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Using renowned chefs for VeriTaste™ as a sensory method analysis in food products – A comparison of Atlantic salmon stored in refrigerated seawater and on ice

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A B S T R A C T

Sensory evaluation is an important quality analysis for examining the characteristics of a food product. This study presents a new sensory analysis method using renowned chefs, branded Veritaste™, to evaluate raw and cooked fillets of Atlantic salmon originating from refrigerated seawater (RSW) versus traditional ice whole fish storage. Quality parameters were also studied, including the fillet index method and cook loss. The raw fillets from the RSW-stored fish had a more distinct salty taste compared to the traditionally stored fish. In addition, the RSW-stored salmon gave a lower cook loss. Otherwise, there were minimal differences in the sensory parameters observed and the fillet index measurements. Both Veritaste™ and the fillet index measurements showed that judges significantly influence the sensory quality parameters. It is concluded that Veritaste™ can serve as supplementary information in addition to the common sensory analyses done today. This method has the potential to be further improved, optimised, and extended to other food products.

1. Introduction

Fish quality is a broad term involving several aspects related to the freshness and safety of a product. Quality can be classified into five main components: sensory, hygienic, nutritional, ethical, and technological (Listrat et al., 2016; Nortvedt et al., 2007). The first quality parameters a consumer usually evaluates in a product is through the human senses, such as colour, appearance, texture, taste and/or aroma. In the fish industries, sensory analysis is an important approach that is widely used (Martinsdóttir et al., 2009) as it can relate to spoilage and provide useful information for product development, marketing and process optimization (Ares et al., 2010; Iannario et al., 2012). Sensory analyses are also important for quality assessment, consumer perspectives, marketing and new product developments in the food industry (Ruiz-Capillas et al., 2021; Świąder and Marczewska, 2021). Sensory evaluation can be classified according to analytical and affective measurements (Ruiz-Capillas et al., 2021). Analytical tests include descriptive and discriminatory analyses to characterize and distinguish the products, while affective tests relate to consumer acceptance and preferences (Meilgaard et al., 2006; Ruiz-Capillas et al., 2021). Examples of common descriptive methods for fish analysis include the quality index method (QIM) for whole fish (Hyldig and Green-Petersen, 2004) and the fillet index method for fish fillets (Chan et al., 2020), where trained panellists perform objective analyses using specific guidelines to determine the product quality and remaining shelf life.

The Norwegian Institute of Food, Fisheries and Aquaculture Research (Nofima) has developed a novel affective sensory analysis that judges the quality of raw materials and food products using renowned professional culinary chefs and their subjective evaluations. The method is branded Veritaste™, where *Veri* means verification, very, verify; *Veritas* is the Latin word for truth, and *taste* refers to the sense of taste. Chefs are professionals who work using their senses and often handle raw materials. They have well-defined senses through years of experience and close contact with consumers. Moreover, they may experience a product differently than trained panellists (Frøst et al., 2015) or scientists (Frøst, 2019). Kawasaki and Shimomura (2015) stated the importance of scientists collaborating with chefs to understand their motivational factors when creating new dishes. Therefore, using experienced chefs in Veritaste™ can serve as supplementary information to the trained sensory panels. Veritaste™ utilizes chefs' experience-based knowledge, know-how and detailed information about food (ingredients, produce and products), and provides information about specific quality aspects. In addition, Veritaste™ will not only be limited to Norwegian seafood products but can also be applied as a method to

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other food products, which can offer food producers a subjective quality assessment by experienced chefs.

