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Consumer perception of farmed caviar: Does production information matter?

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ABSTRACT

This study aimed to investigate whether consumer sensory perception and liking of farmed caviar can be influenced by production-related information. To accomplish this, a consumer study with 222 Danish participants evaluated three caviar types: *Acipenser baerii* (1- and 9-month storage) and *Acipenser gueldenstaedtii* (9-month storage), under blinded (n = 109) and informed (n = 113) conditions. Participants rated sensory attributes and completed a questionnaire on sociodemography, consumption habits, food labeling attitudes, and seafood information interest. A general linear model analysis reveals that while production information did not impact sensory attributes ratings or overall liking (p-value = 0.221), the effect of sample type was statistically significant (p-value < 0.001), indicating the influence of intrinsic characteristics. Post hoc tests indicated that *Acipenser baerii* caviar (1-month storage) had a higher score for appearance, taste, and overall liking. These findings suggest that the intrinsic quality of the product may be the main determinant of the hedonic response, while production-related information may play a role in confidence and purchasing decisions rather than sensory preference. Overall, consumers showed a high interest in food safety, sustainability, and animal welfare information. Ordinal regression results indicated significant gender effects: women tended to give higher ratings for appearance (p-value = 0.013), texture (p-value = 0.016), and overall liking (p-value = 0.039). This study indicates that consumers were interested in information about caviar even though production information might not influence their preferences. Future research should include a cross-national population with a higher caviar consumption frequency to assess possible differences in relation to consumers who are more welcome to information.

1. Introduction

Caviar is a luxury delicacy made from sturgeon salt-cured fish roe. Wild sturgeon populations have significantly declined due to habitat degradation, overexploitation and the lack of trade regulation (Tavakoli et al., 2021). To reduce the decline of sturgeon population, since 1997 it has become illegal to produce caviar and sturgeon meat from wild sturgeon supplies in Europe according to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Raymakers, 2006). Consequently, caviar generated from aquaculture has expanded, and the use of advanced techniques resulted in production relocation, fragmentation, and product diversification (Sicuro, 2019). In this regard, France is one of the biggest producers of caviar (Bronzi & Rosenthal, 2014). More than 70% of French production comes from fish farmers in Aquitaine region, which recently received a protected geographical indication under the EU regulation according to the article 22 of regulation (EU) 2024/1143 (Regulation 2025/342) (Official Journal of the European Union, 2025). This offers tradition, ethical farming practices, and innovation to the product (Caviar D'Aquitaine, 2025).

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Caviar consumers, who are part of the luxury group, should be taken into account when advancing the caviar market, and helpful suggestions can be made by observing their attitudes, such as emotional aspects (Sicuro, 2019). Consumer demand for caviar depends on different sensory attributes, such as size, color, texture and flavor, in which the acceptability depends on the harmony of those attributes and slight changes can impact the quality (Bledsoe et al., 2003; Tavakoli et al., 2021). To improve consumer acceptance, some studies have focused on the evaluation of caviar's composition, quality, and taste (Lu & Rasco, 2014; Lopez et al., 2020). For example, it has been reported that a more favorable lipid composition in the caviar results from sturgeons' diets that contain higher levels of arachidonic acid and lower levels of linoleic acid (Lopez et al., 2020).

It is well known that intrinsic (e.g. flavor, texture, and appearance) and extrinsic factors (labeling, brand, and production method) can influence consumer perception of food products (Piqueras-Fiszman & Spence, 2015; Asioli et al., 2018). Brand trust and loyalty, quality perceived, and emotional intelligence are some of the factors that influence customers' decisions (Asshidin et al., 2016; Kankam & Charnor, 2023). Furthermore, previous studies highlight the increasing significance of information channels regarding nutrition, food safety, and quality (Verbeke, 2005; Pieniak et al., 2007). According to a study on consumer knowledge about fish and aquaculture, people are interested in a quality and food safety label showing that the fish is safe and of good quality (Pieniak et al., 2013). Recently research also indicates the most important aspects when choosing seafood in markets are taste and food safety (Schrobback et al., 2025). Moreover, possible differences in sociodemographic characteristics between segments should be taken into account, for example it has been reported that women are often more willing than men to read food labels, especially those related to nutrition (Stran & Knol, 2013). Additionally, women have proved to be the most enthusiastic consumers who are more interested in information about fish and use labels (Pieniak et al., 2007). To the best of our knowledge, consumer research on caviar has not addressed factors such as information on production method, storage time, species and socio-demographic characteristics. This article provides readers with three important insights: first, we investigate the potential effects of production-related information on sensory perception and caviar preference. Second, we evaluate consumer's attitudes about food labeling and how interested they were regarding sustainability, animal welfare, and food safety. Third, we evaluate the influence of individual characteristics on sensory evaluation. In summary, this study's insights are useful for expanding our knowledge of how customers perceive luxury seafood products and offer insights for more targeted marketing in the caviar sector.

