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Sensory methodology in product optimization of cold smoked Atlantic salmon (*Salmo salar* L.) processed with atomized purified condensed smoke

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Abstract: Atomized purified condensed smoke (PCS) is a smoke processing technique, producing fewer harmful substances during processing, than conventional smoking. Manufacturers of cold smoked salmon (CSS) are however skeptical to PCS due to expected decrease in perceptual quality. The aim of this study was to use sensory methodology (Check All That Apply [CATA], Descriptive Analysis [DA] and Napping®) in optimization of PCS processed CSS. A three-step experiment was performed using five unique PCS condensates and varying process parameters. In each step, PCS processed CSS were perceptually evaluated and compared with conventional CSS. In *Step one*, PCS processed CSS was compared to conventional CSS, initiating process changes prior to the next step. In *Step two*, conventional CSS, two new condensates and the altered CSS from *Step one*, were screened to choose two prototypes for *Step three*. In *Step three*, perceptual differences, consumer acceptance, and physiochemical parameters of the two PCS prototypes and conventional CSS were examined. Napping® was proven effective for sorting and describing samples, distinguishing the dry and smoky ones from the shiny, soft, and mild varieties. CATA with hedonic scaling successfully characterized samples and the ideal CSS, gave useful information about consumer acceptance, and identified salty, smokey and natural to be important drivers of liking. The two descriptive tests CATA and DA in *Step three*, processing yield and physiochemical parameters gave a complete prototype description and input for further development. By combining the results from sensory perception and the physicochemical measurements, the experiment succeeded to produce a promising PCS prototype with sensory quality and consumer acceptance similar to conventional CSS.

Practical Application: The use of atomized purified condensed smoke (PCS) is considered healthier than conventional smoke processing (EU Regulation 2065/2003; Lingbeck et al., 2014). Even if PCS is widely used in meat processing, manufacturers of cold smoked salmon (CSS) are hesitant, fearing loss of perceptual quality. However, by using sensory methodology in product optimization of

PCS processed CSS, a promising prototype was developed. With some more testing and adjustments, it will be possible to produce healthier CSS with similar sensory quality and consumer acceptance to conventionally CSS and offer this to a world-wide market.

KEYWORDS
Product optimization, Sensory methodology, Cold smoked Atlantic salmon, Atomized purified condensed smoke, Consumer acceptance

1 | INTRODUCTION

Traditional methods of product preservation are multifaceted. Salting and conventional smoking provides sensory changes and preservation to products caused by the incorporation of salt and smoke compounds combined with dehydration (Cardinal et al., 2004; Cruz, Martins, Marques, Casal, & Cunha, 2018). In addition, transfer of unwanted substances such as polycyclic aromatic hydrocarbons (PAHs; Cruz et al., 2018; Visciano, Perugini, Amorena, & Ianieri, 2006; Wretling, Eriksson, Eskhult, & Larsson, 2010) and tar, ash, and soot can be challenging reducing the overall food quality (Toledo, 2007). A healthier and more sustainable option for smoke processing of foods is to use atomized purified condensed smoke (PCS) (Clean Smoke Coalition, 2020; Lingbeck et al., 2014), which The European Parliament and the Council of the European Union supports as it is considered healthier than conventional smoking (EU Regulation, 2065/2003). PCS is generated based on purified primary products and contains fewer harmful substances such as PAHs (Clean Smoke Coalition, 2020; Lingbeck et al., 2014).

PCS is widely used in meat processing (Gedela, Gamble, Macwana, Escoubas, & Muriana, 2007; Lingbeck et al., 2014), but Norwegian manufacturers of the traditional food product cold smoked salmon (CSS) are hesitant due to consumer skepticism and the fear of decreased perceptual product quality (Hestad, 2020). Smoke condensates are commercially available and can be tailor-made to obtain substances with a range of perceptual qualities (Martinez, Salmeron, Guillen, & Casas, 2007). Previous studies have compared quality attributes of PCS processed- and conventional CSS. Valø, Jakobsen, and Lerfall (2020) found PCS processed CSS to be darker, less reddish, more yellowish, and slightly firmer than conventional CSS. In another study by Varlet et al. (2007), sensory properties and the occurrence of PAHs were studied in four industrial processes for smoked salmon. The liquid smoke atomization process (PCS) gave the lowest total concentration of PAHs and significantly higher score for the odors “cold smoke” and “vegetal/green.” The study showed moreover insufficient control of the PCS process, and the product odor characteristics to be challenging compared to conventional smoking. These findings suggest that there is a need for an optimization process focusing on the sensory quality of PCS processed CSS.

Successful product development is required to thrive in today’s competitive food market (Costa & Jongen, 2006), and one of the most critical steps is product optimization (Ares & Varela, 2018). It is essential to know which sensory properties distinguish the products and how the consumer acceptance is affected, in all food related optimization. One way to examine perceptual quality is to reveal differences using descriptive sensory methods performed by sensory assessors with varying degrees of training. Conventional profiling using descriptive analysis methodology (Lawless & Heymann, 2010; Stone, Sidel, Oliver, Woolsey, & Singleton, 1974) has been the common industrial approach for years, but cheaper and less time-consuming methods, are continuously being developed (Varela & Ares, 2012). Projective mapping or Napping® (Pagès, 2003) and Check All That Apply (CATA; Adams, Williams, Lancaster, & Foley, 2007) are both examples of such rapid methods, which have gained increased interest among stakeholders (Delarue, Lawlor, Rogeaux & Ares, 2015). Common for these methods are the possibility to use untrained assessors (Ares & Varela, 2017). The idea of using CATA in product optimization was initially introduced by Ares, Varela, Rado, and Giménez (2011) comparing three consumer profiling techniques. Gaarder, Varela, and Hersleth (2015) successfully combined the two descriptive methods Napping® and CATA, in an industrial line extension development process. According to Mancini, Menozzi, Arfini, and Veneziani (2018), a good understanding of perception and consumer attitudes toward innovations in traditional food products, is crucial for success.

The objective of this study was to assess perceptual quality and consumer acceptance in product optimization of PCS processed CSS, and to identify processing parameters resulting in CSS with similar sensory and physiochemical quality and consumer acceptance to those processed conventionally.

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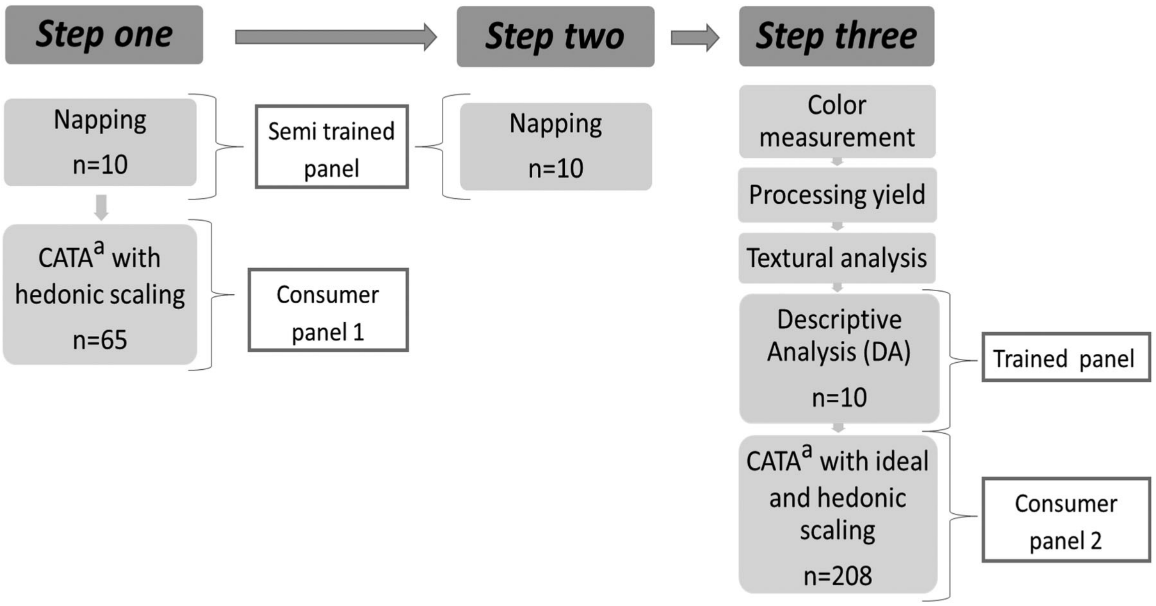

