


# A comparison of cell-based and cell-cultured as appropriate common or usual names to label products made from the cells of fish

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**Abstract:** Using an online experiment with a nationally representative sample of 1200 adult American consumers, two “common or usual names,” “Cell-Based Seafood” and “Cell-Cultured Seafood,” were assessed using five criteria. Displayed on packages of frozen Atlantic Salmon, both “Cell-Based” (60.1%) and “Cell-Cultured” (58.9%) enabled participants to differentiate the novel products from “Farm-Raised” and “Wild-Caught” fish and 74% also recognized that those allergic to fish should not consume the product. Thus, both names met key regulatory criteria. Both names were seen as appropriate terms for describing the process for creating the product, meeting the criteria for transparency. There were no significant differences in the perceived safety, naturalness, taste, or nutritiousness of the products bearing the two names. However, participants’ overall impressions associated with “Cell-Based” were rated as more positive than those associated with “Cell-Cultured” ( $P < 0.001$ ,  $\eta^2 = 0.010$ ), as were their initial thoughts, images, and feelings ( $P < 0.001$ ,  $\eta^2 = 0.008$ ). The participants were also slightly more interested in tasting ( $P < 0.05$ ,  $\eta^2 = 0.004$ ) and in purchasing ( $P < 0.01$ ,  $\eta^2 = 0.006$ ) “Cell-Based” than “Cell-Cultured” seafood. After learning the meaning of the terms, participants’ overall impressions of “Cell-Based” remained higher than “Cell-Cultured” ( $P < 0.05$ ,  $\eta^2 = 0.003$ ) and they remained slightly more interested in tasting ( $P < 0.05$ ,  $\eta^2 = 0.004$ ) and in purchasing ( $P < 0.05$ ,  $\eta^2 = 0.005$ ) “Cell-Based” than “Cell-Cultured” seafood. Therefore, “Cell-Based Seafood” should be adopted as the best common or usual name for seafood made from the cells of fish.

**Practical Application:** Widespread adoption and consistent use of a single “common or usual name” for “Cell-Based” seafood, meat, poultry, and other products by the food industry, regulators, journalists, marketers, environmental, consumer, and animal rights advocates, and other key stakeholders would help shape public perceptions and understanding of this rapidly advancing technol-

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ogy and its products. This study confirms that “Cell-Based Seafood” is the best performing term to label seafood products made from the cells of fish. It meets relevant FDA regulatory requirements and slightly outperforms “Cell-Cultured Seafood” with regard to positive consumer perceptions, interest in tasting, and likelihood of purchasing these novel products.

## 1 | INTRODUCTION

Development of the technology to bring cell-based meats, poultry, and seafood to market at an affordable price is moving at a rapid pace (Dolgin, 2020; Miller, 2020). Stakeholder adoption and consistent use of a single term to refer to and to label cell-based protein products would help settle regulatory issues, shape public perceptions, and promote a clearer understanding of cell-based products (Hallman & Hallman, 2020). Yet, consensus regarding what to call these products remains elusive, with different stakeholders favoring different terms (Ong et al., 2020).

Balancing both marketing and regulatory considerations, Hallman and Hallman (2020) proposed five criteria for choosing a common or usual name that could be used to appropriately label products made from the cells of fish, shellfish, and crustaceans, and by extension, other cell-based meat, poultry, and game products. In their criterion A, they argued that to meet FDA and USDA regulatory requirements, a common or usual name should enable consumers to distinguish cell-based products from conventionally produced products. For seafood, this means that the common or usual name should signal to consumers that the cell-based seafood is neither wild-caught nor the product of aquaculture (i.e., farm-raised).

Although Hallman and Hallman's criterion A is that the common or usual name convey that there are important differences between cell-based and conventional products, their criterion B is that the common or usual name should also signal important similarities. FALCPA, the Food Allergen Labeling and Consumer Protection Act of 2004 (Public Law 108-282), requires that foods that consist of, or that contain, protein from a “major food allergen” bear a label that declares that allergen's presence. Because cell-based seafood products will necessarily be produced using the cells of fish, shellfish, or crustaceans, the common or usual name should not suggest that the products are safe to eat by those who are allergic to other seafood products.

