polystyrene and packed with ice in air freight boxes. The core liver temperature measured at packing was 10.0 °C, and temperature loggers were included. Whole fish mean weight was 2.85 kg, mean gutted weight was 1.4 kg, and mean liver weight was 339±76 g (mean ±SD), resulting in Hepatosomatic index (HSI) of 11.9%. After chilling for 2-6 hours,

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temperature reached 0 °C. The ice was refilled during storage, and five livers were sampled for analysis after 0, 1, 2, 3, 4, 7, and 10 days (Figure 1).

In experiment 2, farmed Atlantic cod were slaughtered after starving, and livers collected after the fish were machine gutted and filleted. The livers were whole or partly in large pieces weighing 124±40 g (mean± SD); data was not available for calculating HSI. Each liver/piece was single-wrapped in polystyrene bags and packed in air freight boxes. Five livers were sampled for analysis after 0, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13 days (Figure 1).

Canning

Livers of different pre-storage periods (experiment 1, days 1-10) were canned. Each can contained ca. 100 g liver and ca. 1.5 g salt. After sealing the cans, autoclaving condition was 110°C, 1.5 bar for 110 min (Bjørkeng pers. comm.). The canned livers were evaluated after three months of storage at room temperature.

Chemical analyses

All samples of livers were stored on ice, and the analyses were carried out on fresh homogenized material. Samples of 30-60 g homogenized liver were weighed, and oil was extracted according to Bligh and Dyer (1959). The chloroform phase was evaporated by a rotavapor under nitrogen atmosphere. The oil was flushed by nitrogen and stored dark until analysis within 5 hours after extraction.

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The extracted oil samples were analyzed for free fatty acids (FFA)(AOCS, 1997), peroxide value (PV) (AOCS, 2003), and anisidine value (AV) (AOCS, 1997). Total oxidation level (Totox) was determined by 2 x PV + AV. The oil was "flushed" by nitrogen and stored at 2-4 °C until analyses of fatty acid composition.

Fatty acid composition was determined by gas-chromatography (GC) of fatty acid methyl esters. The fatty acids were methylated by 2 % sodium-methanolate in methanol before the fatty acid methyl esters were chromatographed on a Quadrex, fused silica capillary column, Carbowax 20M, (25m, 0.25 mm ID, 0.20 μ film thickness) in a PerkinElmer Clarus GC med FID-detector (Waltham, MA, USA. The methyl-esters were determined by comparison to standard 68D (Nu-Check, Elysian, MN, USA) and internal standard solution.

All analyses (AV, PV, and FFA) were carried out in duplicate on five livers per sampling.

Sensory analysis

The quality parameters evaluated were color (greenish or reddish discoloration), odor, visible oil leakage, texture, and process rinsing (Table 1). Each liver was evaluated using a descriptive sensory method, and different quality traits were evaluated by two or three trained experts according to a scale, with scores ranging from 1 to 9 (Lawless and Heymann, 2010). Score 9 to 7 describes the range for consumer acceptance, score 6 to 4 describes a quality for further processing, while score 3 to 1 is not suitable for use.

Greenish color was evaluated according to a scale with scores from 1 to 9. Greenish coloration appears occasionally, and this is not acceptable for consumers. When collecting livers at the

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slaughtering houses, only first class livers were picked so that the livers included in the studies were all acceptable as consumer products at the start of the experiments. Rancid odor was evaluated as the degree of rancid or divergent odor. The livers were evaluated after opening of box (exp1) or polystyrene bags (exp2). The livers were evaluated visually, and rancid odor was registered. Visible oil leakage was evaluated by studying excess oil in the beakers/plates where the livers were placed. The amount of visible oil was evaluated in experiment 2 after 15 minutes storage at the plate on the bench in room temperature. The score 9 was used when no visible oil was observed.

Texture was assessed subjectively by pressing a finger firmly into the liver to observe whether or how fast the mark of the finger disappeared ("fingertest", used in industry). Normal, fresh liver from farmed cod will give firm resistance and immediately return to original shape. When the liver is softer, the score is lower. Shape was evaluated in relation to normal shape in experiment 1. In experiment 2, some of the livers were in pieces after gutting, and shape was therefore not included in evaluation, but visible oil leakage and relative weight percent of oil was included. Blood stain was a term used to describe a pink color in the livers, which was occasionally observed. It was either seen as small red spots or a light pink color. Process rinsing was an expression to describe the appendage of organs to the liver, like the pyloric caecum or intestine (Table 1).