Many factors can influence the sensory quality of fish products in the value chain, including processing and preservation methods. Superchilling is a preservation method that keeps the internal temperature of food between traditional chilling and freezing (Banerjee and Maheswarappa, 2019). A new fish slaughter method was introduced by directly slaughtering salmon onboard a fishing vessel by the sea cage and immersing the gutted fish at superchilled conditions below 0 °C in refrigerated seawater (RSW) tanks. Storing whole gutted Atlantic salmon in RSW has, in recent years, been extensively studied through the whole value chain (Chan et al., 2022; Chan et al., 2021; Chan et al., 2020a; Chan et al., 2020b; Skare et al., 2021). This concept bypasses several steps in the value chain and maintains a low internal temperature of fish immediately after slaughter. Chan et al. (2020a) and Chan et al. (2021) reported that storing salmon in RSW for 4 days and then in boxes for 3 days resulted in an increase in weight between 0.7 and 0.9% with a salt content of 0.2–0.3%. RSW systems usually have a salt content of 3.5% w/w, which is higher than the fish muscle. This leads to salt diffusing into the muscle through the skin or exposed muscle through the belly after gutting. Previous studies reported an undesirable salty taste of cod stored in RSW for 3 days (Graham et al., 1992). However, gutted halibut did not have this challenge, even after several weeks of storage (Graham et al., 1992). Salt uptake is rendered insignificant for fatty fish like salmon due to its large size and subcutaneous fat layer that can hinder salt migration (Šimat and Mekinić, 2019). Nevertheless, sensory characteristics of RSW-stored salmon are important parameters to determine as this reflects the eating quality in real-life. Therefore, the main objective of this experiment was to develop the new sensory method, Veritaste™, using experienced sensory chefs as panellists, and to use this method to evaluate the sensory quality of raw and cooked Atlantic salmon originally stored in RSW and ice. Quality parameters, including fillet index and cook loss, from the two whole fish storage methods, were also studied.

2. Materials and methods

2.1. Experimental design

Whole gutted Atlantic salmon was obtained parallel to the experiments published by Chan et al. (2021) and Chan et al. (2022). Fish were obtained from a nearby fish slaughter facility on November 5, 2020, weighed, tagged and stored in either expanded polystyrene (EPS) boxes containing ice or in small-scale makeshift RSW tanks with a temperature between −0.5 and −1 °C. This makeshift tank was manually set up, and filtered seawater (~3.5% salinity) was collected from a nearby research institute in a 1000L polyethylene tank. The temperature in the tank was maintained at below 0 °C with the regular addition of frozen seawater ice, prepared before the start of the experiment. The proximate composition of the fish was measured, in addition to pH, salt content, colour, texture and water holding capacity (WHC). A more detailed description of the analyses can be referred to Chan et al. (2021).

For the present study, 24 salmon were used for RSW (n = 12) and ice-stored salmon (n = 12). On day 4, the RSW tank was drained, and these fish were kept in boxes containing ice before they were filleted and portioned on day 7.

2.2. Processing

On day 7, both RSW and iced stored fish were manually filleted. Six fish from each group were used for Veritaste™, where each fillet was portioned into three pieces, as seen in Fig. 1; the Flesh quality cut (FQC), Scottish quality cut (SQC) and the Norwegian quality cut (NQC). The right fillets were kept as raw portions placed on white chopping boards (Saf-T-Grip 610 × 457 × 13 mm), covered with plastic wrap and stored at 0 °C. The board was divided into six fields using coloured tapes, and

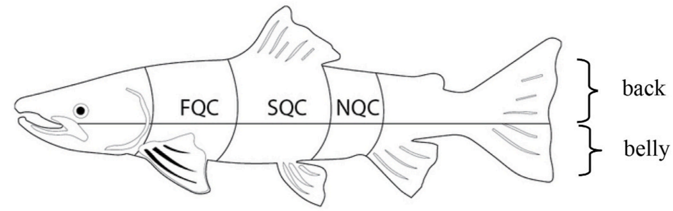

Fig. 1. Graphical illustration of the Flesh quality cut (FQC), Scottish quality cut (SQC), and Norwegian quality cut (NQC) portions of Atlantic salmon after filleting.

each field contained one portioned sample (Fig. 2). The left fillet portions were kept in their respective Dyno trays (210 × 145 × 45 mm, Tray 526, RPC Bebo Food Packaging, Norway) and covered with plastic wrap on a baking tray. They were then kept in chilled conditions (0 °C) before undergoing heat treatment the next day. In addition, the remaining fish were filleted and kept in EPS boxes for fillet index and cook loss measurements.