FIGURE 1 Types of analysis and sensory panels. *Step one*: Initial sensory testing of PCS (atomized Purified Condensed Smoke) condensates, *Step two*: Sample screening using Napping®, and *Step three*: Quality comparison of the two PCS prototypes and conventional cold smoked salmon.
Note: [a]CATA = Check All That Apply

2 | MATERIALS AND METHODS

2.1 | Raw materials and experimental setup

This study was designed as a three-step experiment (hereby denoted as *Step one*, *Step two*, and *Step three*), in which the outcome of one step affected the next (Figure 1). Atlantic salmon (*Salmo salar* L., superior quality, 4–5 kg) used in *Step one* ($n = 16$) and *Step two* ($n = 16$) were purchased from Salmosea AS (Salmosea AS, Rørvik, Norway), whereas the fish used in *Step three* ($n = 30$) were delivered by Lerøy Trondheim AS (Lerøy Trondheim AS, Trondheim, Norway). All fish were purchased head-on gutted and were filleted by hand, as soon as possible after the release of rigor mortis (2 to 4 days postmortem).

All PCS condensates used in this study (SmokEz VTABB RA12012, Beechwood smoked water RA17055, SmokEz LFB SUPRIME C, JJT01 30764575, and SmokEz Enviro R24) were acquired from Red Arrow™ (Red Arrow™, Manitowoc, WI, USA). CSS produced with these condensates are hereby denoted as VTAB, BEECH, SMOKEZ, JJT01, and ENVIRO. CSS produced by conventional smoking is hereby denoted as REF.

In *Step one* and *Step two*, conventional cold smoking was performed on all left fillets (REF). In contrast, PCS processing were performed on all right fillets divided into the same number of groups as the tested PCS condensates (Table 1). In *Step three*, a balanced incomplete block design (BIBD; Næs, Brockhoff, & Tomic, 2010) was used to create three groups consisting of 20 fillets each. One group was conventionally smoked (REF), whereas the other two groups were processed with atomized PCS (VTAB and ENVIRO).

2.2 | Processing

2.2.1 | Salting

The salting procedure was traditional dry salting. All fillets (independent of the smoking protocol) were covered with NaCl (fine-refined salt, minimum 99.0% Ph.Eur.; VWR Chemicals, Oslo, Norway) and stored on grids in a refrigerated room for 16 h at 4°C. After salting, fillets were rinsed with cold tap water (6–8°C) and dried on grids for 150 min (low air circulation, 22°C) in a Kerres smoke-air® show smoker cabinet (CS700 EL MAXI 1001; Kerres, Backnang, Germany) before they were processed conventionally by pyrolysis of wooden chips or by atomized PCS.

2.2.2 | Smoking

Conventional cold smoking was performed for 2 h at 22°C after a method described by Lerfall, Bendiksen, Olsen, and Østerlie (2016). The PCS processing was performed using a Red Arrow™ POWRSMOKER (Model 100, Red Arrow™) connected to Kerres smoke-air® show smoker cabinet

TABLE 1 Experimental setup, types of PCS[f] condensates, and process parameters (seconds of atomization per cycle, number of cycles, and drying between cycles), for all steps

Experimental setup	Step one[a] Left/right[d]			Step two[b] Left/right[d]			Step three[c] BIBD[e]	
PCS[f] condensate	VTAB	BEECH	SMOKEZ	VTAB	JJT01	ENVIRO	VTAB	ENVIRO
PCS[f] condensate added per cycle (s)[g]	40	60	80	52	52	45	52	45
Number of cycles	5	7	7	4	4	3	4	3
Drying between cycles (min)	15	15	15	20	20	20	20	20

[a]Types of condensates and process parameters recommended by the Norwegian supplier.
[b]Adjusted process parameters for VTAB. Process parameters for JJT01 and ENVIRO recommended by the Norwegian supplier.
[c]Production of the two prototypes.
[d]Conventional cold smoking on all left fillets (REF), PCS[f] processing on all right fillets.
[e]Balanced incomplete block design (BIBD).
[f]PCS = atomized purified condensed smoke.
[g]Liquid flow: 15 ml/min, pressure: 5.5 bar.

(CS700 EL MAXI 1001) according to a modified protocol described by Valø et al. (2020). Fillets were processed with PCS in varying numbers of cycles consisting of atomization, air circulation (smoking), and drying (Table 1). One cycle consisted of three times atomization (of the PCS condensate) followed by 7 min of air circulation (smoking) after each atomization. After three times atomization, and air circulation, each cycle ended with a drying step of 15 to 20 min.

2.2.3 | Packing and storing of the experimental parts

After smoke processing, all filets were vacuum packaged (50 mbar vacuum) in Star-Pack pouches (120 × 80 mm, 20-µm PA/70-µm PE; Star-Pack, Cergy-Pontoise, France) using a Webomatic® chamber machine (SuperMax s3000; Webomatic®, Bochum, Germany) and stored in a refrigerated room (4°C) for 10 days. Color and fillet weight were measured (Section 2.5.3) before removing all parts except the Scottish Quality Section (SQS) and the Norwegian Quality Cut (NQC). The experimental parts (SQS and NQC) were thereafter repacked in Star-Pack pouches by the Webomatic® chamber machine and kept frozen (−23°C) until refrigerated thawing (64 h, 4°C) prior to analyzing.

2.3 | *Step one*: Initial sensory testing of PCS condensates

The four sample groups VTAB, BEECH, SMOKEZ (Table 1), and REF were first evaluated by the Semi-trained panel using Napping®, followed by Consumer panel 1 using CATA (Figure 1). For both Napping® and CATA, the samples were kept at room temperature for half an hour before being cut into slices (3 mm thick) and served to each participant (two slices). All samples were served in plastic containers (65 mm in diameter; Veriplast Holland BV, Apeldoorn, The Netherlands), coded with 3-digit codes to eliminate bias, and evaluated in a balanced order to reduce serving order effects. Water (20–22°C) and Korni® crispy bread (Korni® Flatbrød, Kavli®, Bergen, Norway) were available to the participants for palate cleansing.

2.3.1 | Napping® (Semi-trained panel)

The Semi-trained panel consisted of 10 employees (8 women and 2 men) at NTNU, Department of Biotechnology and Food Science, in Trondheim, Norway. The assessors were selected and trained based on the standard "General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors" (ISO 8586, 2012), except for taste blindness, other than the basic tastes, and only for a selection of odors and textures. Because of this, the panel is defined as semi-trained. The evaluation was performed at the Sensory analysis laboratory at NTNU, designed in line with ISO 8589 (2007), including individual white tasting booths, controlled air conditioning, and lighting to ensure unbiased responses.

The samples were evaluated according to the Napping® procedure described by Pagès (2005). The assessors were instructed to arrange the samples in a two-dimensional space based on differences and similarities. After arranging the samples, the assessors were asked to write down descriptors for each sample or group of samples.

2.3.2 | CATA with hedonic scaling (Consumer panel 1)

Consumer panel 1 included 65 participants, mainly students, consuming CSS at least once a year. The assessment was conducted in the canteen of NTNU using portable tasting booths.

The samples were evaluated in line with the CATA procedure described by Dooley, Lee, and Meullenet (2010). The consumers were asked to check all the options they believed were present or relevant to describe the samples. Prior to the CATA, the participants were asked to rate the samples using a 9-point hedonic scale (liking). The CATA questionnaire comprised 16 terms presented in randomized order. The terms considered were: sweet, acidic, perfume, strong, raw, caviar, barbeque, caramel, butter, artificial, too little smoke flavor, right amount of smoke flavor, too much smoke flavor, appealing appearance, not appealing appearance, and not tempting.