Although meeting FDA regulatory requirements is a necessary prerequisite, the common or usual name must also meet the needs of consumers and the companies

making these products. Therefore, Hallman and Hallman (2020) also argued that a common or usual name should be chosen that is seen by consumers as neither “disparaging” of existing conventional products nor of cell-based products (Criterion C). Similarly, they proposed that an effective common or usual name should not elicit consumer reactions that suggest that the cell-based food products are unsafe, unhealthy, or less than nutritious (Criterion D). These latter criteria recognize that if the common or usual name is expected to be adopted voluntarily by producers, it cannot work against efforts to sell either cell-based or conventional products. Although perhaps implicit in the FDA requirements for common or usual names, they set as their Criterion E that consumers view the name as appropriate to identify the product.

Hallman and Hallman (2020) used these five criteria as the basis for testing seven potential common or usual names for cell-based seafood. The names they tested included, “Cultivated Seafood,” “Cultured Seafood,” “Cell-Based Seafood,” and “Cell-Cultured Seafood.” They also tested the phrase “Produced using Cellular Aquaculture” and the phrases “Cultivated from the Cells of \_\_\_\_” and “Grown directly from the Cells of \_\_\_\_,” filling in the blanks with the name of the packaged seafood product. Three controls (wild-caught, farm-raised, and no common or usual name) were also tested as comparisons. To test these names and phrases, they used a 3 × 10 between-subjects experimental design, collecting data online from a quota sample of 3186 U.S. adults drawn from opt-in panels. These common or usual names tested were shown as labels on realistic packages of frozen seafood (salmon, shrimp, and tuna).

The results showed that all of the common or usual names performed equally well in signaling that those allergic to seafood should not eat the products (Criterion B). Each was also seen as an appropriate name to identify the product (Criterion E). However, the majority of the participants were unable to differentiate seafood products labeled with the terms “Cultivated,” “Cultured,” and the phrase “Produced using Cellular Aquaculture” from conventional “Wild-Caught” or “Farm-Raised” seafood. Therefore, none of these terms meet the essential regulatory criterion (A) for common or usual names. Only the

four terms incorporating the word “cell” (“Cell-Based,” “Cell-Cultured,” “Cultivated from the Cells of \_\_\_,” and “Grown directly from the Cells of \_\_\_”) cued more than half of the participants that the products were neither “Wild-Caught” nor “Farm-Raised.”

Yet, the phrases “Cultivated from the Cells of \_\_\_” and “Grown directly from the Cells of \_\_\_” performed poorly with respect to the consumer perception/marketing criteria (C and D). Consumers rated products with those terms the least positively and they were seen as most likely to be genetically modified. Importantly, they also performed relatively poorly regarding consumer perceptions of the associated product’s taste, safety, nutrition, and naturalness, particularly in comparison to conventional “Wild-Caught” and “Farm-Raised” products. Consumers also expressed the least interest in tasting, and were least likely to purchase the products with these terms.

Both of the names, “Cell-Based” and “Cell-Cultured,” met the key regulatory criteria and in direct comparisons, the terms “Cell-Based” and “Cell-Cultured” were not significantly different from each other on most of the consumer perception and marketing-related measures tested. Nevertheless, “Cell-Based” was found to outperform “Cell-Cultured” when comparing the pattern of results for each term to those of the conventional “Wild-Caught” and “Farm-Raised” seafood products, with which these novel products would compete in the marketplace.

Although Hallman and Hallman (2020) recommended “Cell-Based” as the best performing term of the seven tested, “Cell-Based” and “Cell-Cultured” generated similar results. The study also had some limitations. It was designed as an initial evaluation of seven potential common or usual names (and three comparisons) and tested these using three different seafood products. The resulting  $3 \times 10$  experimental design randomly assigned ~100 participants per condition. Because of the large number of statistical tests performed, conservative *P*-values needed to be adopted to reduce experiment-wise error. In addition, the opt-in quota sample was inadequate to project the results to the U.S. population with a reasonable margin of sampling error.

To overcome these limitations, this study examines the two best performing names identified by Hallman and Hallman (2020), “Cell-Based” and “Cell-Cultured,” using a nationally representative sample of 1200 participants, permitting projections of the results to the U.S. population. It also adds measures to better assess the ability of the two names to distinguish the novel seafood product from its conventional counterparts, and measures to further explore consumer perceptions of the products after learning the meaning of the common or usual names.