2. Theoretical framework and aim of study

Several studies have focused on consumers' purchasing habits of seafood products in connection to some factors, including product development, packaging, production techniques, and region of origin (Carlucci et al., 2015). For example, a study on the impact of the production method information on consumer preference and liking for salmon reported that consumers in blind conditions preferred organic smoked salmon, but after receiving information on the production method, consumer liking for wild-caught smoked salmon increased (Budhathoki et al., 2021). Previous studies also suggest that consumer scepticism about food production technologies still presents a challenge to achieve more sustainable diets (Giacalone & Jaeger, 2023). Therefore, there is an urgent need to increase consumer acceptance of sustainable food, and providing information on new production technologies can be useful in increasing their acceptance (Deliza & Ares, 2018). Regarding caviar, only some studies investigated sensory differences between sturgeon species and production techniques (wild and farmed). For example, Cardinal et al. (2002) evaluated the sensory attributes of wild and farmed sturgeon, reporting that sturgeon species had a greater impact on the sensory quality than the rearing environment (Cardinal et al., 2002). Further, a list of descriptors to be considered for appearance, odor, flavor, and texture during the descriptive and quantitative sensory of farmed and wild caviar qualities was reported (Cardinal, 2018). Moreover, a lexicon for standardized sensory evaluation of appearance, aroma, texture, and flavor/taste was proposed for consumer studies through a sensory and consumer evaluation of 55 caviar type with different fed diets and raised in different farms (Baker et al., 2014). The main factors influencing consumer acceptance of caviar were firmness, sea fresh and fresh butter flavor, and black color; being correlated with texture and taste (Baker et al., 2014). Nevertheless, although caviar is a seafood product with a long history in the luxury market, only few studies have been conducted to investigate sensory attributes variations of caviar from different species, production method and storage time. To the best of our knowledge, other aspects of the consumer research on caviar have not been addressed, such as the species, storage time, production technique and country of origin. Therefore, studies still need to explore the effect of information about the product's production process and the influence of storage time on caviar preference and liking in order to expand its use and assess consumer preferences, as well as to evaluating the socio-demographic characteristics of consumers and possible influences on their choices.

The objective of this study is (1) to evaluate how consumers perceive farmed caviar through blind and informed testing sessions. (2) To determine whether consumers' assessments of appearance, texture, odor, taste, and overall liking can be influenced by information regarding the production process and place of origin. Furthermore, (3) to evaluate whether consumer characteristics can mediate the influence of production information on sensory evaluation by investigating the effects of socio-demographic variables. By taking into account individual's characteristics, marketing strategies that increase the consumption of farmed caviar can be developed. Moreover, understanding the aspects that influence consumer decisions will also provide important insights into potential target markets. These findings will add to the academic literature on consumer behavior and sustainable food choices in relation to caviar, as well as offering producers and traders useful insight on how to target possible caviar market niches.

3. Methods and materials

A consumer test, comprising a consumer survey with a caviar test (appearance, odor, taste, texture, and overall liking) was conducted to collect data under blind or informed conditions. Each participant attended in one of two circumstances: blind or informed condition, where the production method and the geographical origin of the caviar product was disclosed in the informed condition. The purpose of the test was to evaluate consumers' perception of the sensory qualities and overall liking of caviar under both conditions.

3.1. Products

A temperature range of −1 to −4°C has been suggested for long-term storage of caviar (up to 24 months) to minimize the influence of storage time on sensory characteristics (Tavakoli et al., 2021). Three commercially available caviar types of the same geographical origin were evaluated: *Acipenser baerii* caviar (1-month storage), *Acipenser baerii* caviar (9-month storage), and *Acipenser gueldenstaedtii* caviar (9-month storage) (Fig. 1). A preliminary pilot sensory test carried out to determine whether the products had perceptible sensory differences indicated that the samples could be distinguished based on their sensory profiles (data not shown). Table 1 represents the different samples and parameters that were evaluated: two different fish species and storage time. The caviar samples were obtained from a French aquaculture caviar manufacturer and due to limitations in the ripening and production of caviar, it was not possible to obtain *Acipenser gueldenstaedtii* caviar stored for 1 month storage.



Fig. 1. Caviar products used as experimental sample.

Table 1
Caviar samples.

Sample ID	Caviar	Location	Storage time
A	*Acipenser baerii*	Saint Fort	9 months
B	*Acipenser gueldenstaedtii*	Saint Fort	9 months
C	*Acipenser baerii*	Saint Fort	1 month

All commercial caviar samples were prepared and stored following the production protocol at the Caviar company to guarantee the same condition as received by consumers. Briefly, 3,3% of salt and 0,5% of borax were added to the caviar samples. The 1-month caviar was stored in aluminum tin and the 9-months caviar was stored in 1 kg iron tin at −4°C. Due to the perishability of the product, all samples were carefully prepared at the company production facility in metal tins and delivered to University of Copenhagen once a week, within two days, in refrigerated vehicles to ensure that the cold chain was respected. After that, all samples were stored at 4°C.

3.2. Participants and consumer study procedure

A total of 222 untrained fish roe consumers evaluated the three caviar products under blinded (109 participants) or informed (113 participants) conditions. Only participants more than 18 years old (mean age 27 years old) who had already eaten fish roe with no known allergy to seafood were recruited. According to previous studies, 90 consumers or more were required to accurately determine variations in hedonic responses (Gacula & Rutenbeck, 2006; Moskowitz, 1997). The motivation for participating was the desire to consume caviar. Participants received a snack bag as compensation for their involvement. To achieve this, the consumer sessions were conducted between 6–31, October 2024, in the hallway outside the canteen 'Gumle' at Frederiksberg Campus of the University of Copenhagen, Thorvaldsensvej 40, Denmark. The participants recruited consisted mainly of students (bachelor's, master's, and PhD), including academic staff (professors and technicians) and administrative staff.

Prior to starting the consumer survey, each participant gave their verbal approval as well as informed consent through the questionnaire, and participation was entirely voluntary. Every participant was made aware of the confidentiality of the data management, and anonymous codes were used to guarantee anonymity. University of Copenhagen's Research Ethics Committee for Science and Health reviewed the study and gave it ethical approval.