2.4 | *Step two*: Sample screening using Napping®

Napping® was used to evaluate a total of six sample groups: three PCS varieties (Table 1), all right fillets (VTAB, JJT01, and ENVIRO), and three references (REFV, REFJ, and REFE) from the corresponding left fillets. The Napping® procedure, the Semi-trained panel, sample preparation and serving were in accordance with *Step one* (Section 2.3).

2.5 | *Step three*: Quality comparison of the two PCS prototypes and conventional CSS

The same procedure as in *Step one* (Section 2.3) and *Step two* (Section 2.4) was followed regarding thawing, tempering, slicing, sample amount, coding, and containers. The Trained panel and Consumer panel 2 (Figure 1) evaluated the three sample groups VTAB, ENVIRO (Table 1), and REF.

2.5.1 | Descriptive analysis (Trained panel)

The Trained panel consisted of 10 professional assessors (10 women) employed at Nofima AS (Nofima AS, ÅS, Norway), which performed a sensory descriptive analysis (DA) according to the "Generic Descriptive Analysis" described by Lawless and Heymann (2010) and the ISO standard 13299 (2016). The assessors are regularly tested and trained according to ISO standard 8586 (2012), and the sensory laboratory follow the practice of ISO standard 8589 (2007).

Ten fillets from each sample group were evaluated by the Trained panel and to prevent fatigue, it was distributed in 10 sessions. The assessors were instructed to evaluate the intensity of 23 preselected attributes on an unstructured scale (15 cm line scale). Water (20–22°C) and neutral yogurt (TINE® Yoghurt Naturell, TINE®, Oslo, Norway) were available to the assessors for palate cleansing.

The selection and description of the attributes (Table 2) was conducted by the 10 professional assessors guided by the panel leader at Nofima AS by evaluating examples from all sample groups (VTAB, ENVIRO, REF). The assessors also evaluated spruce, moss, burnt wood, smoked ham, and barbeque sauce to be able to describe campfire and barbeque (Table 2). The attributes considered were: color hue, color intensity, whiteness, glossiness, overall odor intensity, acidic odor, barbeque odor, campfire odor, stinging odor, overall flavor intensity, acidic taste, sweet taste, salty taste, bitter taste, barbeque flavor, campfire flavor, stinging flavor, juicy, tender, oily, sticky, raw, and crust strength.

2.5.2 | CATA with ideal and hedonic scaling (Consumer panel 2)

Consumer panel 2 (n = 208) was recruited through a local sports club. The participants were mainly relatives to juvenile club members, consuming CSS at least once a year. A sum of money was donated to the team, in the local sports club, that provided the largest number of participants.

The samples were handed out in the sports hall belonging to the sports club. Each consumer was given a box (Duni box 1,000 ml white; Staples®, Oslo, Norway) containing chilled (VWR Cooling packs 89 × 165 × 19 mm; VWR Chemicals, Oslo, Norway) samples. All participants were instructed to temper their samples before evaluation and use room tempered water for palate cleansing. To prevent unwanted heating of samples, all consumers were instructed to taste within 2 h (from receiving their sample box). A letter of information and a link to the test were handed out with the sample box.

In addition to the CATA procedure with hedonic scaling (liking) described in Section 2.3.2, the consumers were asked to characterize their ideal CSS. The CATA questionnaire comprised 29 terms divided by modalities and presented in randomized order within each modality (appearance, odor/flavor, and texture). The terms considered were:

TABLE 2 Attribute description of cold smoked salmon developed by the trained panel and the panel leader at Nofima AS, prior to the descriptive analysis

Appearance	
Color hue	Color assessment on the surface according to NCS system
	No intensity = Y20R
	High intensity = Y80R
Color intensity	Color assessment on the surface according to NCS system
	No intensity = no color intensity
	High intensity = explicit color intensity
Whiteness	Color assessment on the surface according to NCS system
	No intensity = no whiteness, maximum black or colored
	High intensity = explicit whiteness
Glossiness	Degree of gloss on the surface, oiled surface
	No intensity = no glossiness on the surface
	High intensity = explicit glossiness on the surface
Odor	
Overall odor intensity	Total amount of odor in the sample
	No intensity = no odor
	High intensity = explicit odor
Acidic odor	Associated with a fresh, balanced scent due to organic acids
	No intensity = no acidic odor
	High intensity = explicit acidic odor
Barbeque odor	Grill odor (a candied, hefty odor)
	No intensity = no barbeque odor
	High intensity = explicit barbeque odor
Campfire odor	Odor of campfire smoke (woody, fresh, spruce)
	No intensity = no campfire odor
	High intensity = explicit campfire odor
Stinging odor	Sharp, pungent odor (ammonia, sulfur)
	No intensity = no stinging odor
	High intensity = explicit stinging odor
Flavor	
Overall flavor intensity	Total amount of flavor in the sample
	No intensity = no flavor
	High intensity = explicit flavor
Acidic	Related to the basic taste acidic (citric acid)
	No intensity = no acidic taste
	High intensity = explicit acidic taste
Sweet	Related to the basic taste sweet (sucrose)
	No intensity = no sweet taste
	High intensity = explicit sweet taste
Salty	Related to the basic taste salt (NaCl)
	No intensity = no salty taste
	High intensity = explicit salty taste
Bitter	Related to the basic taste bitter (caffeine)
	No intensity = no bitter taste
	High intensity = explicit bitter taste

(Continues)

TABLE 2 (Continued)

Barbeque flavor	Flavor of grill and barbeque (a candied, hefty flavor)
	No intensity = no barbeque flavor
	High intensity = explicit barbeque flavor
Campfire flavor	Flavor of campfire smoke (woody, fresh, spruce)
	No intensity = no campfire flavor
	High intensity = explicit campfire flavor
Stinging flavor	A sharp, pungent flavor (ammonia, sulfur)
	No intensity = no stinging flavor
	High intensity = explicit stinging flavor
Texture	
Juicy	Surface textural attribute that describes liquid absorbed by or released from the product. Liquid released after 4–5 chews.
	No intensity = no juiciness, no liquid released from sample
	High intensity = explicit juiciness, liquid released from sample
Tender	Mechanical structural property that is coherent with time or the number of chews required to prepare the sample for ingestion.
	No intensity = no tenderness, tough
	High intensity = explicit tenderness
Oily	Textural attribute related to the quantity or quality of fat in the sample. A greasy, oily sensation in the mouth after 4-5 chews.
	No intensity = no greasy or oily sensation in the mouth
	High intensity = explicit greasy or distinct oily sensation in the mouth.
Sticky	Gluey or sticky mouthfeel
	No intensity = no stickiness
	High intensity = explicit stickiness
Raw	Sensation of raw fish texture
	No intensity = no raw fish texture
	High intensity = explicit raw fish texture
Crust strength	Sensation of a dry and hard crust
	No intensity = no dry and hard crust
	High intensity = explicit dry and hard crust

glossy, pale, dark, orange, nice reddish salmon color, dry surface, salty, sweet, acidic, smoky, barbeque, campfire, tame, mild, stinging, artificial, bitter, natural, off-taste, rancid, raw, sticky, tender, oily, soft, dry, hard (firm), strong crust, and tough.

2.5.3 | Processing yield and physiochemical parameters

The processing yield was calculated among the two PCS prototypes, and the REF group as % smoked fillet compared to the initial fillet weight (n = 20 fillets of each group). The two prototypes and REF were analyzed post processing for surface color (n = 10 of each group) and fillet texture (n = 6 of each group). The surface color was measured on the same individuals sent to Nofima AS to undergo sensory evaluation (section 2.5.1). Fillet texture was measured dorsal and lateral in the SQS before the rest was sliced and served to Consumer panel 2 (Section 2.5.2).

The surface color (CIE, 1994) was measured on a DigiEye Enclosed Illumination Cube (DigiEye, VeriVide Ltd., Enderby, Leicester, UK), after a method described by Valø et al. (2020). The samples were placed in a standardized light-box (daylight, 6400 K) and photographed using a digital camera (Nikon D80, 35 mm lens; Nikon Corp., Tokyo, Japan). The DigiEye software Digipix (version 2.8) was used to calculate $L^*a^*b^*$ values from RGB values obtained from the fillet image. L^* describes fillet lightness (L^* = 0 = black, L^* = 100 = white), a^* the fillet redness ($a^* > 0$) and b^* ($b^* > 0$) the fillet yellowness.