2.3. Veritaste™

Veritaste™ was conducted on day 8 with experienced Norwegian chefs (n = 5, male, 35–50 years old). The left fillet portions were baked in an oven (MSCC 201, Metos System Rational, Germany) at 50 °C hot air setting for 90 min before the evaluation. The professional culinary chefs were chosen and invited based on their extensive experiences in the Norwegian seafood chain. They were not trained by the researchers prior to the study but had at least 10 years of experience leading renowned seafood restaurants in Norway. They have also participated in or won international gastronomic competitions like Bocuse d'Or and were awarded stars in the Michelin Guide.

Without receiving any information on the different processing methods after slaughter, each chef received two variants based on the whole fish storage treatment (RSW, ice) with three parallels of each treatment for sensory evaluation. Samples were placed randomly and marked with a randomized 3-digit code. Each chef received six portions of raw and cooked samples, and evaluated the same cut for both samples (i.e. one chef received only FQC samples, while two chefs received only SQC or NQC samples). The setup of materials that each chef received was standardized, including chef's knives, assessment forms, disposable gloves, writing materials and, spittoons. Water and apple slices without skin were used as palate cleansers (Fig. 3).

The assessment schemes for raw and cooked fish were based upon well-defined characteristics of quality attributes using a 9-linear scale scoring system (1: uneatable, 9: optimal). These characteristics include (a) appearance, (b) odour, (c) taste and mouthfeel on the back part, and (d) taste and mouthfeel on the belly part for both raw and cooked fish. Furthermore, two additional characteristics were included for raw fish, (e) consistency when touched and cut with a knife and (f) salt and richness of taste on the belly part. For parameters (a) to (e), judges were asked to begin from the highest score of 9 to ensure that they used the scales in the same way, and deducted points from there as they saw fit. For parameter (f), the "just-about-right" scale was used (1: low, 5: just right and 9: high). Examples of deviations were included under each category. Before the evaluation, the organizer gave brief instructions (e.g. sample test sequence, information on assessment schemes, explanation of point scales, availability of materials). Afterwards, 2h were given to evaluate the raw samples (1h) first, then the cooked samples (1h), including a 5–10 min break. The panellists were allowed to taste the samples as often as they preferred.

2.4. Fillet index

In parallel with Veritaste™, fillet index measurements were carried

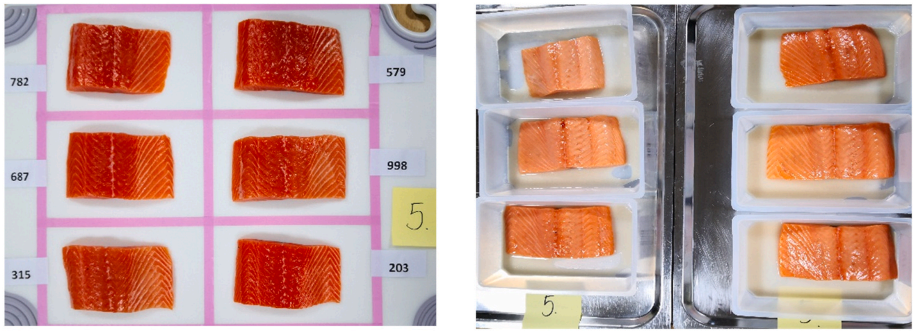

Fig. 2. NQC samples for judge number 5 for raw (left) and cooked (right) fillet portions. Each sample was marked with a randomized 3-digit code.