The consumer study was conducted to explore the effect of production process information on consumers' preferences for caviar. The blind and informed tasting test is a well-known method for examining how food products' sensory and extrinsic (informed) characteristics interact (Piqueras-Fiszman & Spence, 2015; Asioli et al., 2018). The caviar samples received 3-digit codes and were presented at random order, one at a time. To minimize any impact due to oxygen exposure after opening the metal tin, each sample was previously prepared in portions of 3.0 ± 1 g into plastic soufflé covered with lids and immediately kept on the top of an ice pack inside a thermobox until consumer evaluation, with a maximum of 120 min since the time the tin was opened, thus preventing variability and drying out. The evaluation took place one session per day until the necessary number of participants was reached. The randomization of the samples and condition (blind or informed) was carried out using Compusense Inc. software version 25.0.34720, in which participants under informed conditions were presented with a short text informing them about the production method and the geographical origin of the samples. The exact information text is shown in figure S1 of the supplementary material.

3.3. Questionnaire

The questionnaire was developed in English and consisted of 36 questions divided in two sections. The questionnaire lasted approximately 15 min. All participants (blind and informed) received the same questionnaire. The questionnaire is available on annex 1.

The first part of the questionnaire covered the tasting section. Following the taste of each sample, participants were asked to use a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely) to score each of the attributes appearance, odor, taste, texture, and overall liking. Consumers were advised to cleanse their palates with water and saltine crackers between samples.

Sociodemographic factors (age, gender, marital status, education, and household income) and fish roe consumption patterns (frequency, location of purchase, preferred production technique, and information source used to buy fish roe) were covered in the second section of the questionnaire named “consumer survey questionnaire”. Additionally, questions from a prior study on fish and aquaculture knowledge were adapted to assess interest in potential caviar-related information cues (quality/food safety labels, nutritional information, sustainable manner, fish welfare, geographical origin, production method, last month consumption and type of fish roe consumed in the last month) (Pieniak et al., 2013), in which a 5-point hedonic scale, with 1 representing "not at all interested" and 5 representing "extremely interested" were used. Furthermore, six questions from a previous study on how information affects sensory perception were used to examine attitudes toward product information and labels (Asioli et al., 2018), whereby a 9-point hedonic scale with 1 representing “strongly disagree” and 9 representing ‘strongly agree’ were used. For the consumer survey questionnaire

minor wording adaptation were necessary to fit the caviar context.

3.4. Data analysis

SPSS version 29.0.1 (IBM Corp) was used to enter, organize, and analyze the data. A descriptive analysis was carried out for socio-demographic characteristics and fish roe consumption behavior and habits, whereby the data were presented as number and percentage for categorical variables, and Chi-square to analyze the homogeneity of the two groups. For attitudes towards information and labels and potential information cue, the mean and Kruskal-Wallis's data were evaluated.

Consumer liking data was analyzed applying a general linear model (GLM) comprising "samples" (*Acipenser baerii* 1 month *vs Acipenser baerii* 9 months *vs Acipenser gueldenstaedtii* 9 months), "condition types" (blind x informed), and their "interaction effect" (samples *vs* condition types). GLM was performed to understand how the three caviar samples (A, B, C) and the two groups (blinded and informed) affect the dependent variables: appearance, odor, taste, texture, and overall liking. The fixed effects were condition, age, gender, marital status, education and income. Consumer preferences for sensory qualities (taste, texture, appearance, and odor) and overall liking were the dependent variables of interest. One-way ANOVA followed by a post-hoc Bonferroni related to the independent variable group (sample) was conducted. The statistical significance was set at $p < 0.05$.

To investigate possible trends in consumer characteristics and the influence on their preferences, ordinal logistic regression was conducted using JMP® Pro, Version 18.0.2 (SAS Institute Inc., Cary, NC) to examine the perception of caviar for the attributes: appearance, odor, taste, texture, and overall liking considering all participants (N = 222). The analysis considered the independent variables: age, gender, condition (blinded vs. informed), caviar type, caviar*condition interaction and education. Participants who did not accept the consent form or did not answer the entire questionnaire were excluded from the data analysis.

4. Results

4.1. Tasting sessions under blind and informed conditions

Table 2 displays the estimated marginal means (95% confidence interval) and general linear model results for sensory attributes and overall liking of caviar samples under blind and informed conditions. The results demonstrate that the main sample effect, which represents the three caviar samples tasted, was significant (W = 0.9138, F = 5.89, *p*-value < 0.001) which means that there was a significant difference in perception between the three caviar samples. The main effect of condition (blind *vs* informed) was not significant (W = 0.9891, F = 1.40, *p*-value = 0.221). This indicates that, overall, there was no statistically significant difference in the perceptions of the variables between the blind and informed conditions. Furthermore, the interaction between sample and condition was not statistically significant (W = 0.9794, F = 1.34, *p*-value = 0.204). The effect sizes (ηp^2) indicated that, despite the no significant effects of information, the general linear model explained the variation in sensory evaluations (ηp^2 = 0.82–0.92), which suggest that liking scores were driven more by the product intrinsic characteristics.

In the next step, one-way ANOVA was conducted to relate the independent variable group (sample) to the dependent variables (appearance, odor, taste, texture, and overall liking) considering the total number of participants (N = 222). Fig. 2 displays the one-way ANOVA results for sensory attributes and overall liking of caviar samples, and the raw data is shown in Table S1 in the supplementary material. As a result, statistically significant differences in how consumers perceived the sensory attributes among the caviar samples were found for appearance (*p*-value < 0.001), taste (*p*-value = 0.024) and overall liking (*p*-value = 0.044). Post-hoc Bonferroni analysis showed that caviar *Acipenser baerii* 1-month had a higher and statistically significant score rating (*p*-value < 0.001) than caviar *Acipenser baerii* 9-months and *Acipenser gueldenstaedtii* 9-months for appearance. Regarding taste, caviar *Acipenser baerii* 1-month (*p*-value < 0.01) and *Acipenser gueldenstaedtii* 9-months (*p*-value < 0.05) had higher rating score and were significant different from *Acipenser baerii* 9-months. For overall liking, caviar *Acipenser baerii* 1-month (*p*-value < 0.001) had a higher score and showed significant differences compared to sample *Acipenser baerii* 9-months.