Instrumental textural analyses were performed in duplicates after a method described by Valø et al. (2020)

using a Texture Analyzer TA-XT2 (Stable Micro Systems, Godalming, Surrey, UK) equipped with a 25-kg load cell and a flat-ended cylinder probe (20 mm diameter, type P/1SP). The force--time graph was recorded and analyzed by the Texture Exponent light software for windows (Stable Micro Systems, version 4.13). The resistance force (*N*) was recorded with a constant speed of 2 mm/s. The breaking force (Bf) was measured as the force (*N*) recorded when breakage of the sample surface was observed, whereas the force required to press the cylinder down to 60% of fillet thickness (F60%) was used to describe fillet firmness.

2.6 | Statistical analysis and digital data collection

All statistical analysis dealing with sensory and consumer data were performed using the XLSTAT software (Addinsoft, version 2020.1.1, New York, NY, USA) except the profiling data which was analyzed using the statistical tool EyeOpenR® available in the EyeQuestion® software (EyeQuestion®, Version 4.11.61, Gelderland, Elst, The Netherlands).

Repeated paired *t* tests was run to compare hedonic ratings (liking) for all sample groups. CATA data were analyzed by Cochran's *Q* test with McNemar (Bonferroni) procedure for multiple pairwise comparison. Penalty-lift analysis (Meyners, Castura, & Carr, 2013) was performed on the CATA data in *Step one*, and penalty analysis (Ares, Dauber, Fernández, Giménez, & Varela, 2014) with elicitation rates (Meyners et al., 2013) was performed on the CATA data in *Step three*. For Napping, the X and Y coordinates and the frequency of mention of the terms, were analyzed by multiple factor analysis (MFA). The results of the DA were evaluated using a two-way (assessors and samples) analysis of variance (ANOVA), followed by Tukey's (Pairwise).

Statistical analysis of the physiochemical data was performed using IBM® SPSS® Statistics software (IBM® Corp., SPSS® release 27, Armonk, NY, USA). One-way analysis of variance (ANOVA) combined with Tukey's HSD test was used to compare groups.

All sensory data were captured digitally using the software EyeQuestion®.

2.7 | Ethical data handling and consent

The project is approved by the Data Protection Services in Norway (NSD). The approval involves giving information about how to ensure ethical and legal data handling, personal data collection, selection criteria, and data storage. All respondents participated in accordance with the requirement from NSD. Informed consent was acquired prior to the evaluations and the rules of voluntary participation and anonymity were obtained. Food samples were prepared according to good hygiene and local practices. All participants were 18 years of age or older.

3 | RESULTS AND DISCUSSION

3.1 | Step one: Initial sensory testing of PCS condensates

The purpose of the initial Napping® was to generate terms for the CATA questionnaire (Figure 1). The Semi-trained panel identified smoke intensity and appearance to be important discriminants evaluating the three sample groups VTAB, BEECH, and SMOKEZ. With this in mind, terms (check options) usually not recommended (Ares & Jaeger, 2015) in a CATA questionnaire were included to seek information about the desired smoke intensity and appearance which could be useful in the upcoming optimization process. In retrospect, the three terms "Appealing appearance", "Not appealing appearance", and "Not tempting" provided no useful information and were therefore excluded from further analysis.

Consumer panel 1 preferred conventionally smoked CSS (REF) to all PCS processed salmon (VTAB-REF: $p = 0.042$, BEECH-REF: $p = 0.037$ and SMOKEZ-REF: $p = 0.007$). On the 9-point hedonic scale, the mean ratings for liking were 6.78 for REF, 6.08 for VTAB, 6.11 for BEECH, and 5.98 for SMOKEZ. No significant difference in liking were observed between the PCS processed samples (VTAB-BEECH: $p > 0.929$, VTAB-SMOKEZ: $p > 0.783$, and BEECH-SMOKEZ: $p > 0.735$). The CATA questionnaire revealed significant differences between the samples in 6 (sweet, strong, raw, barbeque, too little smoke flavor, and too much smoke flavor) out of the 16 terms (Table 3).

Penalty-lift analysis was conducted to evaluate how the presence of each term impacted the overall liking across all samples (Figure 2).

Right amount of smoke flavor was found to be an important driver of liking and increased overall liking by 2.3 (Figure 2). The presence of sweet and barbeque increased overall liking by 0.5 points on the 9-point hedonic scale. Of all the terms where significant differences between samples ($p \leq 0.05$) were found (Table 3), too little smoke flavor, too much smoke flavor, and the presents of raw, had largest negative impact on liking. All the PCS condensates were considered less smoke flavored than REF and both BEECH and SMOKEZ were considered rawer than REF ($p \leq 0.05$). The presence of the terms perfume, artificial, caramel, and caviar all inhibited liking. However, significant differences between the samples regarding

TABLE 3 Frequency (counts) with which the terms[a] of the CATA questionnaire were used by consumers ($n = 65$) to describe four groups of cold smoked salmon[b], and results from Cochran's Q test for each term (p-value) and McNemar (Bonferroni) for comparison between groups[c]

Term	REF	VTAB	BEECH	SMOKEZ	p-value
Sweet	6a	10ab	18b	14ab	0.020
Strong	24b	7a	1a	8a	< 0.001
Raw	5a	6ab	21c	17bc	< 0.001
Barbeque	14b	9ab	3a	2a	0.001
Too little smoke flavor	1b	16a	26a	20a	< 0.001
Too much smoke flavor	20b	5a	2a	2a	< 0.001

[a]Terms revealing significant differences between the groups.
[b]VTAB, BEECH, and SMOKEZ was cold smoked Atlantic salmon processed using three different PCS condensates (atomized purified condensed smoke). REF was smoked conventionally.
[c]Different letters inline indicate significant variation ($p \leq 0.05$) between the respective groups.

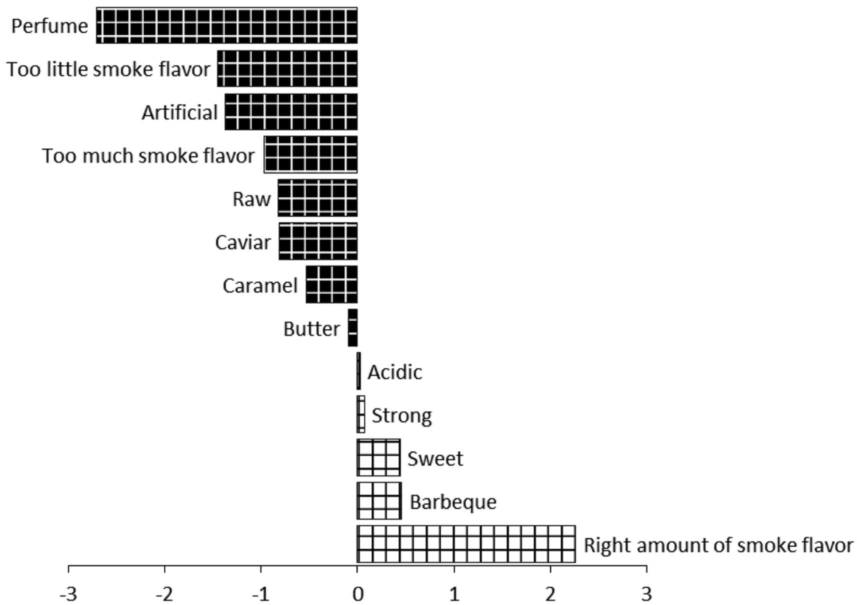

FIGURE 2 Penalty-lift analysis from CATA and overall liking[a] across all samples conducted by 65 consumers evaluating four samples of cold smoked salmon[b]. The values indicate changes in liking observed when the respective term was checked, compared to not checked
Notes: [a]Rated on 9-point hedonic scale (1 = dislike extremely, and 9 = like extremely)
[b]VTAB, BEECH and SMOKEZ was cold smoked Atlantic salmon processed using three different PCS condensates (atomized purified condensed smoke). REF was smoked conventionally

these terms, were not found ($p > 0.05$). BEECH was considered significantly sweeter than REF and both BEECH and SMOKEZ were considered less barbeque flavored, rawer, less strong and smoke flavored than REF ($p \leq 0.05$). VTAB was found more similar to REF than BEECH and SMOKEZ only described as less strong and smoke flavored ($p \leq 0.05$).