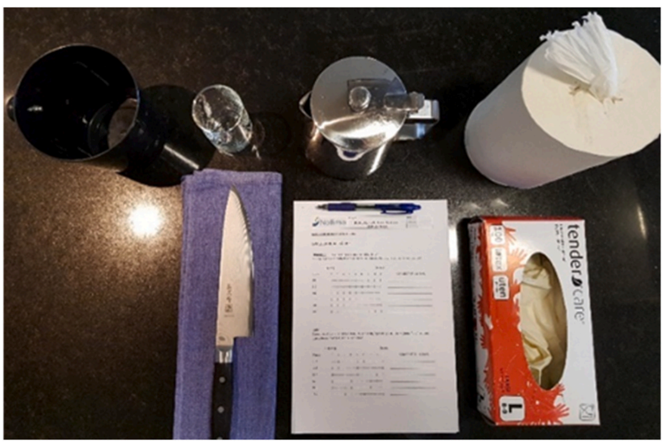

Fig. 3. Materials set up for each chef.

out on day 8 on RSW and ice-stored fillets using a semi-trained panel with more than 15 years of experience (n = 4, female, 45–65 years old). The panellists were trained based on the standard ISO 8586:2012 (International Organization for Standardization, 2012). The fillet index method gives a demerit point for five key attributes (odour, gaping, colour, consistency, surface). The criteria for odour, gaping, colour and consistency were graded using a 4-point scale (0: best, 3: worst), while the surface texture was graded with a 2-point scale (0: dry, 1: loose). Finally, the overall demerit points were summed (0: best, 13: worst) (Chan et al., 2020b).

2.5. *Cook loss*

The fillets used for fillet index analyses were cut into three portions (FQC, SQC, NQC) and heat-treated using the same parameters as the cooked samples for Veritaste™ (50 °C, 90min). Thermocouples type K (PR Electronics Inc., USA) were inserted randomly in salmon samples and in the surrounding environment during heat treatment. The temperatures were logged in an Eval Flex recorder per second (Eval Flex, Denmark). Cook loss was calculated as the percentage difference (%) of the cooked sample (g) with respect to its initial raw sample weight (g).

2.6. *Statistical analysis*

Minitab Version 21 (Minitab Inc., USA) was used for all statistical analyses. A general linear model (GLM) was used to evaluate the relationship between the response variables and treatments (RSW, ice) and judges as categorical factors. The assumptions of GLM (normality and homoscedasticity) were first tested using the Shapiro-Wiik and Levene's test. Otherwise, a non-parametric Kruskal Wallis test was used. All results are presented in mean ± standard deviation, and the α-value was set to 0.05.

3. Results and discussion

3.1. *General quality parameters*

The initial compositions of the samples after slaughter were reported by Chan et al. (2021). The temperature of the RSW fish was maintained rather stable at −0.9 ± 0.2 °C for 4 days of storage. As the RSW was drained, fish were transferred to boxes containing ice where the internal temperature remained at −0.7 ± 0.1 °C for 3 days. The iced fish remained constant at −0.1 °C during the 7 days. An overall weight gain of 0.9% was observed for the RSW fish after 7 days. In addition, as reported by Chan et al. (2021), the WHC was higher for fish stored in RSW (94.6 ± 2.1%) than those on ice on day 7 (91.9 ± 2.5%, $p = 0.042$).

The salt content for RSW fish (0.23 ± 0.04%) was higher than ice-stored fish (0.16 ± 0.02%, $p = 0.007$). This was likely attributed to the salt uptake through the abdominal cavity from the concentration difference between the muscle and surrounding seawater. Referring to the results of Chan et al. (2021), there were no differences in colour and texture (firmness) between the two storage methods. However, firmness significantly decreased through storage until the processing day ($p < 0.001$), which is an established phenomenon of muscle softening within the flesh due to protein denaturation (Erikson et al., 2011; Hultmann and Rustad, 2002).

3.2. *Veritaste™*

The sensory profiles of raw salmon samples evaluated by the chefs showed no significant differences between RSW or iced stored fish among the attributes, apart from the salt and richness of taste (Fig. 4, Table 1). The RSW fish (5.8 ± 1.7) had a significantly saltier taste on the belly side than the iced fish (4.6 ± 2.0, $p = 0.004$). Nevertheless, both groups were close to the scale of 5 ("just right"), indicating that the fish were at optimal levels in salt and richness of taste. In this study, parameters of salty taste were focused on the belly part for sensory analysis. This was due to the belly of the gutted fish being more exposed to RSW from the opening of the abdominal cavity. Therefore, the difference in salt concentration induces salt uptake into the muscle. There were no significant differences among the attributes for cooked samples (Fig. 4, Table 2). However, the taste on the belly of RSW fish was slightly more preferred ($p = 0.062$), possibly linked to the saltier taste.