Table 2
Estimated marginal means (95% confidence interval) and General Linear Model results for sensory attributes and overall liking of caviar samples under blind and informed conditions. A – *Acipenser baerii*, 9-months storage; B – *Acipenser gueldenstaedtii*, 9-months storage; C – *Acipenser baerii*, 1-month storage. [a, b, c,d].

Sensory attributes	Sample	Type		General Linear Model (*p*-value)	**Effect size (ηp^2 value)[e]**
		Blinded Mean ± SD	Informed Mean ± SD		
Appearance					
	A	6.55 ± 1.39[a]	5.97 ± 1.61[a]	0.344	0.90
	B	6.36 ± 1.56[b]	6.05 ± 1.64[b]	0.972	0.82
	C	6.68 ± 1.23[c]	7.01 ± 1.28[c]	0.876	0.85
Odor					
	A	5.95 ± 1.41[a]	5.67 ± 1.37[a]	0.657	0.88
	B	5.97 ± 1.47[b]	5.97 ± 1.47[b]	0.969	0.83
	C	5.84 ± 1.57[c]	6.05 ± 1.31[c]	0.827	0.86
Taste					
	A	6.41 ± 1.80[a]	6.08 ± 2.01[a]	0.135	0.92
	B	6.82 ± 1.82[b]	6.47 ± 2.00[b]	0.686	0.87
	C	6.65 ± 1.75[c]	6.72 ± 1.85[c]	0.830	0.86
Texture					
	A	6.44 ± 1.48[a]	6.26 ± 1.81[a]	0.784	0.86
	B	6.55 ± 1.62[b]	6.23 ± 1.93[b]	0.835	0.86
	C	6.30 ± 1.70[c]	6.61 ± 1.71[c]	0.549	0.89
Overall Liking					
	A	6.46 ± 1.65[a]	6.08 ± 1.83[a]	0.238	0.91
	B	6.80 ± 1.71[b]	6.32 ± 1.85[b]	0.804	0.86
	C	6.64 ± 1.54[c]	6.70 ± 1.73[c]	0.738	0.87

Note: [a] A 9-point hedonic scale, with 1 representing "dislike extremely" and 9 representing "like extremely."
[b] The data displayed is based on 222 distinct untrained customers' liking (Blinded:109 and Informed: 113 participants).
[c] Fixed factors: condition, age, gender, education, marital status, and income.
[d] Superscript letters within the same sensory attribute for the same sample indicate no significant differences among samples comparing blinded *versus* informed condition based on Bonferroni post hoc test ($p < 0.05$).
[e] Effect size (ηp^2) was calculated as $SS_{effect} / (SS_{effect} + SS_{error})$ based on Type III sums of squares from the GLM. Values refer to the overall model effect.

4.2. Socio-demographic profile and fish roe consumption

Table 3 displays the sociodemographic details of the participants (blinded: n = 109; informed: n = 113). Although the survey was heterogeneous, the results showed some age bias with a preponderance of

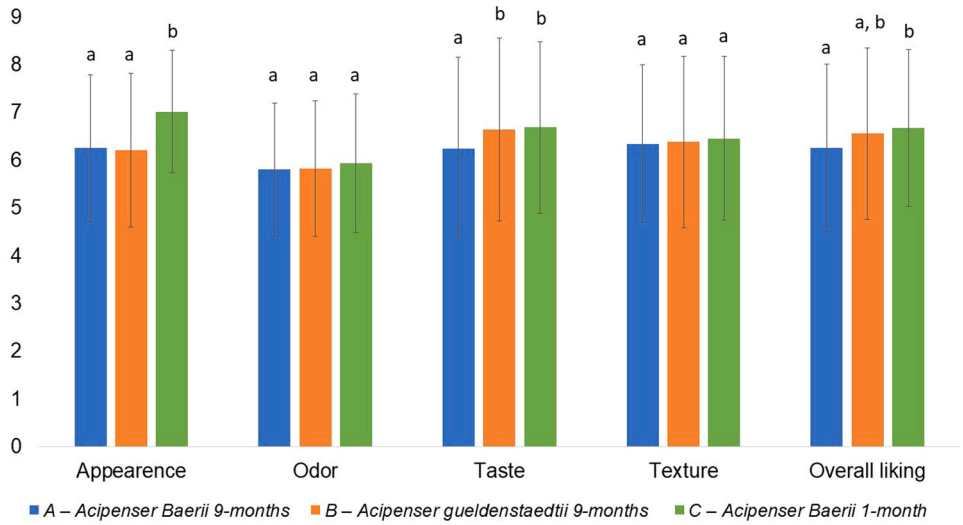


Fig. 2. Mean hedonic scores (± SD) results for sensory attributes (appearance, odor, taste, and texture) and overall liking of caviar samples considering the total number of participants (N=222). For each sensory attribute, distinctive lowercase letters indicate significant differences between caviar samples within each attribute, determined by one-way ANOVA followed by Bonferroni post hoc analysis ($p < 0.05$).

young adults (21–30 years old) in both conditions (73–75%). Nevertheless, age distribution was similar between the two groups (p-value = 0.588).