Because BEECH and SMOKEZ were found to be both rawer and less smoke flavored than the significantly preferred REF ($p \leq 0.05$), and the Penalty-lift analysis found too little smoke flavor and raw to affect liking negatively, further testing with BEECH and SMOKEZ were ended. VTAB was selected for further adjustments in *Step two*. VTAB was found to have too little smoke flavor compared to REF ($p \leq 0.05$). Simultaneously, REF was found to be too smoke flavored, compared to VTAB (Table 3). This somewhat inconsistent result may be due to the fact that the terms (check options) were contradictory, which is not usual in a CATA questionnaire (Ares et al., 2015). Even so, based on the Penalty-lift analysis that found too little smoke flavor to inhibit liking more than too much smoke flavor, the total amount of VTAB condensate was slightly boosted (from 200 s in *Step one* to 208 s in *Step two*) to increase smoke flavor. The drying time between each cycle was increased by 5 min to prevent rawness (*Step two*, Table 1).

In this step, 65 consumers were recruited who regularly ate CSS and the findings showed the samples were dissimilar. Even if the number of consumers was near the lower limit of the recommended amount of participants assessing samples with variety (Ares, Tárrega, Izquierdo, & Jaeger, 2014), it was considered sufficient as a starting point or a preliminary guidance for future development.

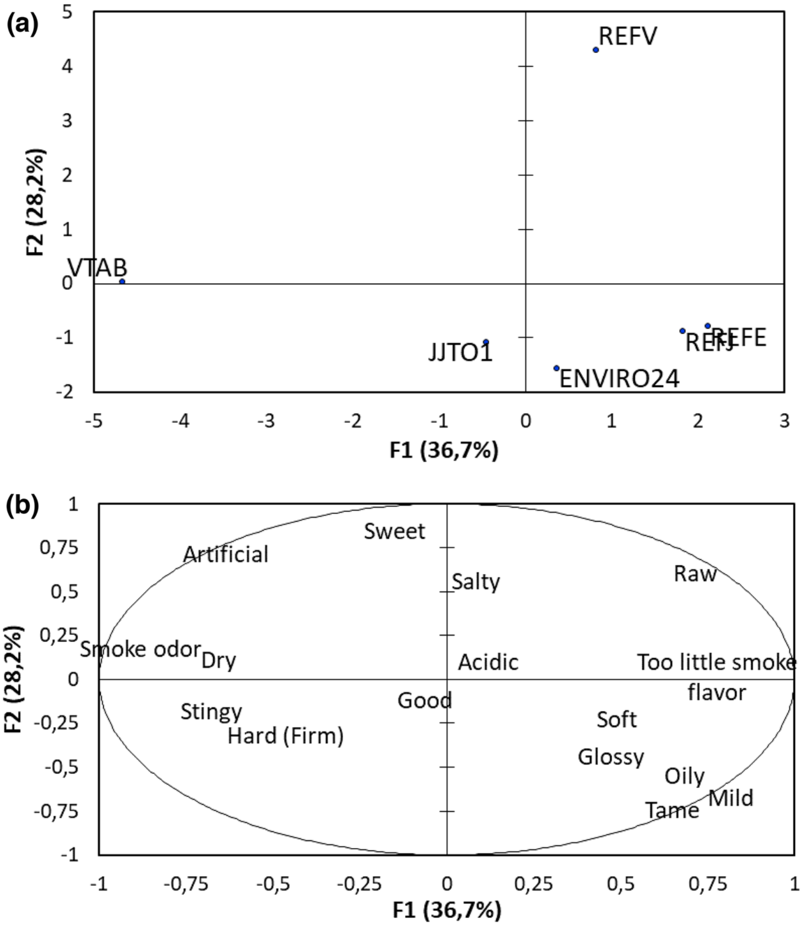

FIGURE 3 Observation plot (a) and variables plot (b) showing terms mentioned six times, or more, obtained from Napping® of six samples of cold smoked salmon[c] conducted by 10 semi-trained assessors

Note: [c]VTAB, BEECH and SMOKEZ was cold smoked Atlantic salmon processed using three different PCS condensates (atomized purified condensed smoke). REFV, REFJ and REFE, was the corresponding fillets smoked conventionally

3.2 | Step two: Sample screening using Napping®

The Napping® (Figure 1) in this step was carried out to evaluate two new PCS condensates (ENVIRO and JJT01) and the adjusted VTAB to compare them all to the references (REFE, REFJ, REFV). The MFA showed an explained variance of ≈65% for the first two dimensions of the observation plot, ≈37% and ≈28%, respectively (Figure 3a). Out of the 49 terms used in this study, only 16 terms were mentioned the recommended 6 times or more (Liu, Grønbeck, Di Monaco, Giacalone, & Bredie, 2016; Perrin & Pagès, 2009; Reinbach, Giacalone, Ribeiro, Bredie, & Frøst, 2014) by the Semi-trained panel (Figure 3b).

VTAB differed from the other two PCS condensates and was described as drier and smokier than JJT01 and ENVIRO. VTAB and REFV were perceived dissimilar from each other, and the rest of the samples. The divergent smoking protocol may explain the differences, but the individual fillet quality influence cannot be ruled out. REFV was perceived somewhat differently from the other two references if we look at the observation plot. However, REFV (squared cosines 0.98) was better explained by looking at the two first dimensions than REFE (squared cosines 0.5) and REFJ (squared cosines 0.43).

JJT01 and ENVIRO were found oily, mild, and too little smoke flavored. The two references, REFE and REFJ, were similar and described as tame, mild, oily, glossy, and soft. All samples and references were perceived sweet and salty, which is expected considering the products in question.

Based on the results, two prototypes were selected (VTAB and ENVIRO), and terms for the CATA questionnaire in *Step three* were generated.

Even if VTAB was considered the most diverse sample (Figure 3a), it was selected as a prototype. In *Step one*, VTAB was described as less smoke flavored than REF. By adding more condensate and increase drying time in *Step two*, it was described as dry and smoky. The Penalty-lift analysis in *Step one* (section 3.1) revealed that low intensity of smoke flavor and the presents of raw, inhibited liking. Because of this, a dry and smoky prototype seemed to be right to include.

Diverse prototypes are recommended to reach dissimilar consumer groups, with varying perception and acceptance (Ares, Tárrega, et al., 2014). For the upcoming CATA in *Step three*, diverse prototypes were selected (VTAB and ENVIRO). The small distance between JJT01 and ENVIRO

(Figure 3a) indicates similarities between the samples and both samples were perceived as quite mild and low in smoke intensity, glossy, and soft (Figure 3b). ENVIRO was chosen in favor of JJT01 because ENVIRO is a commercial product, and easier to purchase for manufacturers of CSS.

3.3 | *Step three*: Quality comparison of the two PCS prototypes and conventional CSS

3.3.1 | Descriptors obtained by DA (Trained panel) and CATA (Consumer panel 2)

The results from the DA (Figure 1) showed significant differences between the three sample groups VTAB, ENVIRO, and REF in 11 of 23 attributes (Table 4). The CATA questionnaire (Figure 1) revealed significant differences between VTAB, ENVIRO, and REF in 14 of 29 terms (Table 5).

Both panels found the appearance of the samples quite similar. The Trained panel (Table 4) found ENVIRO less glossy than VTAB and REF, and Consumer panel 2 (Table 5) found VTAB less glossy and orange than REF and paler than both REF and ENVIRO. The Trained panel perceived no sample difference in color hue, color intensity or whiteness ($p > 0.05$), although Consumer panel 2 found variance in orange color and pallor ($p \leq 0.05$). This may be due to the fact that each assessor in the Trained panel evaluated ten fillets in each sample group and thus assessed more samples than Consumer panel 2.