Excluding the salty taste attribute, all groups of raw and cooked samples scored above 5, but none obtained the most optimal score of 9. There was a significant difference among chefs on consistency ($p = 0.018$), taste (back) ($p = 0.044$), taste (belly) ($p = 0.030$), salty taste (belly) ($p < 0.001$) on raw samples, and odour on cooked samples ($p < 0.001$). Although only a small group of chefs participated, they had at least 10 years of experience in seafood and handling. Hence, their culinary senses were assumed to be well-trained. Unlike objective sensory assessments where panellists are calibrated against one another, the

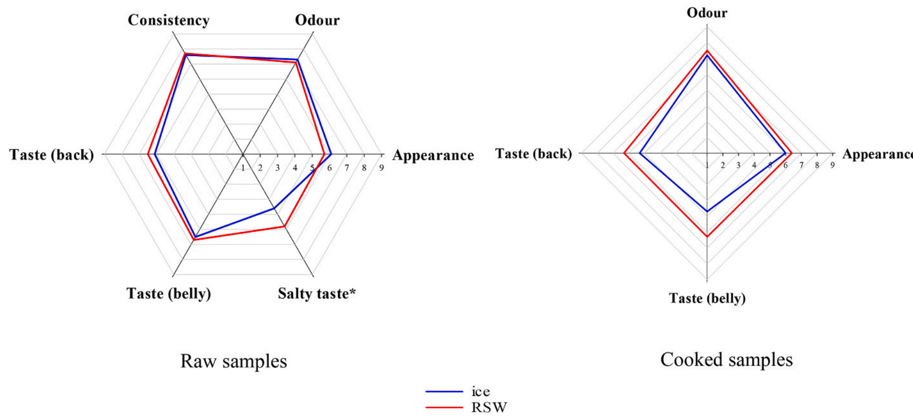

Fig. 4. Plots of raw and cooked salmon samples from RSW and ice-stored fish, with different sensory attributes as analysed by the chefs. "Salty taste" represents salt and richness of taste in the belly part, and "Taste (belly)" and "Taste (back)" represent taste and mouthfeel in the belly and back part, respectively. *denotes significant levels $p < 0.05$.

Table 1
Scores of sensory attributes for raw salmon samples from RSW and ice stored fish as analysed by the chefs. p_G and p_c are the significant levels for the effects of group (RSW, ice) and chefs, respectively. *significant levels with $p < 0.05$.

Group	Appearance	Odour	Consistency	Taste (back)	Taste (belly)	Salty taste (belly)
RSW	5.7 ± 1.9	7.1 ± 1.6	7.7 ± 1.1	6.5 ± 1.6	6.7 ± 1.8	5.8 ± 1.7
ice	6.1 ± 2.2	7.3 ± 1.0	7.6 ± 1.3	6.1 ± 1.8	6.5 ± 1.5	4.6 ± 2.0
p_G	0.518	0.949	0.855	0.552	0.704	0.004*
p_c	0.207	0.089	0.018*	0.044*	0.030*	<0.001*

Table 2
Scores of sensory attributes for cooked salmon samples from RSW and ice-stored fish as analysed by the chefs. p_G and p_c are the significant levels for the effects of group (RSW, ice) and chefs, respectively. *significant levels with $p < 0.05$.

