Quality characteristics and consumer acceptance of diploid and triploid cold smoked Atlantic salmon reared at 5, 10 and 15 °C

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Abstract

This study determined the processing characteristics, textural and colorimetric properties, NaCl content and consumer’s acceptability of dry salted cold smoked triploid Atlantic salmon (average weight of 1.6±0.3 kg) reared at different temperatures (5, 10 and 15 °C). As a reference, diploid siblings kept and processed under equal conditions was used. Ploidy did not affect the raw material biometrics but increased holding temperature gave increased blood lactate and decreased muscle pH at point of death. Triploid Atlantic salmon was found to be suitable for cold smoke processing but the differences in quality between diploid and triploid was significant. Cold smoked triploid salmon have on average lower processing yield, higher weight loss throughout processing and storage, and was softer as compared to diploids. Ploidy did however not affect the NaCl content. A consumer test did also distinguish between cold smoked diploid and triploid salmon originally kept at 10 °C. In addition, increased holding temperature was found to give a step-wise lower weight loss during processing and significant darker fillets after cold smoking and storage.

Keywords: Triploid Atlantic salmon; holding temperature; cold smoking; yield; color quality
1. Introduction

Because of the 45 “green production concessions” in Norwegian aquaculture (FOR-2013-06-24-754) the raw material used in production of cold smoked Atlantic salmon (*Salmo Salar* L.) today includes triploids. The use of sterile triploids (O’Flynn, et al., 1997) in aquaculture is supported by several conservation and management organizations including North Atlantic Salmon Conservation Organization (NASCO) and Food and Agricultural Organization (FAO) (Taranger and Albretsen, 2014). The use of triploids will therefore probably increase in the future. Due to the scant knowledge about flesh quality of triploid salmon this may be an unknown challenge for the processing industry. The triploid genetic setup (2n+1) (Benfey, 1999) gives all triploid cells one extra set of chromosomes. This leads to increased nuclear volumes and cell size to accommodate the extra genetic material (Benfey, 1999). Consequently, triploid cells are 30% larger than diploids. Larger cells may induce new challenges related to drip loss and textural properties during processing and storage.

The quality of the raw material is an important factor to produce a high quality smoked product. Triploid Atlantic salmon is known to have lower proportions of superior quality as compared to diploids at slaughter (Fraser et al., 2013; Taylor, Preston, Guy, & Migaud, 2011). The flesh quality of triploid Atlantic salmon is however not well documented, where only a few studies deal with the topic. In a recent study by Lerfall et al. (2017) triploids were characterized by lower blood hematocrit (Hct) and rigor index (Ir), and higher fillet drip loss (DL) and collagenase activity. They were moreover found to be paler and less yellowish compared to diploids. Bjørnevik, Espe, Beattie, Nortvedt, and Kiessling (2004) reported triploids to have more gaping and softer fillets, which can be related to the muscle cellularity (Johnston et al., 2000) where diploid salmon have one third fewer muscle fibers than triploids (Johnston, Strugnell, McCracken, & Johnstone, 1999). The colorimetric characteristics are affected by several parameters including ploidy, genetic variations, variation in muscle density and different seasonal factors (Bjørnevik et al., 2004; Choubert, Blanc, & Vallée, 1997; Johnston et al., 2000). The literature is however not sure about which of the mentioned discriminants that are of
highest significance for the flesh color. Significant differences in growth, and differences in flesh properties between diploid and triploid Atlantic salmon, shows the importance of increased knowledge about processing characteristics of triploid Atlantic salmon in a cold smoke process.