Some of the odor and flavor attributes scaled by the Trained panel were not suitable as check options in the CATA questionnaire like overall odor and flavor intensity, but some similarities were found. VTAB was described as more odor intense than ENVIRO and REF, and more flavor intense than ENVIRO, by the Trained panel (Table 4). Looking at the results from the CATA questionnaire, VTAB was assessed less tame, less mild, stingier, and with more off-taste than ENVIRO and REF, describing a more intense sample (Table 5). Both panels described VTAB to be more barbeque intense, than REF ($p \leq 0.05$). The Trained panel also found VTAB to contain more barbeque odor and flavor, than ENVIRO ($p \leq 0.05$). Consumer panel 2 detected no significant difference between the samples regarding acidity ($p > 0.05$) but the Trained panel found VTAB to be less acidic in odor and ENVIRO to be less acidic in flavor, than REF ($p \leq 0.05$). The trained panel rated VTAB and REF to be saltier than ENVIRO ($p \leq 0.05$) whereas Consumer panel 2 found the two PCS samples saltier than REF ($p \leq 0.05$). These are inconsistent results. The salting procedure (Section 2.2.1) was the same for all samples, but other factors could have affected perceived saltiness. The Trained panel was calibrated for salty taste based on sodium chloride concentration and each assessor's ability to taste salty taste, were known. Consumer panel 2 consisted of untrained participants who probably perceived salty taste differently based on dietary habits and varying number of salt receptors (Garcia-Bailo, Toguri, Eny, & El-Sohemy, 2009; Tan et al., 2021). Consumer panel 2 perceived the two atomized PCS samples to be less natural than REF ($p \leq 0.05$), which is interesting even though "natural" is a nonspecific attribute.

The two panels described similar textural differences between the samples. The Trained panel evaluated ENVIRO to be less juicy than REF (Table 4) and Consumer panel 2 found VTAB and ENVIRO to be drier than

TABLE 4 Mean values (scale 1–9[a]) from DA[b] performed by 10 assessors to describe three groups of cold smoked salmon[c], and results from ANOVA (p-value per attribute), followed by Tukey's (Pairwise) for comparison between groups[d]

Attribute	REF	ENVIRO	VTAB	*p*-value
Appearance				
Color hue	5.22a	5.04a	5.06a	> 0.121
Color intensity	5.71a	5.61a	5.59a	> 0.175
Whiteness	4.17a	4.28a	4.26a	> 0.172
Glossiness	5.3a	4.93b	5.27a	0.003
Odor/flavor				
Overall odor intensity	5.53a	5.45a	6.22b	< 0.001
Acidic odor	3.11a	2.78[ab]	2.7b	0.035
Barbeque odor	2.31a	2.56a	3.82b	0.013
Campfire odor	3.87a	3.35a	4.2a	> 0.082
Stinging odor	2.14a	2.28a	1.96a	> 0.389
Overall flavor intensity	5.71ab	5.55a	6.04b	0.038
Acidic	3.06a	2.57b	2.62ab	0.025
Sweet	2.84a	2.85a	3.06a	> 0.131
Salty	5.42ab	5.1b	5.46a	0.030
Bitter	3.67a	3.81a	3.96a	> 0.081
Barbeque flavor	2.27a	2.43a	3.74b	0.013
Campfire flavor	4.13a	3.44a	4.08a	> 0.068
Stinging flavor	2.3a	2.58a	2.49a	> 0.711
Texture				
Juicy	5.34a	5.08b	5.19ab	0.018
Tender	5.85a	5.73a	5.69a	> 0.358
Oily	5.55a	5.38a	5.4a	> 0.091
Sticky	3.48ab	3.77a	3.4b	0.042
Raw	3.12a	2.94a	2.98a	> 0.495
Crust strength	3.35a	3.19a	3.98b	< 0.001

[a]The unstructured scale was converted to a 1–9 scale, prior to statistical analysis in EyeOpenR®.
[b]Descriptive analysis (DA) performed by Nofima AS' trained sensory panel (10 fillets per sample group).
[c]VTAB and ENVIRO was cold smoked Atlantic salmon processed using two different PCS condensates (atomized purified condensed smoke). REF was smoked conventionally.
[d]Different letters inline indicate significant variation ($p \leq 0.05$) between the respective groups.

TABLE 5 Frequency (counts) with which the terms of the CATA questionnaire were used by consumers ($n = 208$) to describe three groups of cold smoked salmon[a], and results from Cochran's Q test for each term (p- value) and McNemar (Bonferroni) for comparison between groups[b]

Term	REF	ENVIRO	VTAB	p- value
Appearance				
Glossy	112a	94ab	76b	0.001
Pale	49a	58a	85b	< 0.001
Dark	18a	21a	13a	> 0.303
Orange	76a	60ab	47b	= 0.003
Nice reddish salmon color	90a	77a	89a	> 0.318
Dry surface	26a	39a	42a	> 0.053
Odor/flavor				
Salty	43a	73b	70b	< 0.001
Sweet	20a	18a	19a	> 0.934
Acidic	16a	19a	20a	> 0.734
Smoky	98a	98a	119a	> 0.051
Barbeque	7a	15ab	23b	0.007
Campfire	34a	39^{ab}	62b	0.001
Tame	52a	45a	25b	0.001
Mild	114a	99a	60b	< 0.001
Stinging	6a	8a	25b	< 0.001
Artificial	15a	18a	28a	> 0.066
Bitter	2a	4a	9a	> 0.062
Natural	79a	56b	52b	0.003
Off-taste	8a	8a	25b	0.001
Rancid	1a	3ab	10b	0.008
Texture				
Raw	12a	17a	15a	> 0.590
Sticky	10a	19a	10a	> 0.080
Tender	120a	111a	101a	> 0.122
Oily	78a	62a	65a	> 0.152
Soft	101a	91a	88a	> 0.276
Dry	9a	28b	30b	< 0.001
Hard (firm)	10a	8a	13a	> 0.468
Strong crust	13a	28b	33b	0.004
Tough	17a	20a	20a	> 0.803

[a]VTAB and ENVIRO was cold smoked Atlantic salmon processed using two different PCS condensates (atomized purified condensed smoke). REF was smoked conventionally.

[b]Different letters inline indicate significant variation ($p \leq 0.05$) between the respective groups.

REF (Table 5). Dry and juicy could be assumed to be opposites. The Trained panel found ENVIRO stickier than VTAB ($p \leq 0.05$) although Consumer panel 2 found no significant differences between the samples for this term ($p > 0.05$). It is likely that a trained sensory panel are more inclined to find significant differences, compared to a consumer panel, because of assessor training and calibration (Ares et al., 2017). The last texture attribute/term where significant differences were found, was crust strength. The Trained panel evaluated VTAB to possess higher crust strength than ENVIRO and REF ($p \leq 0.05$) and Consumer panel 2 found both VTAB and ENVIRO to have stronger crusts than REF ($p \leq 0.05$).

3.3.2 | Consumer acceptance and ideal (Consumer panel 2)

Consumer panel 2 (Figure 1) preferred REF to VTAB ($p = 0.004$) but not to ENVIRO ($p > 0.210$). No significant difference in liking were observed between VTAB and ENVIRO ($p > 0.063$). On the 9-point hedonic scale, the mean ratings for liking were 6.60 for REF, 6.41 for ENVIRO, and 6.10 for VTAB.

The consumers were asked to describe their ideal CSS using the same terms available for the three served samples. The Ideal CSS was described as less glossy, pale, tame, artificial, oily, tough, and more dry, salty, smoky, natural, and tender than ENVIRO, VTAB, and REF ($p \leq 0.05$). In addition, the Ideal sample should have less off- taste and more reddish salmon color than all the served samples ($p \leq 0.05$; data not shown).