In terms of the frequency of fish roe intake, the majority of consumers (85% of the participants in both conditions) eat fish roe less than once a month, followed by those who eat fish roe 1–2 times per month (blinded: 12% and informed: 13%). According to their purchasing habits, the preference for wild-caught caviar was higher in the informed condition (blinded: 14% and informed: 27%), however, this difference was only borderline significant between groups (*p-value* = 0.060) was observed. Most consumers (blinded: 69% and informed: 58%) had no preference for the method of production when purchasing fish roe (wild or farmed). In addition, almost half of consumers (blinded: 50% and informed: 53%) relied on labels as their primary source of information. Furthermore, individuals' consumption of fish roe during the last month was comparatively low in both conditions (blinded: 29% and informed: 28%). Regarding the type of fish roe consumed, the most commonly reported species were salmon (blinded: 25% and informed: 43%) and others (blinded: 41% and informed: 19%). In contrast, sturgeon, the fish species from which caviar is derived, was among the one of the least frequently consumed (blinded: 13% and informed: 19%).

4.3. Interest in fish roe-related information cues

Table 4 displays the results regarding the participants' interest in fish roe-related information. The results show that when purchasing fish roe, consumers are most interested in information cues about whether the product is fished or farmed in a sustainable manner (blinded: 4.13 ± 0.91 and informed: 3.95 ± 1.00), followed by interest in quality/food safety labels (blinded: 3.95 ± 0.86 and informed: 3.99 ± 0.90), and fish welfare (blinded: 3.94 ± 1.02 and informed: 3.80 ± 0.94). No significant differences were observed between the blinded and informed condition).

4.4. Attitudes towards fish roe information and labels

In terms of attitudes toward fish roe information and labels (Table 5), consumers strongly agreed that labels are useful to purchase high-quality items (blinded: 6.85 and informed: 6.76) and confirmed that sensory properties information are also useful to find the type of taste they are searching (blinded: 6.17 and informed: 6.20). Additionally, consumers affirm that they pay attention to label information (blinded: 6.17 and informed: 6.01) and have a favorable attitude regarding labels that mention sensory qualities (blinded: 6.11 and informed: 6.01), which would serve as a helpful indicator of their preferred flavor. There were no statistical differences between the two groups blinded and informed condition ($p > 0.05$).

4.5. Ordinal logistic regression analysis

The raw data for the ordinal regression analysis are displayed in the tables S2-S6 in the supplementary material. According to the results, the gender (*p*-value = 0.00174) had a significant effect on appearance, in which women showed a higher liking rating for the caviar samples compared to men. For odor, age had a significant effect (*p*-value = 0.03980), in which the older participants (51 years or more) scored a higher liking value for the caviar samples. Regarding texture, statistically significance difference was observed for gender (*p*-value = 0.01604) and caviar *Acipenser baerii* 9-months *condition (*p*-value = 0.03760). For texture, women rated a higher liking score in general and caviar *Acipenser baerii* 9-months was also rated with higher scores by participants in blinded conditions. For overall liking the gender was statistically significant different (*p*-value = 0.03977), in which women showed a higher liking rating for caviar compared to men. No statistical significance difference was observed for taste (*p*-value ≥0.05).

4.6. Key results at a glance

Table 6 provides an overview of the main sensory results, information effects, and significant covariates. *Acipenser baerii* 1-month had the highest hedonic scores for appearance, taste, and overall liking, while the information condition (blinded *vs* informed) had no significant effect. Ordinal logistic regression analysis identified gender as the most frequent significant covariate, affecting appearance, texture, and overall liking; age was significant only for odor, and an interaction between caviar type and condition was observed for texture.

5. Discussion

The purpose of this study was to investigate whether sensory attributes and consumers' liking of farmed caviars can be affected by disclosing information about production method and origin of the product, with special focus on the impact of sociodemographic factors, interest in fish roe-related information cues, attitudes toward labeling,

Table 3
Participants' sociodemographic profile in the consumer test (Blinded: n = 109; Informed: n = 113).

Socio-demographic profile	Classification	Blinded n (%)	Informed n (%)	p-value Chi-square
Age	18–20	2 (2)	7 (6)	0.588
	21–30	82 (75)	83 (73)	
	31–40	19 (17)	17 (15)	
	41–50	1 (1)	1 (1)	
	51 or older	5 (5)	6 (5)	
Gender	Male	54 (50)	62 (55)	0.427
	Female	55 (50)	51 (45)	
Marital Status	Single	48 (44)	60 (53)	0.004
	Partner/married	41 (38)	49 (43)	
	Partner/married with children	15 (14)	4 (4)	
	Other	5 (5)	0 (0)	
Education	School	1 (1)	2 (2)	0.410
	High School	17 (16)	16 (14)	
	Bachelor	39 (36)	52 (46)	
	Master or above	47 (43)	40 (35)	
	Other	5 (5)	2 (2)	
Household Income (after tax in 2024)	DKK 100,000–249,999	54 (50)	48 (42)	0.089
	DKK 250,000–499,999	26 (24)	21 (19)	
	DKK 500,000–649,999	8 (7)	6 (5)	
	DKK 650,000 and more	7 (6)	19 (17)	
	No statement	13 (12)	19 (17)	
Consumption frequency	Less than once a month	93 (85)	96 (85)	0.929
	1–2 times a month	13 (12)	15 (13)	
	3–4 times a month	1 (1)	1 (1)	
	More than 4 times a month	2 (2)	1 (1)	
Place of purchase	Supermarkets (Føtex, Irma, etc.)	54 (50)	43 (38)	0.207
	Specialty shops	28 (26)	35 (31)	
	Direct from caviar producers	0 (0)	2 (2)	
	Others	27 (25)	33 (29)	
Preferred production method	Wild-caught fish	15 (14)	30 (27)	0.060
	conventional farmed fish	19 (17)	17 (15)	
	No preference	75 (69)	66 (58)	
Used information source to buy fish roe	Label	58 (53)	56 (50)	0.714
	Seller	26 (24)	28 (25)	
	Internet	14 (13)	15 (13)	
	Newspaper	0 (0)	2 (2)	
	Others (research paper, television, etc.)	11 (10)	12 (11)	
Last month consumption	Yes	32 (29)	32 (28)	0.864
	No	77 (71)	81 (72)	
Fish roe consumed in the last month (n = 64)	Rainbow trout	2 (6)	1 (5)	
	Salmon	8 (25)	9 (43)	
	Sturgeon	4 (13)	4 (19)	
	Other	13 (41)	4 (19)	
	I don't remember	5 (16)	3 (14)	