Cold smoke processing of Atlantic salmon consists of several steps including salting, drying and smoking and the quality of the end product is both affected by raw material characteristics and all processing steps applied (Bencze Rørå et al., 1998; Birkeland, Bencze Rørå, Skåra, & Bjerkeng, 2004; Birkeland & Bjerkeng, 2005; Cardinal et al., 2001; Espe, Nortvedt, Lie, & Hafsteinsson, 2002; Lerfall, Akse, Østerlie, & Birkeland, 2011; Lerfall & Rotabakk, 2016). Salt is usually added to fillets by dry salting or injection of brine where dry salting is driven by diffusion (Dyer, 1942; Rørå, Furuhaug, Fjæra, & Skjervold, 2004). Triploid cells contain by definition 50% more DNA than diploids, which results in increased nuclear volume and cell size compared to diploids (Benfey, 1999). Larger muscle cells in triploid salmon raise questions about how this will affect factors such as product yield, DL, color, salt diffusion and sensory properties throughout dry salting, cold smoking and refrigerated storage. It is important that the technological properties of diploid and triploid Atlantic salmon is as equal as possible. Hence, the aim of the present study was to investigate the processing characteristics, textural and colorimetric properties, salt content and consumer’s acceptability of dry salted and cold smoked triploid Atlantic salmon reared at different temperatures. As reference, diploid siblings reared and processed under equal conditions was used.

2. Material and methods

2.1. Fish material and experimental design

The salmon used were of the same selection as presented in Lerfall et al. (2017). In short, triploidy was induced by subjecting fertilized eggs for approximately 6 min to a hydrostatic pressure of 65,500 kPa. Diploid eggs were not pressurized. All eggs were then incubated at 5.8 ºC. Following smoltification, both groups (diploid and triploid smolts less than a year old) were transferred to an Institute of Marine Research, Matre, Norway (IMR) sea-pen system (seawater, mass salinity 34 g/kg)
in Smørdalen (Masfjord, Norway). At an average weight of 1 kg, both groups were hauled and transported to the experimental facilities at IMR, Matre. The fish were evenly distributed into six 3 m in diameter tanks (9 m$^3$) with three tanks for each ploidy. The temperature was then adjusted to 5, 10 and 15 °C over 30 d and thereafter held constant over 27-29 d until the fish were slaughtered. After four d of starvation, 60 farmed Atlantic salmon (50% diploid and 50% triploid, average weight of 1.6±0.3 kg) were slaughtered between the 19$^{th}$ and 21$^{st}$ of August 2014. The fish were killed one by one by a sharp blow to the head (approximately 3 min between each fish).

The sampling procedure resulted in a full factorial design with six groups of salmon with different ploidy and water temperature: Group 1, Diploid salmon kept at 5 °C; Group 2, Triploid salmon kept at 5 °C; Group 3, Diploid salmon kept at 10 °C; Group 4, Triploid salmon kept at 10 °C; Group 5, Diploid salmon kept 15 °C and Group 6, Triploid salmon kept at 15 °C.

Immediately after killing, the first five salmon from each group (n = 10) were sampled for a blood analysis of the lactate. All the fish were analyzed for muscle pH, temperature at death, length and whole body weight before the fish was stored, on ice during rigor mortise (60 h). All fillets were thereafter hand filleted, frozen individually, and kept frozen (-30 °C) for 60 d before processing.

**2.2. Raw material control**

Muscle pH and temperature was measured right after death in the anterior dorsal muscle close to the gills by using a Mettler Toledo SevenGo proTM pH-meter (Mettler Toledo International Inc., USA) connected to an Inlab puncture electrode. Blood samples were immediately extracted from the caudal vein (n = 30). The blood lactate was measured immediately using a Lactate Pro 2 analyzer (Arkay Factory Inc., Koka-Shi, Japan).

**2.3. Salting and smoking procedure**

After thawing (48 h, 2 °C), all fillets were covered with sodium chloride (fine-refined salt, minimum 99.8% NaCl) and stored on grids in a refrigerated room (20 h, 2 °C). All fillets were thereafter rinsed
in cold water (approximately 8 °C) to remove excess of NaCl. Salt-cured fillets of all six groups were then randomized on grids, dried separately for 60 min, followed by four circles of 50 min smoking (beech chips) and 10 min drying (23 °C, relative humidity: 75-83%, air velocity: 0.4-0.8 m/s) according to Birkeland, Skåra, Bjerkeng, and Rørå (2003). Vacuum packaged fillets from all protocols were stored in a refrigerated room (2 °C) for 28 d.