The hedonic scaling and the evaluation of the samples and the ideal CSS was analyzed by Penalty analysis to find the differences between real and ideal products and the impact on liking. Figure 4 shows the mean change in overall liking as a function of the proportion of consumers that checked a term differently than for the ideal CSS, across all samples. By being present, the terms either increase or inhibit overall liking. The "must have" terms were salty, smoky, and natural (grey tag). The "must not have" terms were glossy and pale (dotted tag) and the "does not harm" terms were tagged with an empty frame. No "nice to have" or "does not influence" terms were found.

To compare VTAB, ENVIRO and REF with the ideal CSS, the difference between the proportion of elicitations for the real and the ideal product was used (Figure 5). The 208 consumers associated the terms natural, salty, and smoky more frequent with the ideal CSS (Figure 4) than VTAB, ENVIRO, and REF (Figure 5). VTAB was perceived paler (Figure 5a), ENVIRO tamer (Figure 5b) and REF both milder and glossier (Figure 5c), than the ideal CSS.

3.3.3 | Processing yield and physiochemical parameters

Conventionally smoked salmon (REF) had a lower processing yield and higher L^* value (fillet lightness), than the two PCS processed prototypes (VTAB and ENVIRO; Table 6). High processing yield without quality loss is

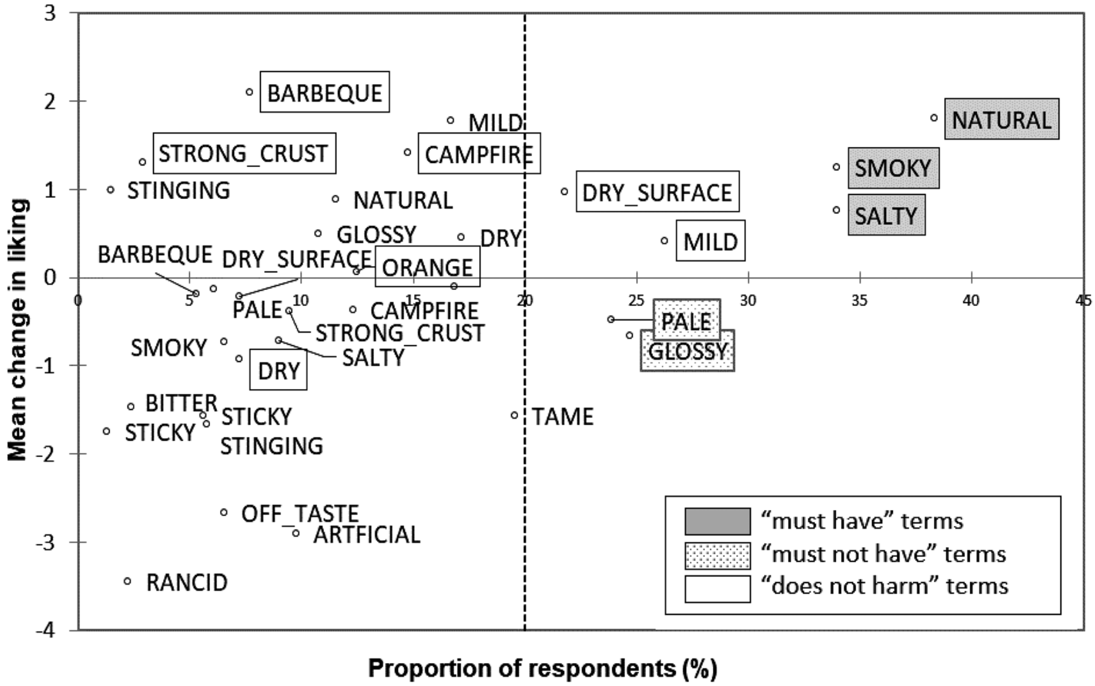

FIGURE 4 Penalty analysis from CATA with ideal and overall liking[a] conducted by 208 consumers evaluating three samples of cold smoked salmon (CSS)[b] and the ideal CSS. The values indicate changes in overall liking as a function of the percentage of consumers that checked a term differently than for the ideal product

Notes: [a]Rated on 9-point hedonic scale (1 = dislike extremely, and 9 = like extremely)

[b]VTAB and ENVIRO was cold smoked Atlantic salmon processed using two different PCS condensates (atomized purified condensed smoke). REF was smoked conventionally

TABLE 6 Average values ± standard deviation (SD) of processing yield (%)[a], colorimetric parameters[b], and textural properties[c] of three groups of cold smoked salmon[d] and the results from ANOVA, followed by Tukey's comparison test[e]

			Group			
Parameter		***n***	**VTAB**	**ENVIRO**	**REF**	***p*-value**
Processing yield	%	20	90.8 ± 1.1a	91.0 ± 0.9a	89.9 ± 0.8b	0.001
Colorimetric parameters	L^*	10	56.0 ± 0.5b	56.1 ± 0.5b	56.9 ± 0.6a	0.003
	a^*	10	10.7 ± 1.6	10.7 ± 2.2	11.6 ± 1.9	>0.462
	b^*	10	2.4 ± 4.1	1.5 ± 5.2	2.3 ± 4.0	>0.883
Textural properties	F60%, *N*	6	42.0 ± 7.4	38.7 ± 6.8	39.2 ± 6.8	>0.690
	Bf, *N*	6	41.6 ± 5.8	37.1 ± 8.6	33.0 ± 8.7	>0.192

[a]% smoked fillet compared to the initial fillet weight.

[b]L^* fillet lightness ($L^* = 0$ = black, $L^* = 100$ = white), a^* fillet redness ($a^* > 0$) and b^* ($b^* > 0$) fillet yellowness.

[c]F60%, *N* = the force (N) required to press the cylinder down to 60% of fillet thickness. Bf, *N* = force (N) needed to break sample surface using the resistance force of 2 mm/s.

[d]VTAB and ENVIRO was cold smoked Atlantic salmon processed using two different PCS condensates (atomized purified condensed smoke). REF was smoked conventionally.

[e]Different letters inline indicate significant variation ($p \leq 0.05$) between the respective groups.

strived for in the food industry. The processing yield was found to be lower for conventional smoking in this study ($p \leq 0.05$), but this should be investigated further when full-scale production is implemented. No significant differences in colorimetric parameters ($p > 0.05$) except for fillet lightness ($p \leq 0.05$) was measured. The Trained panel (Table 4) found no difference in color between the samples (hue, intensity, or whiteness). This could possibly be explained by the fact that the colorimetric measurement was performed on the fillet surface, while the visual sensory assessments were conducted on sliced fish.

The Trained panel found significant differences in crust strength and Consumer panel 2 detected differences regarding crust strongness (Strong crust) between the