Evaluation of canned liver:

Cans were opened, and sensory analysis was carried out before yield was measured by separation of liver and oil. Sensory parameters were texture, smell, color of oil, and particles in oil. The

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liver pieces were separated from the oil in the cans and weighed separately, and the percent oil was calculated.

Statistical analysis

Effect of pre-storage were analyzed by one-way analysis of variance (ANOVA) using Stata (StataCorp, 2009) where significant differences between means were established at a level of $p<0.05$. The statistical analyses are based on the mean of the measurements of FFA, PV, and AV.

The correlation between the sensory variables were carried out by non-parametric correlation test, Spearman rank correlation test. A post-hoc test, Bonferroni, was used to detect significant differences in correlation to ANOVA. A two-way ANOVA was used to test whether the results in the two experiments differed.

Results and discussion

Chemical analyses

Hydrolytic state measured as FFA increased significantly after seven days of cold storage in both experiments (Table 2). AV, PV, and Totox increased significantly from day seven to day 10 in experiment 1. However, this was not confirmed in experiment 2, where the levels varied more. FFA in wild cod livers stored on ice were reported to be significantly lower than in farmed cod at days 6 (0.4% and 1.5%) and 14 (3.9% and 7.2% of TFC), respectively (Mach, 2004), in accordance with our findings, despite slightly lower levels.

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Fatty acid composition

Fatty acid composition in the raw material of the two experiments was significantly different for 17 different fatty acids, but not for the EPA and DHA, which contained 21.9% of EPA and DHA, close to the content reported by Mach (2004)(Table 3). The fatty acid composition is in the same range as found by Guil-Guerro et al. (2011), even though there was a lower amount of PUFA.

The fatty acid composition showed a n-3/n-6 ratio of 4.5-5.5, in the same range as previously described livers from cod associated with salmon farms at Øksfjord and cod associated with farms at Hitra (Fernandez-Jover et al., 2007). We found a higher amount of monounsaturated fatty acids and lower polyunsaturated fatty acids then previously described (Fernandez-Jover et al., 2007). The raw material in the two experiments differ in MUFA, PUFA, and n-3/n-6 ratio. How this influences the oxidative stability is unknown.

Sensory analyses

Texture of the liver softened as a sign of degradation, followed by increased rancid odor in both experiments, in the period of days 3-4 for experiment 1 and days 5-8 in experiment 2. There was a slightly different course for the two experiments with two different batches of liver of different origin (Table 4). The degradation was further documented after 10 days of storage, even though it was not significant in experiment 2.

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During chilled storage, visible oil leakage from the fresh liver appeared after five days of cold storage and increased during further storage in experiment 2 (Table 4 and Figure 2). From day nine, the amount of visible oil leakage was significantly higher than the previous days. Color did not change significantly during chilled storage.

In experiment 2, the oxidation state showed high standard deviation after 13 days of storage and indicates that the livers oxidize at different speeds. Further studies should include increased number of sampled livers. This also points out differences between the raw materials in the two experiments. The results indicate a longer shelf life of livers from experiment 2, which might be caused by the single wrapping of livers. Process rinsing is an important factor to increase shelf life. The pyloric caecum, gall bladder, or intestines releases exogenous enzymes that may increase degradation and reduce shelf life. Prolonged shelf life found in experiment 2 is most likely due to single wrapping of livers, but other factors in fish background and slaughtering may also have influenced this. At day 13, the variations between livers reveal challenges of co-packing. In our opinion, a standard for sorting and packaging may increase shelf life beyond the current observations.

Comparison of correlations between sensory quality attributes and chemical analyses of hydrolytic and oxidation state show that the highest correlations are between rancid odor and FFA (-0.84) and texture and FFA (-0.91). No significant correlations were found between AV and sensory parameters and only significant correlations between PV and oil leakage (0.47). FFA and PV were significantly correlated (0.73). Rancid odor seems to be easier to detect than texture changes.

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Canned liver

Evaluation of quality of canned liver showed significantly softer texture after four days of cold storage prior to canning (Table 5). The oil observed in the cans was colorless when the liver was canned within 24 hours after slaughtering. After two days storage prior to canning, the oil turned yellowish, and visible particles in the oil appeared after 3 days, followed by the oil turning darker. The ratio of liver pieces versus oil (proportions of solids vs oil) was significantly reduced when the liver was stored four days prior to canning.