2.4. Processing yield, weight loss and NaCl content

The weight loss (WL) at each processing step and throughout storage were calculated as the difference in fillet weight between raw, and salted and smoked fillets, respectively (Lerfall, et al., 2016). Moreover, the WL during 28 d refrigerated vacuum storage was calculated as the difference in fillet weight between smoked fillets and fillets stored 28 d. The processing yield was moreover calculated as % smoked fillet compared to the initial fillet weight.

Content of NaCl was analysed on samples of minced smoked salmon. The salt content was determined conductivimetrically after a method described by Birkeland, et al. (2004) and analyzed on a Dicromat 11-6 Salt Analyser (PCL Control Instrumentation Ltd., Leicester, UK).

2.5. Textural properties

Instrumental textural analyses were performed in the dorsal part of the Norwegian quality cut (NQC) using a Texture Analyzer TA-XT2 (SMS Ltd., Surrey, England) equipped with a 30 kg load cell. A flat-ended cylinder probe (10 mm diameter, type P/1SP) was used. The force-time graph was recorded by a computer equipped with the Texture Exponent software for windows (version 6.1.7.0, SMS), which was also used for the data analyses. The analyses were performed in duplicates (average values were used for data analyses) of each fillet at the end of the storage period (28 d post smoking). The resistance force (N) was recorded with a constant speed of 5 mm/s, and the force required to press the cylinder down to 80% of fillet thickness was used to describe firmness.

2.6. Colorimetric properties
Surface color (CIE, 1994) was measured on a DigiEye full system, VeriVide Ltd., Leicester, UK of the raw material, after each processing step, and after 28 d refrigerated storage. The software Digipix (version 2.7) was used to calculate $L^*a^*b^*$ values from RGB values obtained from the fillet image.

### 2.7. Consumer acceptance

Participants in the consumer test were recruited in the canteen of IPARK, Stavanger, Norway. Before testing, they were told that they would taste a cold smoked salmon product produced from diploid and triploid Atlantic salmon. The average age of the participants was 43±11 years ranging from 23 to 68 years old and 34% was females.

Sensory evaluation of vacuum packaged, diploid and triploid cold smoked salmon, consisting of a triangle test that were performed 35 d post smoking (Table 1). A total of 144 participants were divided into three groups (46, 48, and 48 participants) testing salmon kept at 5, 10, and 15 °C, respectively. All panelist was served two triangles each where both triangles consists of three coded clear 50 mL cups containing a slice of smoked salmon (~10 g). Before testing, all samples were equilibrated to ambient temperature in order to avoid any possible effect of the product temperature during evaluation. Sample presentation was randomized and water was provided for rinsing between samples. Triangle discrimination tests were conducted in order to determine if a perceived difference existed between diploid and triploid cold smoked salmon. Panelists were asked to identify the odd sample. In addition, all participants were asked to answer if they prefer cold smoked salmon with high or low intensity of redness, salty taste and smoke aroma. They were moreover asked about how often they consume cold smoked salmon products.

### 2.8. Statistics

The data were analyzed by a general linear model (GLM) with the ploidy and holding temperature as fixed factors. Multivariate GLM with $L^*, a^*$ and $b^*$, and different processing steps as multiple Y were used to analyze fillet appearance and weight loss, respectively. To compare different groups, GLM and Duncan’s comparison test was used. Pearson’s correlation coefficient ($r$) was used to calculate
the linearity dependence between the variables X and Y. The consumer test was analyzed with a Z-test approximation of the binomial test. All statistical analyses were performed using an IBM Statistical Package for the Social Sciences statistics software (release 23, IBM corporation, New York, USA). The alpha level was set to 5% (P < 0.05). All results are given as an average ± standard deviation (SD), unless otherwise stated.

3. Results

3.1. Biometrics and raw material characteristics

The raw material characteristics of diploid and triploid salmon from the experimental design is thoroughly documented in Lerfall et al. (2017) whereas biometrics and raw material characteristics of the selection used in the smoking trial is presented in Table 2. Whole body weight was only found affected by holding temperature (GLM, P=0.028) where significantly highest body weight was found of salmon kept at 10 °C. No effect of ploidy was however found regarding body weight (GLM, P>0.46). A similar effect of holding temperature was found for the condition factor, cf (GLM, P=0.002). The cf was however close to be affected by ploidy (GLM, main effect) where diploid salmon have numerically higher cf as compared to triploids (GLM, P>0.067, cf on average 1.1 and 1.0, respectively).