## 2 | MATERIALS AND METHODS

### 2.1 | Experimental design

Two proposed common or usual names, “Cell-Based Seafood” and “Cell-Cultured Seafood,” were tested using a two-group between-subjects design. Group assignment was random and each participant viewed only one of the names tested.

### 2.2 | Materials

Each name was tested on the label of packages of frozen Atlantic Salmon Fillets. Salmon was chosen because it is one of the most commonly consumed seafood products in the United States (Seafoodhealthfacts.org, 2018), so participants were expected to be familiar with it. Salmon is also high in Omega 3 fatty acids and low in methylmercury, so it is recommended by the FDA and EPA as a “best choice” for consumption by women who are (or might become) pregnant, breastfeeding mothers, and young children (U.S. Food & Drug Administration, 2019).

High-resolution pictures of the front of packages containing frozen Atlantic Salmon were created for this experiment, identical to those used in Hallman and Hallman (2020) (see Figure 1). These were designed to mimic conventional seafood packages currently available in the supermarket. As is typical of such packages, the top one-third depicted a cooked salmon fillet, presented as a “serving suggestion.” The middle third displayed the product title, “Atlantic Salmon Fillets.” The common or usual name to be tested was printed directly below the product title. A Nutrition Facts Label (NFL) with accurate values corresponding to those of conventional Atlantic Salmon Fillets appeared on the bottom third of the package. The net weight was printed at the bottom of the package along with declarations that the product “CONTAINS SALMON,” and is “PERISHABLE,” and advising consumer to “KEEP FROZEN” and to “COOK THOROUGHLY.”

### 2.3 | Participants

Data were collected between October 6 and October 13, 2020. The study participants consisted of adult American consumers (18 and older) recruited from the YouGov.com web-based consumer panel. YouGov initially interviewed 1780 respondents from whom, a sample of 1600 participants were selected to produce the final dataset, matching a sampling frame derived from the 2018 American



FIGURE 1 Package images

Community Survey (ACS). Of these 1600 participants, 1200 were randomly assigned to complete one of the two experimental conditions reported in this study. A total of 591 participants viewed packages displaying the common or usual name, “Cell-Based Seafood,” whereas 609 viewed packages displaying the common or usual name, “Cell-Cultured Seafood.” Sampling error associated with  $N = 600$  is  $\pm 4\%$  when projected to the population.

The median length of the experiment was approximately 11.8 min. Consistent with census data, 51.3% of the 1200 participants were female. Mean age was 47.41,  $SD = 17.69$ ; 10.8% reported children under age 5 in the household. When asked “who does the grocery shopping for the household,” 55.4% reported doing “all of it,” 17.7% “most of it,” 15.5% “about half of it,” 8.5% “some of it,” and 2.9% “someone else does all of it.” About nine-in-10 (90.5%) of the participants reported having eaten one or more meals containing seafood in the 12 months prior to the survey. Moreover, 63.6% reported they had eaten at least one seafood meal a month, 31.4% reported that they had eaten at least one seafood meal a week, and 1.2% indicated that they had consumed one or more meal containing seafood

per day. About four-in-10 (42.9%) reported having eaten a salmon fillet in the previous 12 months. Only 8.1% reported that they were “not familiar at all” with salmon in general. Consistent with this, 70.0% reported that they had previously purchased uncooked salmon fillets in a store, online, or at a fish market, 69.5% reported that they had cooked salmon fillets, and 42.0% reported that they had ordered a salmon fillet in a restaurant. The majority (58.6%) reported having previously tasted Atlantic Salmon specifically, with 83.5% of these indicating that they liked its taste. Additional sociodemographic characteristics of the sample provided by YouGov as part of its panel recruitment are shown in Table 1.

## 2.4 | Procedure

The procedures used were adapted from those reported in Hallman and Hallman (2020). The participants provided informed consent and confirmed that they were 18 years of age or older and so eligible to participate. They then read an inclusive description of the term “seafood” and were asked