Heating of fresh cod liver released oil and resulted in oil richer in free fatty acids, but lower in polyunsaturated fatty acids (Kolakowska et al., 2002). The heating resulted in increased lipid oxidation, and total oxidation was always higher in lipids in the canned product solids than in the oil (Kolakowska et al., 2002). Sensory attributes showed a decrease in texture, odor, and amount of solids in the tins after longer pre-storage before canning in experiment 1. The reduction of solids from 62 % to 45 % during storage was in the same range as found by Kolakowska et al. (2002), but we focused on chilled storage prior to canning, while Kolakowska analyzed the oil and solids after canning. Our experience with canned liver from wild and farmed cod is that the farmed liver is lighter and has a milder taste. Our raw material had much lower oxidation level at the time of processing. Even after 7 days of storage, we did not achieve as high oxidation levels as Kolakowska et al. (2002) with liver originating from wild cod. However, Totox was calculated with a coefficient of 2.6, while we used 2.0 in our calculations.

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Conclusion:

Comparison of chemical and sensory evaluation of shelf life indicates that rancid odor and softer texture are detected prior to chemically detected oxidation. Sensory evaluation is cheaper and easier for industrial use, indicating sensory evaluation as a practical and economical tool to evaluate quality and oxidation state of consumer products. Hydrolytic and oxidation state is acceptable for 8-10 days during chilled storage, while texture is reduced. The highest ratio of solids versus oil in the tins is achieved when the livers are processed by canning within two days after slaughtering. However, the fresh cod livers maintained good quality for consumption and canning during 4 days of cold storage. Single wrapping of livers may prolong shelf life.

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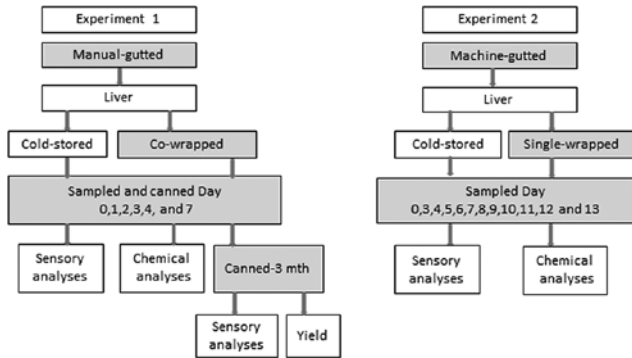
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Figure 1. Overview of the two experiments. Differences between procedures are shown by shading the current text.

Figure 2. Shelf life and oil leakage. Figure 2a Day 1: Firm texture, no oil loss, Figure 2b Day 5: Softer texture, some visible oil leakage, Figure 2 c Day 10: >50 % visible oil leakage.
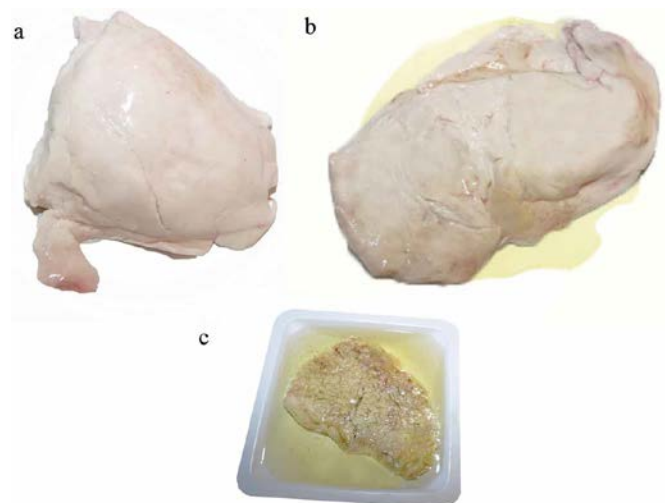
Table 1 Sensory quality of fresh liver

Quality attributes	Quality for consumption, Score 9-7	Quality for processing, Score 6-4	Quality for discarding, Score 3-1
Colour/ greenish discoloration	Light and beige, barely greenish	Some green discoloration	Greenish through the organ
Odor	Sea-fresh, low intensity	Some rancid odour	Strong rancid odour
Texture	Firm, good elasticity	Too soft	Partly dissolved
Visible oil leakage	No visible oil leakage	<50 % visible oil leakage	> 50 % visible oil leakage
Blood stains	Not observed	Some blood spots	Blood spots and discoloration
Process rinsing	Liver only	Some appendage of intestine	Intestine appended to the liver

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Overall impression	Superior	Good	Rejected for consumption

Score from 1 to 9, where Score 9 is highest, description simplified by pooling.