Table 4
Interest in fish roe-related information cues (Min = 1; Max = 5). [a,b].

Information cues	Blinded Mean ± SD	Informed Mean ± SD	Kruskall-Wallis p-value	Mean Difference (95% CI)
Quality/Food safety labels	3.95 ± 0.86	3.88 ± 0.90	0.664	0.069
Nutritional information	3.35 ± 1.11	3.20 ± 1.14	0.471	0.145
Product fished or farmed in sustainable manner	4.13 ± 0.91	3.95 ± 1.00	0.189	0.182
Production with respect to fish welfare	3.94 ± 1.02	3.80 ± 0.94	0.135	0.148
Geographical origin of the product catches or farm	3.45 ± 1.20	3.53 ± 1.10	0.700	-0.081

Note: [a] A 5-point Likert scale was used to measure the information cues, with 1 represented as "not at all interested " and 5 represented as "extremely interested." [b] Mean differences (blinded and informed) are provided with 95% confidence intervals (CI). Positive mean differences indicate higher ratings in the blinded condition; negative values indicate higher ratings in the informed condition.

Table 5
Attitudes towards fish roe information and labels (Min = 1; Max = 9). [a,b].

Consumersattitudes	Blinded Mean ± SD	Informed Mean ± SD	Kruskall-Wallis p-value	Mean Difference (95% CI)
I read very carefully what is written on the packaging of food products	6.17 ± 1.90	6.01 ± 1.88	0.519	0.156
The amount of information on food products doesn't help me make a buying decision	3.94 ± 2.00	3.86 ± 1.92	0.918	0.077
I would like to get more information about sensory properties of food products	6.11 ± 1.81	6.01 ± 1.78	0.761	0.101
Labels are useful to evaluate the quality of food products	6.85 ± 1.55	6.76 ± 1.45	0.613	0.092
Labels referring to the sensory properties of food could help me to find the kind of taste I am looking for	6.17 ± 1.78	6.20 ± 1.57	0.933	-0.029
Sensory perception should be a matter of experience; a label is not useful at all	4.55 ± 1.97	4.44 ± 1.73	0.920	0.117

Note: [a] A 9-point Likert scale (1 = strongly disagree; 9 = strongly agree).was used to evaluate attitudes toward fish roe information and labels.
[b] Mean differences (blinded and informed) are provided with 95% confidence intervals (CI). Positive mean differences indicate higher ratings in the blinded condition; negative values indicate higher ratings in the informed condition.

and sensory evaluation. While information cues often influence product perception (Deliza, 1995; Napolitano et al., 2010), our findings suggest a more complex relation between intrinsic and extrinsic factors in shaping caviar preferences. The sensory attributes and overall liking scores of the three caviar types didnt present significant differences between the two groups (blinded and informed). Further, consumers' characteristics (gender) tends to influence their preferences.

The sample population was dominated by young adults aged 21–30. Although this may introduce an age-related bias in generalizing the findings to the broader population, previous studies demonstrated that young adults are more willing to consume farmed fish (Cardoso et al., 2016). Further, it has been reported that this age group is more open to experimental consumption, including luxury food items, due to their desire for social distinction and lifestyle expression through food choices (Schade et al., 2016). Marital status, however, was the only socio-demographic factor that significantly differed between the groups. This suggests potential differences in life stage and household composition between the two groups. Indeed, previous studies reported that lifestyle influences the fish intake, in which consumers with a better perception of life quality more physically active tend to consume more fish (Maciel et al., 2019). Regarding fish roe consumption, participants had a low caviar consumption frequence, which was expected considering that caviar is still a niche commodity that is usually saved for special events or upscale dining experiences (Tavakoli et al., 2021). Nevertheless, even

Table 6
Summary of main results: sensory outcomes, condition main effects (blind *vs* informed), and significant covariates in ordinal models.

Sensory attribute	Highest-scoring sample[a]	Information effect (Blinded *vs* Informed)[b]	Significant covariates[c]
Appearance	*Acipenser baerii* 1-month	No	Gender
Odor	No differences between samples	No	Age
Taste	*Acipenser baerii* 1-month and *Acipenser gueldenstaedtii* 9-months	No	None
Texture	No differences between samples	No	Gender and Caviar type*Condition
Overall liking	*Acipenser baerii* 1-month	No	Gender

Note: [a] Refers to the sample with the highest hedonic score identified by one-way ANOVA across all participants (N = 222) for appearance, odor, taste, texture, and overall liking.
[b] The information effect corresponds to the main effect of condition (blinded *vs* informed) using a general linear model (GLM).
[c] Significant covariates were identified using ordinal logistic regression analysis ($p < 0.05$).

with this low frequency of consumption, consumer ratings can still yield insightful information. According to previous studies, even infrequent consumers can develop consistent sensory preferences and offer insightful information on the quality of the product due to external cues and sensory expectations (Deliza, 1995).