**TABLE 1** Sociodemographic characteristics of the sample ( $N = 1200$ )

Sociodemographic characteristic <sup>a</sup>	% of total
<b>Gender</b>	
Male	48.7%
Female	51.3%
<b>Marital status</b>	
Married	44.7%
Single, never married	33.2%
Divorced or separated	14.2%
Living with partner	6.2%
Widowed	5.8%
<b>Educational level</b>	
Less than high school	4.7%
High school/GED	33.8%
Some college	23.0%
2-year college degree (Associate)	8.7%
4-year college degree (BA, BS)	18.4%
Postgraduate	11.5%
<b>Race/Ethnicity</b>	
White	63.1%
Black/African-American	12.1%
Hispanic/Latino	16.2%
Asian	3.5%
Native American	1.3%
Two or more races	2.1%
Other	1.6%
Middle Eastern	0.2%
<b>Household income</b>	
<\$10,000	6.8%
\$10,000–\$19,999	8.5%
\$20,000–\$29,999	12.9%
\$30,000–\$39,999	11.1%
\$40,000–\$49,999	7.7%
\$50,000–\$59,999	6.9%
\$60,000–\$69,999	6.0%
\$70,000–\$79,999	8.3%
\$80,000–\$119,999	4.2%
\$120,000–\$249,999	1.8%
\$250,000–\$349,999	1.7%
\$350,000–\$499,999	0.6%
≥\$500,000	0.4%
Prefer not to say	7.9%

<sup>a</sup>Categories and data provided by YouGov, collected as part of their panel recruitment.

how often they had eaten a meal containing seafood in the previous 12 months, and if they had not eaten any seafood, to indicate why. Those who had consumed seafood were then shown a list of seafood and asked to indicate which

they had eaten. The participants were also asked about their familiarity with dietary guidelines for eating seafood, and how many 4-ounce portions of seafood they had eaten in the prior week.

The participants were then shown the image of the package bearing the common or usual name to which they had been randomly assigned. The participants were asked to look at the package carefully, to record (in free text) the “first thought, image, or feeling that comes to mind when seeing this package.” After recording their open-ended responses, each participant rated how positive or negative their thought, image, or feeling was, using a scale ranging from 1 (*extremely negative*) to 7 (*extremely positive*).

To ensure that each participant actively considered the package and its label, the participants saw the package a second time and were asked to repeat the same exercise. Finally, they were presented with the package a third time and asked how positive or negative their overall reactions to the salmon product were, how interested they would be in tasting the salmon, and if it were sold in their grocery store, how likely they would be to purchase it in the next 6 months.

The participants then viewed an enlarged version of the picture of the cooked salmon fillet that appeared on the package. They were asked how familiar they are with salmon overall, whether they had ever tasted Atlantic Salmon, and if so, how much they liked or disliked the taste. Those who indicated that they had previously eaten salmon were asked if they had ever ordered a salmon fillet in a restaurant or purchased it in a store, online, or at a fish market. They were also asked about their likelihood of purchasing uncooked and fully cooked salmon fillets in a store in the next 6 months, whether they have ever cooked salmon fillets, whether it is true or false that salmon is a good source of “heart-healthy” Omega 3s, and if they or anyone who lives in their households is allergic to salmon or to any other seafood.

The participants were then shown an enlarged image of the product name “Atlantic Salmon Fillets” along with the common or usual name to be tested printed below it. While viewing the image, the participants were asked, “Which of the following best describes this salmon?” The response categories were “Wild-Caught,” “Farm-Raised,” and “Neither Wild-Caught nor Farm-Raised.” Those who indicated that it was “Neither Wild-Caught nor Farm-Raised” were then asked a follow-up question, “Which of the following best describes this salmon?” The response categories were “Made from the cells of Salmon,” “Made from the cells of Plants,” and “Made from neither Salmon nor Plant cells.”

The proteins in the cells of fish can cause allergic responses in some individuals. Therefore, it is important that consumers recognize that cell-based seafood products

will also contain potential allergens and avoid eating them. To test this, participants were shown the product title and common or usual name, and were asked, "If you are allergic to fish, is it safe for you to eat this salmon?" They then rated the product's naturalness and how likely they thought that it had been genetically modified.

The NFL was then shown, enlarged so that it could be easily read. While the NFL was still on screen, the participants indicated how nutritious the salmon is, and how good or bad they thought the salmon tastes. Finally, they were asked whether pregnant women should eat the salmon and separately, whether children should consume it.

Because a common or usual name must convey appropriate meaning on its own, no definition of either "Cell-Based" or "Cell-Cultured" Seafood was provided to the participants prior to the final part of the experiment. Participants then read the following description ("Cell-Cultured Seafood" was substituted for those randomly assigned to that condition).