The average death temperature of the fish from each group reflected the experimental holding temperature of the respective tank. Muscle pH at point of death decreased and blood lactate increased as a function of increased holding temperature (Table 2). A significant correlation was found between muscle temperature, and muscle pH and blood lactate at point of death (r=-0.40, P=0.002 and r=0.61, P<0.001, respectively). Muscle pH and blood lactate at point of death were moreover found to correlate (r=-0.57, P=0.001).

3.2. Processing yield, weight loss and NaCl content
The salting step was found to be the major contributor to the weight loss from fillets during processing (on average: 9.3±1.1%) followed by the smoking step (on average: 4.2±0.7%) and 28 d refrigerated storage (on average: 2.6±0.6%). The total weight loss after smoking and storage ended at 13.1±1.5% and 15.3±1.7%, respectively.

The weight loss for all groups at each processing step is presented in Table 3. All processing steps were significantly affected by the experimental design (Multivariate GLM: P<0.001) where holding temperature were found to be the main discriminant (Multivariate GLM: P<0.001, F=11.8) followed by ploidy (Multivariate GLM: P=0.007, F=4.2). Main effects of ploidy and holding temperature on the weight loss after each step are shown in Fig 1.

The processing yield (Table 3) was significantly affected by the experimental design (GLM: P=0.008) where significantly higher yield was observed of diploid as compared to triploid salmon (on average: 87.2% and 86.7% respectively, GLM: P=0.045). A significant effect of holding temperature was moreover found, where lower yield was found of salmon kept at 5 °C as compared to those kept at 10 and 15 °C, respectively (GLM: P<0.001).

The NaCl content (Table 3) of the cold smoked salmon was significantly affected by the experimental design (GLM: P<0.041). The salt content did however not differ between ploidy (P>0.36). The main discriminant related to salt content was found to be temperature where cold smoked salmon originally kept at 5 °C was found to be salter compared to those originally kept at 15 °C (Table 3, P<0.013).

3.3. Textural properties

The fillet firmness (N) was significantly lowest in cold smoked triploid salmon kept at 10 °C whereas diploid salmon kept at 5 °C were found to be firmest (Fig.2). Cold smoked diploid salmon was moreover found to be significantly firmer as compared to triploids (on average: 12.4N and 11.3N respectively, GLM: P=0.024, F=5.2). The most discriminant factor was however, holding temperature, where significant lowest firmness was observed in cold smoked fillets of salmon kept at 10 °C (on
average 10.5N GLM: P<0.001, F=10.1). As a comparison, cold smoked fillets of salmon kept at 5 and 15 °C showed a firmness of 12.9 and 12.3N, respectively.

3.4. Colorimetric properties

The fillet appearance (CIE, 1994) was found to be affected by both ploidy (diploid versus triploid) and holding temperature (5, 10 or 15 °C) (Multivariate GLM, P<0.001, Fig. 3A-F).

Raw diploid salmon was found to be darker compared to triploids (P=0.001, Fig. 3A). This pattern continued after salting (L*= 53.5±1.8 (diploid) versus 54.0±1.9 (triploid), P=0.042) whereas after smoking and 28 d refrigerated storage these differences were found to be insignificant although statistical tendencies towards significance were still observed (P = 0.074 and 0.174, respectively). No significant main effects of ploidy was however found related to fillet redness (a*, Fig. 3C) or yellowness (b*, Fig 3E).