Group	Appearance	Odour	Taste (back)	Taste (belly)
RSW	6.4 ± 1.6	7.5 ± 1.6	6.3 ± 2.0	6.3 ± 2.3
ice	6.0 ± 1.3	7.2 ± 1.3	5.3 ± 2.0	4.7 ± 2.2
p_G	0.516	0.510	0.140	0.062
p_c	0.191	<0.001*	0.067	0.206

Veritaste™ method serves as a subjective assessment to better understand the products intended for the market and should, therefore, not replace the former method. Nevertheless, calibration or training in sensory characteristics among the chefs before the study could be considered in the future. In the study, the differences observed may be explained by the specific parts of the salmon obtained by each chef, as quality parameters may differ within the sections of a salmon fillet. Although the judges assessed raw and cooked samples from the same fish, only one chef judged the FQC samples compared to two chefs who evaluated the SQC and NQC samples. This may introduce an erroneous assessment as the samples may not be equally well-represented. As seen in previous studies, the thickness and fat content of the fillets decrease while hardness increases from head to tail (Bjørnevik et al., 2004; Einen et al., 1998; Jonsson et al., 2001; Mørkøre et al., 2009). As a result, the among and within variations of the fillets may have influenced the sensory quality perceived by the chefs. Therefore, a suggestion in the future is to randomize the samples or use the same fish cuts during the analysis.

This study is the first to employ the Veritaste™ method using renowned chefs for sensory analysis. Therefore, there is a need to develop further and optimize this method to cater for a wider range of raw and cooked products in the future. For instance, not all parameters analysed for the raw fish were included in the cooked samples (i.e., consistency and salty taste). The reason for choosing the specified sensory attributes was to provide a simpler scoring system for chefs when they handle raw materials and the products they prefer, including holding, cutting and tasting.

3.3. Fillet index

There was a significant difference among judges ($p = 0.001$) but not storage method ($p = 0.399$) on the overall fillet index scores (Fig. 5a). Generally, the average scores for both RSW (0.26 ± 0.3) and iced fish (0.20 ± 0.3) were low, indicating good sensory quality. When each parameter was compared, there was a significant difference among judges in the assessment of odour ($p < 0.001$), colour ($p = 0.014$) and consistency ($p = 0.010$) of the samples. In line with the results from Veritaste™, no differences were seen between the two storage methods regarding odour, appearance and consistency on the raw fillets. The similarity between a sensory panel and chefs as judges is their utilization of senses in assessing a food product. Judges can significantly influence the sensory quality score due to variations in human sensory evaluation (Njoman et al., 2017). Furthermore, Veritaste™ allows the chefs to taste the products while they are still safe to consume, giving more valuable information on the eating quality. Hence, this present study shows that Veritaste™ could serve as a supplementary analysis to the common sensory methods done today.

3.4. Cook loss

The temperature during heat treatment of fillet portions for cook loss measurements is shown in Fig. 6. The internal temperature of the fish gradually reached 44.9 ± 0.6 °C after 90 min of heat treatment, while the ambient temperature in the oven ranged from 47.7 to 58.3 °C with an average of 50.2 ± 1.9 °C.

Fig. 5b illustrates the average cook loss of fish samples from whole fish originating in RSW and on ice. There were no differences between cook loss on the three portions for RSW ($p = 0.182$) and iced fish ($p = 0.088$), so the average of these portions was used for analysis. In general, cook loss of RSW stored fish (10.1 ± 0.9%) was significantly lower than those from ice (12.6 ± 1.3%, $p < 0.001$). Using a thermal force to measure cook loss is a conventional approach to WHC. This loss mainly consists of intra and extracellular water from the muscle due to protein denaturation and cell membrane disintegration (Bowker, 2017). Therefore, the lower cook loss of RSW stored fish may be attributed to its greater WHC, indicating a better ability of the muscle to retain water. Skare et al. (2021) conducted a sensory profile analysis on RSW and