"The term Cell-Based Seafood indicates that this salmon differs from both wild-caught and farmed salmon. It tastes, looks, and cooks the same and has the same nutritious qualities as Atlantic Salmon produced in traditional ways. Yet, it involves a new way of producing just the parts of salmon that people eat, instead of catching or raising them whole. Cell-Based Seafood means that a small number of cells from Atlantic Salmon were placed in a nutrient solution, where they grew and reproduced many times. The resulting meat was then formed into fillets that can be cooked or eaten raw."

After reading this definition, the participants were asked to indicate their existing familiarity with "the *idea* of producing just the parts of salmon that people eat, instead of catching or raising them whole." They were asked to indicate how appropriate the term was "for describing this new way of producing just the parts of salmon that people eat, instead of catching or raising them whole?" They then rated the clarity of the term in communicating that the product "was not caught in the ocean," how clear it communicated that the product was not farm-raised, and whether they agreed or disagreed that Atlantic Salmon that is "Cell-Based" (or "Cell-Cultured") should be "sold in the same section of the supermarket as wild-caught and farm-raised fish."

After having read the description of "Cell-Based" (or "Cell-Cultured") Seafood, the participants were prompted to take a final look at the package of Atlantic Salmon. They were then asked how positive or negative their overall reactions to the salmon were, how interested they would be in tasting it, how likely they would be to buy the product in the next 6 months if it were sold in their grocery store, and how likely they would be to recommend that preg-

nant women buy the salmon. They then answered questions related to a second experiment, the results of which will be summarized in a subsequent article. The participants finished by reporting whether they have any children under the age of 5 living in the household and whether they are the primary shopper in their household.

## 2.5 | Statistical analyses

Analyses were conducted using IBM SPSS Statistics for Windows (version 27; IBM Corp., Armonk, New York). Differences in means were analyzed using analysis of variance to produce effect sizes using partial eta-squared ( $\eta_p^2$ ). Z-tests of column proportions with Bonferroni correction were used to analyze differences in proportions. A *P*-value of 0.05 was used to distinguish significant differences within statistical tests. Where appropriate, weighted data are reported in the tables reporting percentages projected to the U.S. population. To avoid potential distortions in the variance associated with key variables, sample weights were not used when reporting means, standard deviations, the results of ANOVAs, effect sizes, and correlations.

## 3 | RESULTS AND DISCUSSION

### 3.1 | Criterion A: Ability to distinguish from conventional products

As shown in Table 2, the majority of those who viewed the name "Cell-Based" (60.1%) and those who saw "Cell-Cultured" (58.9%) on the package label correctly identified the salmon as "neither wild-caught nor farm-raised." There were no statistically significant differences in these percentages, projected to the population. Thus, even in the absence of additional labeling information describing their meaning, both names do a good job of indicating to American consumers that the products are different from conventional wild-caught and farm-raised fish. However, a greater proportion of those who saw the name "Cell-Cultured" (30.1%) assumed that the product was farm-raised than those who saw the name "Cell-Based" (24.9%). In contrast, a greater proportion of those who saw the name "Cell-Based" (15.0%) assumed that the product was wild-caught than those who saw the name "Cell-Cultured" (11.1%).

As shown in Table 2, the largest percentage of those who viewed "Cell-Cultured" (43.9%) and of those who viewed "Cell-Based" (40.8%) indicated that "Made from the cells of Salmon" was the best descriptor for the product. There are no statistically significant differences in these percentages,

TABLE 2 Common or usual name

	Cell-based		Cell-cultured		Total	
	N	%	N	%	N	%
Wild-Caught	88 <sub>a</sub>	15.0%	68 <sub>b</sub>	11.1%	156	13.0%
Farm-Raised	146 <sub>a</sub>	24.9%	185 <sub>b</sub>	30.1%	331	27.6%
Neither Wild-Caught nor Farm-Raised	352 <sub>a</sub>	60.1%	362 <sub>a</sub>	58.9%	714	59.5%
Made from the Cells of Salmon	239 <sub>a</sub>	40.8%	270 <sub>a</sub>	43.9%	509	42.4%
Made from Neither Salmon nor Plants	66 <sub>a</sub>	11.3%	74 <sub>a</sub>	12.0%	140	11.7%
Made from the Cells of Plants	47 <sub>a</sub>	8.0%	18 <sub>b</sub>	2.9%	65	5.4%

Note:  $N = 1201$  (weighted data to project to the U.S. population, rounded to whole numbers). Each subscript letter within a row denotes a subset of Common Name categories whose proportions do not differ significantly from each other at the 0.05 level using the Z-test of column proportions with a Bonferroni correction determining the critical value. Only those indicating that the Salmon was Neither Wild-Caught nor Farm-Raised were asked the follow-up question asking whether the product was made from the cells of Salmon, Plants, or Neither, so these answers are shown as a subset of "Neither Wild-Caught nor Farm-Raised."