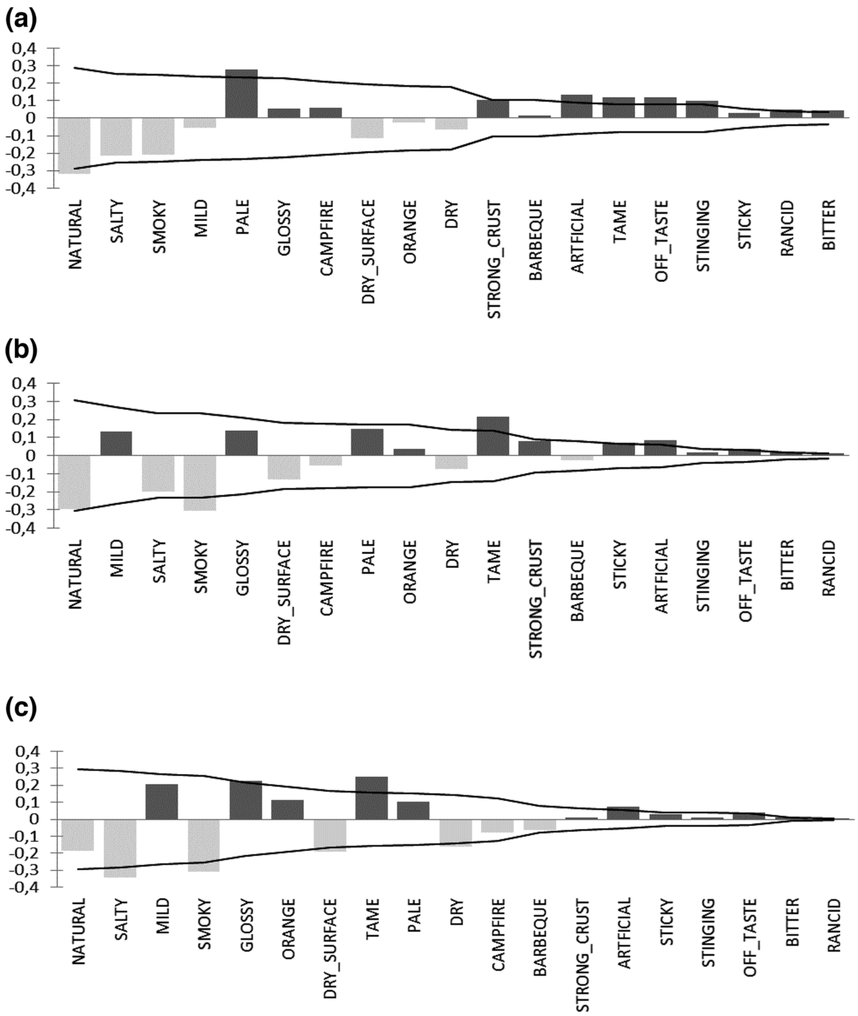

FIGURE 5 Differences in elicitation rates (vertical axis) between a) VTAB and the ideal cold smoked salmon (CSS) b) ENVIRO and the ideal CSS and c) REF and ideal CSS including a 95% confidence interval per figure (a, b and c). The terms on the horizontal axis are ordered by decreasing effective sample sizea based on the total base size of 208 consumers evaluating three samples of cold smoked salmon (CSS)b using CATA with ideal

Notes: [a]The number of consumers, out of the 208, that discriminated between the real and the ideal CSS regarding each term

[b]VTAB and ENVIRO was cold smoked Atlantic salmon processed using two different PCS condensates (atomized purified condensed smoke). REF was smoked conventionally

samples ($p \leq 0.05$). However, no significant differences in texture were measured instrumentally (Table 6). Over time, instruments have been developed to measure multiple attributes of texture, but how well this information represents human perception, has not been thoroughly investigated (Garcia-Loredo & Guerrero, 2011). Previous studies have examined the relationship between instrumental and sensory texture measurement, but apart from hardness, the correlation is not good (Szczesniak, Brandt & Friedman, 1963; Meullenet, Lyon, Carpenter & Lyon, 1998; Szczesniak, 2002).

3.4 | Sensory methodology in product optimization and further recommendations

In this study, no significant difference in liking were found between the conventionally smoked REF and the PCS processed ENVIRO ($p > 0.210$). Only 3 of the 23 attributes, scaled by the Trained panel, separated REF from ENVIRO (Table 4). Consumer panel 2 differentiated ENVIRO from REF in 4 of the 29 terms in the CATA questionnaire (Table 5). The physiochemical parameters only separated ENVIRO from REF in processing yield and L^* value (fillet lightness), with higher processing yield for ENVIRO (Table 6). The processing parameters leading to the PCS processed ENVIRO were three cycles, 45 s of condensate added per cycle, and 20 min of drying between cycles (Table 1). On the basis of the results mentioned above, we were able to identify processing parameters resulting in a promising PCS prototype with similar sensory- and physiochemical quality and consumer acceptance to conventionally smoked CSS.

In addition to comparing ENVIRO with REF, the served samples were compared to the ideal CSS by Consumer panel 2. By adding an ideal sample description to the questionnaire, input for changes prior to the next development step, full-scale production (Cooper, 1990), or further recommendations for optimal consumer liking (van Trijp, Punter, Mickartz, & Kruithof, 2007), were found. The presence of the terms natural, salty, and smoky were found to be drivers of liking, while pale and glossy were found to inhibit liking (Figure 4). All the served samples including the conventionally smoked REF was associated less frequently with the terms natural, salty, and smoky and more frequent with the terms pale and glossy, than the ideal CSS (Figure 5). ENVIRO was considered tame and too little smoky compared to the ideal CSS. Including one more cycle or slightly increasing the number of seconds per cycle, could prevent tameness and increase smokiness. ENVIRO was perceived less salty than the ideal CSS but increasing NaCl content is not recommended. High sodium intake for humans is unhealthy (Champagne & Lastor, 2009) and the food industry is encouraged to reduce the salt content of all foods, including seafood (WHO, 2013). Consumers are particularly positive toward innovations giving health benefits (Mancini et al., 2018). It is probably not a good idea to choose healthier processing (PCS) and simultaneously decrease healthiness by adding more salt. Salt substitutes such as potassium chloride or potassium lactate (Desmond, 2006; Valø et al., 2020) could be alternatives to increase salty taste in CSS, but further testing is necessary. Like all the other served samples, ENVIRO was found less natural than the ideal CSS (Figure 5b). Natural is a nonspecific term and the meaning probably varies with consumers and products. According to Roman, Sánchez-Siles, and Siegrist (2017), the importance of food naturalness can be classified into three categories. The first two categories deal with food origin, technology, and ingredients. The third category considers natural as a product attribute. Further research is needed, in all three categories, to investigate the meaning and importance of the term natural, evaluating CSS. Exploring the term's importance using both qualitative and quantitative methodology will presumably contribute to new insights within this product category. ENVIRO was considered paler than the ideal sample (Figure 5b). The Trained panel and the physiochemical measurements did not support these findings. By setting minimum color requirements for unprocessed fish and standardizing the atomized PCS protocol, the problem will be minimized in a full-scale industrial production.

The Napping® in *Step two* thrivingly differentiated the PCS processed samples, which made the selection of the prototypes possible. In an early development or optimization process, Napping® is previously identified to be an efficient method to sort and describe samples in an easy-to-understand way (Delarue & Lawlor, 2014). In *Step three*, the terms were additionally adapted to the DA attributes, selected by the Trained panel. To use descriptive characteristics from trained- or semi-trained assessors to generate CATA terms are commonly used (Ares et al., 2013; Valentin, Chollet, Lelievre, & Abdi, 2012), but care must be taken to ensure that consumers easily understand the terms (Ares et al., 2015). Even if effort were done to choose the right terms in this study, some important terms, or attributes which in turn could be important drivers of liking or disliking, might be missed or misunderstood. CATA has gained popularity for its simplicity and ease of use (Bruzzone, Ares, & Giménez, 2012; Dooley et al., 2010; Popoola, Bruce, McMullen, & Wismer, 2019; Varela et al., 2012). This study was no exception. CATA successfully described samples and the ideal CSS and gave useful information about consumer acceptance and drivers of liking. Both CATA, DA, Napping® and combinations of these methods, are frequently used with success in product optimization processes (Ares, Dauber, et al., 2014; Delarue et al., 2014; Lawless et al., 2010; Reinbach et al., 2014).

Consumers are not only choosing food because of health, sensory perception, and acceptance. The psychological and physiological factors as well as branding, labeling, country of origin, familiarity, and trends are also important (Lawless & Heymann, 2010; Steptoe, Pollard, & Wardle, 1995; Torrico et al., 2018). Even so, changes in process parameters leading to healthier alternatives with similar sensory quality and consumer acceptance to conventional products, are probably more likely to succeed (Mancini et al., 2018; Guerrero et al., 2009).

4 | CONCLUSION

Using sensory methodology, the three-step experiment ended up with a promising PCS prototype with similar sensory quality and consumer acceptance to conventionally CSS. This study gave an important insight about how to apply sensory methodology in product optimization.

AUTHOR CONTRIBUTIONS

Lene Waldenstrøm: Conceptualization; data curation; formal analysis; investigation; methodology; software; validation; visualization; writing—original draft; writing—review & editing. Mari Øvrum Gaarder: Conceptualization; data curation; formal analysis; methodology; software; supervision; writing—review & editing. Jørgen Lerfall: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; software; supervision; writing—review & editing

CONFLICTS OF INTEREST

We declare that there is no conflicts of interest to disclose.

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