Besides no statistically significant differences were observed between the participants in both conditions for interest in fish roe-related information cues, participants showed a strong interest in information about sustainability, food safety and quality in seafood products. This finding is in line with some studies that highlight sustainability, food safety and taste as a major extrinsic incentive for seafood purchases (Carlucci et al., 2015; Birch et al., 2018; Schrobback et al., 2025). For example, Maesano et al. (2020) evaluated consumer preferences for sustainable fish products and the relationship between sustainable fish labels and consumers' willingness to purchase, in which consumers were willing to pay more for sustainable items and had favorable opinions about sustainable fish products (Maesano et al., 2020). Additionally, it has been reported that the attribute that matters most to consumer choice was the country of origin (Maesano et al., 2020). The high agreement on the usefulness of labeling by the participants of the present study, especially with regard to quality and sensory information, suggests that consumers appreciate label guidance when searching for fish roe. This result is in line with previous findings that labels serve as an indicator for quality and authenticity, especially in the fish market (Verbeke et al., 2007).

The results presented here demonstrate that the sensory attributes and overall liking were not statistically significant different between the blind and informed groups, which suggests that the perception of sensory attributes may not be significantly affected only by the production information provided for caviar. This result is in contrast with a previous consumer study in salmon reporting that consumers in blind conditions preferred organic smoked salmon, but after receiving information about the production method preferred wild-caught smoked salmon (Budhathoki et al., 2021). Therefore, some aspects that may influence the results of the present study should be taken into account: (i) since wild caviar is forbidden in Europe, only farmed caviar could be presented to the participants and the differences between wild *vs* farmed caviar were not assessed; (ii) each participant evaluated caviar products in one of the conditions (blinded or informed) and the potential differences for each individual in both conditions were not assessed. In addition, participants had a low fish roe consumption frequency, and this lower familiarity with the product might affect beliefs, choice, and acceptability (van Kleef et al., 2005; Yang & Lee, 2019). Nevertheless, the findings of the present study are supported by a previous study in apple juice, which indicated that besides the higher liking score in the informed group, the product information did not entirely determine consumer's liking and the sensory qualities were significantly important (Stolzenbach et al., 2013). Furthermore, consumers aversion to unknown attributes can be reduced and product expectation can be created when information about product properties are provided, thus increasing novel food products acceptance (Schifferstein, 2001; Ullrich et al., 2013).

According to the results of this study, the differences in consumer perception were more strongly driven by the type of caviar than by the information condition. Caviar *Acipenser baerii* 1-month consistently received the highest ratings across appearance, taste, and overall liking, indicating that intrinsic quality differences were important enough to influence consumer preference. This highlights the importance of product-intrinsic cues in in promoting acceptance when sensory variations are noticeable (Piqueras-Fiszman & Spence, 2015). In the present study, the storage time seems to influence more the sensory perception, which is in accordance with previous studies about sensory changes in rainbow trout caviar salted at different ratios (Inanli et al., 2010). Within this context, the addition of borax in all samples may also have influenced the perceived sensory differences. Borax is a food additive used to help preserve product quality during prolonged storage and a maximum concentration of 4 g/kg is permitted in Europe (Tavakoli et al., 2021). Furthermore, as preservative additive it can inhibit the growth of microorganisms but also reduce some amino acids, which might lead to a change in sensory properties (Erkan et al., 2026). It is also worthy to mention that due to production and availability limitations, it was not possible to obtain *Acipenser gueldenstaedtii* 1-month storage. As a result, the experimental design includes a partial lack of results necessary for comparison between species *versus* storage time, which was considered when interpreting the differences between samples.

The results from ordinal regression analysis demonstrated that appearance, texture, and overall liking were significantly influenced by gender, in which female participants tend to give higher liking ratings than men for the caviar samples. To the best of our knowledge there is no previous studies to support this result for caviar or fish roe products. Nevertheless, previous findings reported that food evaluation and purchasing behavior might differ by gender due to cultural factors (Jensen, 2006). For example, Fagerli and Wandel (1999) investigated gender differences in perceptions and practices regarding healthy diets., reporting that women appreciate the advantages of eating fish products and relate this to healthy food more than men (Fagerli & Wandel, 1999).

6. Limitation and further Research

This study's main strength is that it is the first of its kind to examine caviar acceptance and the relationship between extrinsic (information about production methods) and intrinsic (sensory qualities), as well as to identify sociocultural determinants of consumers in order to comprehend their caviar liking. The consumer tasting of the samples was randomized to minimize biases and carryover effects. The methodology and design, which combine quantitative and qualitative data, are itself the strength of this study.

Despite its advantages, this study has some limitations. First, due to limitations in relation to the production of caviar *Acipenser gueldenstaedtii* 1-month storage, only two species with incomplete ageing times were tested in this study (*Acipenser baerii* caviar 1-month, *Acipenser baerii* caviar 9-month, and *Acipenser gueldenstaedtii* caviar 9-month). Thus, missing the opportunity to study the impact of the ageing period on both species. Second, the convenience sampling used to select the participants is susceptible to selection biases. There was age bias, with the majority of participants (blinded:75% and informed: 73%) being young adults (21–30 years old), which could restrict the results'