Holding temperature was found to be the main discriminant related to fillet appearance. Raw fillets of salmon kept at 5 °C was found to be significantly palest (higher L*-value), followed by salmon kept at 10 °C. Salmon kept at 15 °C were found to be significantly darkest (Fig. 3B). This pattern continued after salting, smoking and 28 d refrigerated storage. The fillet redness (a*) of the raw material was moreover found to increase with increased holding temperature (Fig. 3D). On average, this trend continued during processing, and throughout 28 d refrigerated storage. The intensity of b* (yellowness) followed the same pattern as observed for the fillet redness (Fig. 3F). An equalization of yellow perception was however observed after smoking and 28 d refrigerated storage showing smaller effects of holding temperature on the end product as compared to the raw material.

3.5. Consumer acceptance

The majority of the participants (63%) consumed cold smoked salmon products 2-3 times per month or more often. Among the participants, 60% prefer cold-smoked salmon with high intensity of redness, whereas 66% and 70% prefer high intensity of smoke aroma and low salt content,
respectively. The sensory evaluation of diploid and triploid cold smoked salmon is presented in Table 4. The participants managed to distinguish between diploid and triploid cold smoked salmon kept at 10 °C (P=0.008). It was however not possible to distinguish between diploid and triploid salmon kept at 5 and 15 °C (P>0.263 and >0.344, respectively).

4. Discussion

All the fish examined in the present study were of the Aquagen strain (Aqua Gen AS, Trondheim, Norway) but differed in ploidy, and in holding temperature throughout the last period of the life cycle. Feeding and rearing strategies together with the pretreatment before salting and smoking were on the other hand equal. Hence, observed differences in biometrics and measured parameters throughout salting, cold smoking and 28 d refrigerated storage were likely caused by differences in ploidy and holding temperature.

Dry salting of salmon fillets results in a salting out process where salt diffuse into the muscle structure whereas solutes leaking out (Dyer, 1942; Horner, 1997). This process is affected by several factors such as lipid content (Gallart-Jornet et al., 2007), freezing prior to salting (Deng, 1977) and the ratio between the surface area and fillet thickness. In the present study, small salmon (1.6 kg) with a relatively high surface to flesh ratio (thin fillets) were processed. This resulted in a relatively high weight loss during dry salting (on average: 9.3%) and after cold smoking (total weight loss of 13.1%). Other studies on fresh unfrozen commercial sized salmon (±5 Kg) have shown lower weight loss during dry salting (±20 h) and cold smoking (5-6% and 10-11%, respectively) (Lerfall, Bendiksen, Olsen, & Østerlie, 2016; Lerfall & Rotabakk, 2016). All fillets used in the present study were on the other hand frozen prior to processing. Freezing is known to affect the muscle structure of smoked salmon fillets (Sigurgisladottir, Ingvarsdottr, Torrissen, Cardinal, & Hafsteinsson, 2000) but only small effects on yields and weight loss during processing is reported (Cardinal et al., 2001; Sigurgisladottir, Ingvarsottir, et al., 2000). Cardinal et al. (2001) reported moreover that lean salmon fillets were more affected by freezing compared to salmon with higher fat content.
Holding temperature is known as a significant factor to manage the growth rate of Atlantic salmon (Austreng, Storebakken, & Åsgård, 1987; Brett, 1979; Hevrøy et al., 2013). In a controlled experiment reported by Hevrøy et al. (2013), diploid salmon were fed (45 d) at 13 °C, 15 °C, 17 °C and 19 °C, respectively. The most efficient growth was achieved in water temperature of 13 °C. Furthermore, salmon reared at 15 °C and 17 °C grew efficiently the first two wk but exhibited reduced feed intake and growth in the last part of the study. The weight loss of raw salmon fillets is known to be affected by the temperature in the sea (Nordgarden, et al., 2003), where increased growth rate (e.g. in summer) is known to increase the fillet drip loss during storage (Mørkøre, et al., 2010; Roth, et al., 2006).

In the present study a significant relationship between weight loss during processing and 28 d storage, and fish size was observed (r=-0.719 to -0.772, P<0.001). This indicate small fishes to lose more weight during processing, probably because of a higher surface to flesh ratio and lower fillet thickness. The weight loss is also related to the diffusion of salt into the muscle tissue (Dyer, 1942). In the present study, the fish size correlated significantly with the salt content (r=-0.80, P<0.001) showing small fish with higher surface to flesh ratio to have higher salt content. Larger cell size of triploids does however not affect the salt diffusion (P>0.36) or induce any growth advantages to triploids (Benfey, 1999).