Table 2 Hydrolysis and oxidation of fresh chilled liver

Day	FFA (%)		AV		PV (meq kg^{-1})		Totox	
	Exp. 1	Exp. 2	Exp. 1	Exp. 2	Exp. 1	Exp. 2	Exp. 1	Exp. 2
0	0.32±0.38 [a]	0.17±0.1 [a]	0.38±0.17 [a]	0.40±0.1 [a]	0.54±1.20 [a]	0±0 [a]	1.45±2.44 [a]	0.17±0 [a]
1	0.41±0.20 [a]		0.52±0.08 [a]		0.16±0.16 [a]		0.84±0.29 [a]	
2	0.45±0.17 [a]		0.36±0.20 [a]		0.21±0.13 [a]		0.78±0.36 [a]	
3	0.61±0.48 [a]	0.50±0.5 [a]	0.35±0.29 [a]	0.68±0.1 [a]	0.15±0.11 [a]	0.10±0.2 [a]	0.65±0.33 [a]	0.50±0.2 [a]
4	0.80±0.66 [a]	0.40±0.2 [a]	0.76±0.28 [a]	0.49±0.1 [a]	0.16±0.16 [a]	0±0 [a]	1.08±0.35 [a]	0.40±0.1 [a]

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5		1.47±1.1 a		0.99±0.3 a		0.38±0.1 a		1.47±0.5 a
6		2.25±1.1 a		0.18±0.8 a		0.26±0.1 a		2.23±0.5 a
7	1.76±1.03 a	1.3±0.8[a]	0.70±0.13 a	0.53±0.5 a	0.48±0.22 a	0.29±0.3 a	1.67±0.54 a	1.73±0.4 a
8		3.01±1.4 b		0.90±0.7 a		1.15±1.0 a		3.01±0.6 a
9		4.69±0.8 b		0.19±0.2 a		0.55±0.2 a		4.01±0.4 a
10	3.63±1.33 b	3.75±0.9 b	1.72±0.76 b	0.47±0.6 a	2.64±0.67 b	0.70±0.7 a	7.00±0.72 b	3.75±0.4 a
13		6.41±2.7 c		0.74±2.4 a		1.79±1.9 a		6.41±1.2 a

Mean ± standard deviation; FFA (Free Fatty Acids), AV (Anisidine Value), PV (Peroxide Value), Totox (2 * PV + AV). Different letters in superscript represent significant differences at level $p<0.05$, by Bonferroni.

Table 3 Fatty acid composition of liver

	Exp. 1	Exp. 2	ANOVA
Fatty acid	**Mean± SD**	**Mean± SD**	**P-value**
C14:0	3.3±0.4	3.0±0.2	NS
C15:0	0.3±0.0	0.3±0.0	0.02
C16:0	12.6±0.4	13.3±0.5	0.03
C18:0	4.4±0.8	5.1±0.3	NS
Total Saturated Fatty Acids (SFA)	20.5±0.8	21.7±1.0	0.06
C14:1	0.1±0.0	0.2±0.0	0.03
C16:1 n-7	4.7±0.5	5.5±0.3	0.02

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C16:4n-1	0.2±0.0	0.3±0.0	0.01
C18:1n-9	22.8±1.9	23.1±1.2	NS
C18:1n-7	4.9±0.2	5.0±0.2	NS
C18:1n-5	0.3±0.1	0.3±0.0	0.04
C20:1n-11	1.7±0.1	1.1±0.1	0
C20:1 n-9	6.8±0.5	4.6±0.2	0
C20:1n-7	0.2±0.0	0.2±0.0	0.00
C22:1n-11	5.0±0.7	2.9±0.2	0.02
C22:1n-9	0.1±0.1	0.2±0.0	0.01
C24:1	0.6±0.1	0.2±0.0	0
Total Monounsaturated	47.1±1.0	43.2±1.0	0.00

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Fatty Acids (MUFA)			
PUFA			
C18:2n-6	4.3±0.2	5.5±0.1	0
C18:3n-3	1.0±0.1	1.4±0.1	0
C18:4n-3	1.6±0.2	1.9±0.1	0
C20:2n-6	0.2±0.0	0.3±0.0	0
C20:4n-6	0.4±0.0	0.6±0.0	0
C20:3n-3	0.1±0.0	0.1±0.0	0
C20:4n-3	0.6±0.0	0.8±0.0	0
C20:5n-3 EPA	10.5±0.3	10.4±0.4	NS
C21:5n-3	0.5±0.1	0.5±0.0	NS