applicability to older populations. Therefore, more demographically diverse participants should be included in future studies, especially with regard to age and socioeconomic factors, even though young adults are known to exhibit increasing interest in luxury and niche food markets (Cardoso et al., 2016; Schade et al., 2016). From this perspective, the present consumers can be considered as representative of potential future consumers rather than the traditional caviar consumers. Third, our research is limited to evaluate the interaction between intrinsic (sensory attributes) and extrinsic (production technique) factors, however dietary and food choice can be dynamic and complex, and it depends on individual's life stage (Franchi, 2012). Therefore, a deeper comprehension of caviar preference can be obtained with the inclusion of additional elements and their interactions, such as price, convenience, brand loyalty, and health (Olsen, 2003; Asioli et al., 2018). Furthermore, even though the experiment applied blind and informed conditions to separate the effect of production-related information on sensory evaluation, the low frequency of fish roe consumption among participants may indicate a low familiarity with the product category. Therefore, participants' capacity to differentiate minor sensory differences or properly interpret production information may have been limited by this low frequency consumption (van Kleef et al., 2005). To better understand the interaction between expertise and extrinsic cues, future research should consider dividing consumers into groups based on their level of product knowledge or familiarity with caviar.

It is important to note that this study used a between-subjects design, which is commonly applied in food research for avoiding sensory carry-over effects or fatigue due to repetition. For example, consumer preferences for conventional and alternatives seafood were investigated using a between-subject study design (Kim et al., 2023). As a result, a high degree of heterogeneity was observed in preferences for plant-based alternatives to seafood products, which varied according to the product, processing, and the specific characteristics of the individual (Kim et al., 2023). Although between-subject designs allow for independent comparisons between groups, those are generally less efficient compared to within-subject designs, which control for individual differences and reduce error variance (Charness et al., 2012). Although within-subjects designs may experience carry-over and order effects, demanding intervals and more palate cleansing, it is usually require fewer participants to achieve comparable statistical power to detect treatment effects (Charness et al., 2012). Therefore, future research should explore within-subjects design for caviar consumption to increase sensitivity in detecting possible influences of information on sensory perception.

A more extensive and statistically representative consumer number and a comparison between countries are advised for future research. In addition, to find out how knowledge about production methods could impact certain consumer segments differently, future studies can potentially use a segmentation strategy. Lastly, this study evaluated consumer choices using a combination of parametric (GLM and ANOVA) and non-parametric (Kruskal-Wallis) tests. However, in certain models, treating the results as interval data may result in minor deviations from the assumptions, especially with regard to homogeneity of variance and distributional normality. Therefore, ordinal regression models were added to offer a more detailed understanding of the ways in which demographic characteristics, such as age and gender, affected consumers ratings. The use of ordinal modeling structures at the beginning of the study design can be advantageous for future research, with greater statistical power and cautious control of multiple testing and interaction effects. Nevertheless, the statistical mixed-method used here is still a reliable and instructive way to identify important trends in consumer preference and perception.

7. Conclusion

The findings indicate that consumers' perceptions of sensory attributes and their overall liking were not depending on the disclosure of production information. When consumers' preferences for the three-caviar type were compared without differentiating for the condition (blinded and informed), they were more influenced by intrinsic product attributes, thus the variations in consumer preferences were more sample-driven than information-driven. Caviar *Acipenser baerii* 1-month had the highest liking ratings for appearance, taste, and overall liking. Additionally, consumers showed a strong interest in extrinsic cues such as food safety, sustainability, and animal welfare, suggesting a greater knowledge and appreciation of ethical in production techniques. Futhermore, gender had a significant effect since women tended to give the highest liking scores for appearance, texture, and overall liking of caviar. Furthermore, the results mainly reflect the perceptions of young adults and low frequent caviar consumers, who may represent an emerging, rather than traditional, segment of the caviar market. Thus, the no information effect should be interpreted within this consumption context.

Finally, the results of this study have practical implications for the farmed caviar industry. From a product perspective, prioritize offerings with shorter storage times when feasible should be considered, as *Acipenser baerii* 1-month had a higher score than samples stored for longer periods in terms of appearance, taste, and overall liking. In terms of labeling and communication, although the information did not increase hedonic scores, consumers' strong interest in food safety, sustainability, and welfare indicates that these points are important for trust and choice. Furthermore, future studies should explore specific certifications and storytelling that create an emotional connection and investigate these effects with frequent caviar consumers, where intra-subject designs can be used to quantify the relative importance of sensory and informational cues. These findings also highlight the need of taking consumer segmentation and product-specific characteristics into account in seafood products, like caviar.

CRediT authorship contribution statement

Andrea Buettner: Writing – review & editing, Supervision, Funding acquisition. **Mikael A. Petersen:** Writing – review & editing, Conceptualization. **Bastien Debeuf:** Writing – review & editing, Resources, Conceptualization. **Qian Janice Wang:** Writing – review & editing, Conceptualization. **Mariana Rodrigues da Silva:** Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Silvia Sapio:** Writing – review & editing, Data curation. **Ramya Rao:** Writing – review & editing, Data curation.

Ethical statement

Ethical approval for the involvement of human subjects in this study was granted by Research Ethics Committee for Science and Health at the University of Copenhagen.

Prior to participating in the study, participants gave informed consent in order to enter the experiment. They were able to withdraw from the study at any time and without explanation. The products examined were safe and commercially available for consumption were examined. Participants were tracked using an anonymous code and no personal data was collected. The data was not associated with specific individuals. They received a snack bag as compensation for their involvement.

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Declaration of Competing Interest

The authors declare the following financial interests/personal

relationships which may be considered as potential competing interests: Andrea Buettner reports financial support was provided by Horizon Europe. One of the authors, Bastien Debeuf, is employed by SCEA Sturgeon, which is related to the topic of this study. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.foohum.2026.101146.

Data Availability

Data will be made available on request.

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