Triploid salmon is earlier reported to be softer compared to diploids which has been explained with less small muscle fibers and 23% larger mean cross-sectional fibers area in triploid than diploid salmon (Bjørnevik et al., 2004). There is also found indications on an inverse relationship between average fiber diameter and flesh firmness (Hurling, Rodell, & Hunt, 1996). Lerfall et al. (2017) reported differences in fillet firmness to be dependent on the holding temperature. At low temperatures (5 and 10 °C), triploid salmon tends to have firmer tissue as compare to diploids. Significantly higher fillet firmness in cold smoked fillets of triploids, as compared to diploids, is therefore likely to be a result of increased effect of the salting and smoking process on factors.
affecting the textural properties in the salmon muscle. *i.e.* dehydration, increased ionic strength and changed microstructure (Birkeland et al., 2004; Jittinandana, Kenney, Slider, & Kiser, 2002; Sigurgisladottir, Sigurdardottir, Torrissen, Vallet, & Hafsteinsson, 2000).

The color of salmon fillets is mainly due to the carotenoid concentration in the muscle tissue (Skrede & Storebakken, 1986) whereas decomposition of carotenoids during salting and smoking has little influence on the color changes during processing (Birkeland, 2004; Lerfall et al., 2011). The development of color during smoking is caused by a series of chemical reactions such as protein and lipid oxidation (Hidalgo & Zamora, 2000) as well as Maillard reactions (Martins, Jongen, & van Boekel, 2000). Ploidy is earlier reported to affect the flesh color in rainbow trout (Choubert et al., 1997), and Bjørnevik et al. (2004) reported a darker (lower $L^*$ value) and a more reddish color (higher $a^*$ value) of raw triploid salmon. In the present study, main effects of ploidy indicate raw and salted triploids to be paler than diploids, whereas only tendencies of paler triploid were observed after smoking and refrigerated storage. Differences in colorimetric characteristics between diploid and triploid cold smoked salmon is most likely affected by the fish growth where a significant correlation between the fish weight and $a^*$ and $L^*$ were observed ($r=0.419, P<0.001$ and $r=-0.276, P=0.002$, respectively). The intensity of redness (increased $a^*$ value) was moreover found to increased stepwise with increased holding temperature independent of ploidy.

In the present study largest effects of ploidy was observed for salmon kept at 10 °C (data not shown). Triploid salmon kept at 10 °C were found to be softer (lower firmness), less reddish and paler as compared to respective diploids. Color is a key attribute of food items (Francis, 1995) and an important decision maker for consumers when purchasing smoked salmon products (Gormley, 1992; Røra, Monfort, & Espe, 2004). In the presented study, the majority of the consumers was attracted by the red color of the smoked product which probably affected the consumers to distinguishes between diploid and triploid cold smoked salmon originally kept at 10 °C. Of the other selections (5 and 15 °C), only minor differences in quality was found (only small differences in fillet firmness and...
colorimetric characteristics). Hence, it was harder for the consumers to distinguish between the diploid and triploid cold smoked product.

5. Conclusion

It is concluded that triploid Atlantic salmon is suitable for cold smoke processing but the differences in quality between diploid and triploid cold smoked salmon is significant. Triploid cold smoked salmon have on average lower processing yield, higher weight loss throughout processing and storage, and was softer as compared to diploids. The ploidy did however not affect the NaCl content.

It is moreover concluded that a consumer test distinguishes between cold smoked diploid and triploid salmon originally kept at 10 °C. In addition, increased holding temperature gives a step-wise lower weight loss during processing and significant darker fillets after cold smoking and storage.

Acknowledgment

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Figure captions:

Figure 1. Main effects (GLM) of (A) ploidy (∎ diploid and □ triploid) and (B) holding temperature (∎ 5 °C, □ 10 °C and □ 15 °C) on the weight loss (average±SE) of salmon fillets during cold smoke processing and 28 d refrigerated storage. Different letters indicate significant variation (P<0.05) between the respective groups by GLM and Duncan’s comparison test.