C22:5n-3	1.56±0.11	1.7±0.1	0.1
C22:6n-3 DHA	11.4±0.6	11.6±0.4	NS
Total Polyunsaturated Fatty Acids (PUFA)	32.3±0.6	35.1±0.8	0.00
n-3 fatty acids	27.2±0.5	28.4±0.8	0.02
n-3/n-6 fatty acids ratio	5.51±0.23	4.47±0,13	0

Table 4 Sensory quality of fresh chilled liver

Day	Color		Rancid odor		Texture		Oil leakage	Oil (%)
	Exp. 1	Exp. 2	Exp. 1	Exp. 2	Exp. 1	Exp. 2	Exp. 2	Exp. 2
0	9 ± 0^a	8.4 ± 1.3^a	9 ± 0^a	9 ± 0^a	9 ± 0^a	9 ± 0^a	9 ± 0^a	0 ± 0^a
1	8.2 ± 1.1^a		9 ± 0^a		8.6 ± 0.5^a			
2	8.4 ± 0.9^a		9 ± 0^a		8.2 ± 1.1^a			
3	9 ± 0^a	8.6 ± 0.9^a	9 ± 0^a	9 ± 0^a	8 ± 0^a	8.6 ± 0.5^a	9 ± 0^a	0.6 ± 0.8^a
4	9 ± 0^a	8 ± 1.4^a	8.2 ± 0.8^b	9 ± 0^a	7.6 ± 0.5^b	8.4 ± 0.9^a	9 ± 0^a	1.0 ± 0.8^a
5		8.4 ± 0.9^a		9 ± 0^a		7.2 ± 1.3^a	8.6 ± 0.9^a	2.1 ± 1.4^a
6		8.6 ± 1.2^a		7.6 ± 1.1^a		5.8 ± 1.9^b	7 ± 1.4^a	3.3 ± 2.8^a

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7	9 ± 0^a	8.6 ± 0.5^a	6.4 ± 0.5^c	8.6 ± 0.9^a	7 ± 0.7^b	6.6 ± 1.5^b	6.8 ± 2.2^a	7.5 ± 12.5^a
8		8.6 ± 0.9^a		7 ± 1.4^b		5 ± 1.4^c	7 ± 1.4^{ab}	4.9 ± 4.6^a
9		7.6 ± 1.5^a		4.2 ± 0.4^c		3.4 ± 0.5^c	4.4 ± 0.5^b	6.5 ± 2.2^a
10	9 ± 0^a	8.4 ± 1.3^a	4 ± 0^d	5 ± 0.7^c	3 ± 0^c	3.2 ± 1.3^c	3.8 ± 1.1^b	9.9 ± 2.6^a
11		8 ± 1.4^a		5.2 ± 0.4^c		5 ± 1.2^c	6 ± 0.7^b	3.2 ± 3.0^a
12		9 ± 0^a		3.5 ± 0.6^c		3 ± 1.2^c	5.8 ± 0.5^b	2.2 ± 4.6^a
13		8.4 ± 0.9^a		4 ± 1.9^c		3.2 ± 1.3^c	5 ± 2.5^b	5.4 ± 1.9^a

Means $\pm$ standard deviation, different letters in superscript represent significant differences at level $p<0.05$, by Bonferroni. Score 9 is superior, score 1 lowest.

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Table 5 Canned liver quality (experiment 1)

Pre storage (days)	Weight (g)	Liver color	Texture	Rancid Odor	Oil (%)	Oil color	Particles in oil
0	115.0±3.3	7.8±8.2^a	8.9±0.7^a	9±0.3^a	38.4±8.2^a	9±0^a	9±0^a
1	117.6±1.6	7.9±0.8^a	8.6±0.6^a	9±0^a	34.9±7.2^{ab}	9±0^a	9±0^a
2	117.0±1.5	7.7±0.9^a	8.6±0.7^a	8.9±0.4^a	43.0.±7.2^{ab}	8.1±0.4^b	8.8±0.4^a
3	116.1±1.4	7.8±0.9^a	8.0±1.1^a	8.5±0.6^a	42.4±7.7^{ab}	7.5±0.5^c	8.5±0.7^b
4	117.2±6.8	7.4±1.1^a	7.7±1.1^b	8.2±1.3^a	46.1±6.3^b	7.4±0.6^c	8.4±0.6^b
7	112.3±2.9	7.0±0.7^a	3.5±1.9^c	6.9±1.8^b	55.9±18.7^c	6.2±0.4^d	6.8±0.8^c

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Mean ±standard deviation. Different letters in superscript represent significant differences at level $p<0.05$, by Bonferroni