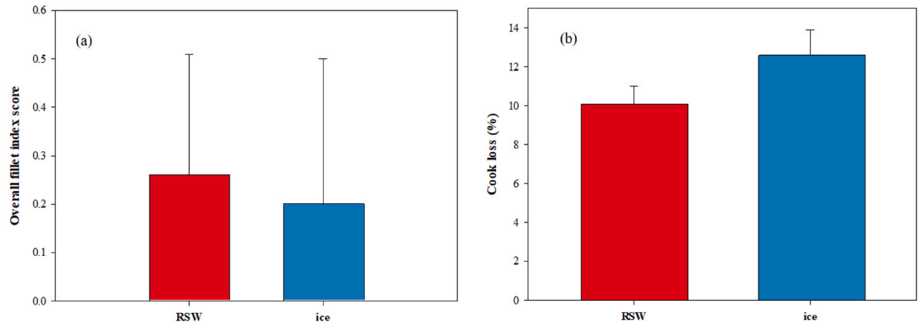

Fig. 5. (a) Overall fillet index scores of samples from whole fish stored in RSW and ice ($n = 4$; judges: $p < 0.001$; group: $p = 0.399$). (b) Average cook loss of samples from whole fish stored in RSW and ice ($n = 6$; group: $p < 0.001$).

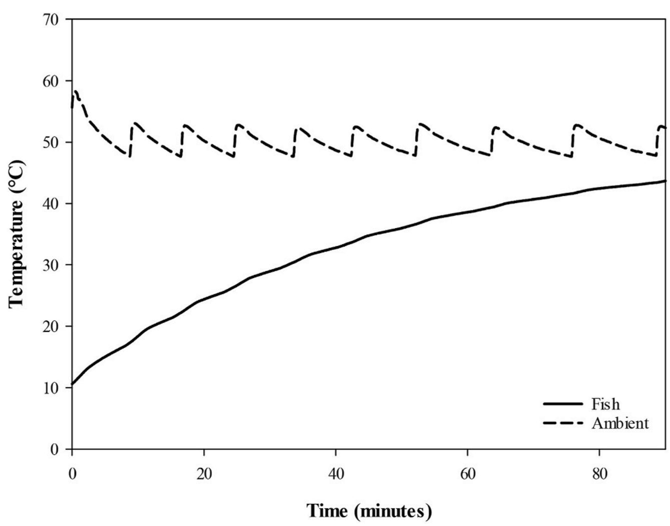

Fig. 6. Average temperature profile of fish and ambient environment in the oven during heat treatment.

ice-stored cooked salmon. They found no differences between the two groups in all measured attributes, apart from higher protein precipitation from the ice-stored fish. This indicates that the sensory quality of cooked salmon from both storage methods was comparable, along with a better cook loss for RSW stored fish, as observed in this study.

4. Conclusion

This study introduces a novel concept of using experienced and renowned chefs as judges in a new sensory analysis method, branded VeriTaste™, on two different storage methods of whole gutted Atlantic salmon. Fish stored in RSW presented a saltier taste with a lower cook loss than traditional ice storage. Otherwise, the quality between RSW and ice-stored fish was comparable. The results showed that judges could significantly influence the perceived sensory quality score. Nevertheless, VeriTaste™ can serve as supplementary information to the sensory analyses often used today. Since this is a new concept, it can be further developed, improved, and customized to cater for different raw materials often handled by chefs.

Implications for gastronomy

This research focused on Atlantic salmon products from two whole fish storage methods. Direct onboard fish slaughter and then storing the gutted whole fish in RSW is a novel fish slaughter method. The novel sensory method VeriTaste™ using chefs as panellists, provides subjective evaluations that can complement the sensory analysis using the trained panel. Chefs handle and use their senses to analyse food materials frequently and work closely with consumers to identify their preferences. While VeriTaste™ is developed as a seafood analysis method, this can be further extended to analyse other raw materials and food products. Therefore, the results obtained from this research serve as a benchmark for the possibility of performing VeriTaste™ in the future to determine a product's quality and potentially increase the chance of the product succeeding in the market.

Author contributions

Sherry Stephanie Chan – Methodology, Formal analysis, Writing – original draft; Stian Gjerstad Iversen – Conceptualization, Methodology, Formal analysis; Aase Vorre Skuland – Conceptualization, Methodology, Formal analysis; Bjørn Tore Rotabakk – Methodology, Formal analysis, Writing – review and editing; Jørgen Lerfall – Methodology, Formal analysis, Writing – review and editing; Guro Helgesdotter Rognså – Conceptualization, Methodology, Writing – review and editing; Bjørn Roth – Conceptualization, Methodology, Writing – review and editing, Supervision, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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