Figure 2 Firmness (average±SE) of □ diploid and □ triploid smoked salmon kept at 5, 10 and 15 °C determines instrumentally as the force at 80% compression of the fillet height (GLM; model: P<0.001; ploidy: P=0.024; holding temperature: P<0.001).

Figure 3 Main effects (GLM) of ploidy (A, C, E, □ diploid and □ triploid) and holding temperature (B, D, F, □ 5 °C, □ 10 °C and □ 15 °C) on CIE L*a*b* values (average±SE) (CIE, 1994) of raw, salted, smoked and stored (28 d) diploid and triploid salmon kept at 5, 10 and 15 °C, respectively. Different letters (abc) indicate significant variation (P<0.05) between respective groups within each processing step by GLM and Duncan’s comparison test.
Figure 1.
Figure 2.
Figure 3.
<table>
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Table 2
Raw material characteristics. Average biometrics, death temperature, pH and blood lactate of diploid and triploid Atlantic salmon kept at 5, 10 and 15°C

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<td>1.7±0.8</td>
<td>2.1±1.4</td>
<td>2.5±1.0</td>
<td>2.6±1.1</td>
<td>0.031 0.52 0.004 0.94</td>
</tr>
</tbody>
</table>

a Average values of 10 individuals per group, in total 60 individuals.
b Average values of 5 individuals per group, in total 30 individuals.
c General Linear Model (GLM) analyses of variance, where P M, P P, P T, and P P×T are the significance levels for the effects of the model, ploidy, holding temperature and the interaction between ploidy and holding temperature, respectively.
Table 3
Processing yield, weight loss and content of NaCl (% of wet weight) after each processing step during cold smoke processing of diploid and triploid Atlantic salmon kept at 5, 10 and 15°C

<table>
<thead>
<tr>
<th></th>
<th>5 °C</th>
<th>10 °C</th>
<th>15 °C</th>
<th>GLM b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diploid</td>
<td>Triploid</td>
<td>Diploid</td>
<td>Triploid</td>
</tr>
<tr>
<td>Weight loss salting, %  a</td>
<td>9.5±1.3</td>
<td>9.9±1.2</td>
<td>9.1±0.9</td>
<td>9.3±0.9</td>
</tr>
<tr>
<td>Weight loss smoking, %  a</td>
<td>4.5±0.9</td>
<td>4.7±0.6</td>
<td>3.8±0.4</td>
<td>4.3±0.4</td>
</tr>
<tr>
<td>Weight loss storage, %  a</td>
<td>2.5±0.4</td>
<td>2.9±0.4</td>
<td>3.2±0.8</td>
<td>2.6±0.3</td>
</tr>
<tr>
<td>Yield, after smoking, %  a</td>
<td>86.4±1.8</td>
<td>85.8±1.5</td>
<td>87.4±1.0</td>
<td>86.8±1.1</td>
</tr>
<tr>
<td>NaCl content, %  a</td>
<td>6.2±1.2</td>
<td>6.6±1.1</td>
<td>5.3±0.6</td>
<td>5.8±0.8</td>
</tr>
</tbody>
</table>

a Average values of 10 individuals per group, in total 60 individuals. An average of the left and right fillet was used for statistical analyses.
b General Linear Model (GLM) analyses of variance, where $P_{M}$, $P_{P}$, $P_{T}$, and $P_{P\times T}$ are the significance levels for the effects of the model, ploidy, holding temperature and the interaction between ploidy and holding temperature, respectively.
Table 4
Sensory evaluation of cold smoked salmon discriminated by a triangle test

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of answers</th>
<th>Correct answer</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5°C</td>
<td>92</td>
<td>33</td>
<td>0.263</td>
</tr>
<tr>
<td>10°C</td>
<td>98</td>
<td>44</td>
<td>0.008</td>
</tr>
<tr>
<td>15°C</td>
<td>97</td>
<td>34</td>
<td>0.344</td>
</tr>
</tbody>
</table>

* The consumer test was analyzed with a Z-test approximation of the binomial test