TABLE 3 Ratings of thoughts, images, or feelings and overall reactions by common or usual name

	M	SD	N	F	P-value	$\eta^2$
Rating of first thought, image, or feeling				10.267	<0.001	0.022
Cell-Based	4.84	1.78	591			
Cell-Cultured	4.49	1.94	609			
Rating of second thought, image, or feeling				7.633	<0.01	0.018
Cell-Based	4.69	1.73	591			
Cell-Cultured	4.40	1.91	609			
Overall reactions				11.514	<0.001	0.023
Cell-Based	4.82	1.72	591			
Cell-Cultured	4.46	1.93	591			

Scale: 1 = extremely negative; 2 = moderately negative; 3 = slightly negative; 4 = neither positive nor negative; 5 = slightly positive; 6 = moderately positive; 7 = extremely positive.

projected to the population. Thus, even in the absence of additional labeling, both names do a good job of indicating to American consumers that the products are made from the cells of fish. The smallest percentage (8.0%) of those who saw "Cell-Based" and "Cell-Cultured" (2.9%) thought that the product was "made from the cells of plants." A z-test of column proportions indicated that these proportions are statistically different. A similar proportion (11.3%) of those who viewed "Cell-Based" and 12.0% of those who viewed "Cell-Cultured" thought that the product was made from "neither plant nor salmon cells."

### 3.2 | Criterion B: Signal the presence of potential allergens

"Cell-Based" and "Cell-Cultured" were equally competent in signaling allergenicity ( $H(1) = 1.687$ ,  $P = 0.194$ ). Overall, participants understood that those with allergies to fish should "not" eat the product ( $Mdn = 2.0$ ), scale: 1 (definitely not), 2 (probably not), 3 (probably yes), and 4 (definitely yes).

### 3.3 | Criteria C and D: Not be viewed as disparaging of cell-based or conventional products

Each of the open-ended responses to the question, "What is the first thought, image, or feeling that comes to mind when seeing this package?" was coded using one of the 28 categories developed by Hallman and Hallman (2020) (see Table S1). Each response was independently coded by two trained researchers, with any discrepancies resolved by consensus. As shown in Table 3, the thoughts, images, and feelings associated with "Cell-Based" were rated by the participants as more positive than those associated with "Cell-Cultured." Similarly, the participants' overall reaction to "Cell-Based" was also rated more positively than their overall reaction to "Cell-Cultured."

The participants were asked how safe it would be to eat the salmon if one is not allergic to fish, responding using the scale: 1 (very unsafe), 2 (moderately unsafe), 3 (somewhat unsafe), 4 (neither safe nor unsafe), 5 (somewhat safe), 6 (moderately safe), and 7 (very safe). Both the "Cell-Based" ( $M = 5.58$ ,  $SD = 1.64$ ) and "Cell-Cultured" Salmon

( $M = 5.54$ ,  $SD = 1.65$ ) were equally rated as “somewhat” to “moderately” safe to eat ( $F(1, 1198) = 0.178$ ,  $P = 0.673$ ,  $\eta_p^2 = 0.000$ ). They were also equally rated as “moderately” nutritious; “Cell-Based” ( $M = 3.55$ ,  $SD = 0.95$ ), “Cell-Cultured” ( $M = 3.55$ ,  $SD = 0.98$ ) ( $F(1, 1197) = 0.002$ ,  $P = 0.97$ ,  $\eta_p^2 = 0.000$ ) (scale: 1 = [not at all nutritious], 2 [slightly nutritious], 3 [moderately nutritious], 4 [very nutritious], and 5 [extremely nutritious]).

Both products were also equally imagined to taste “slightly” good; “Cell-Based” ( $M = 5.09$ ,  $SD = 1.59$ ), “Cell-Cultured” ( $M = 4.99$ ,  $SD = 1.64$ ) ( $F(1, 1198) = 1.337$ ,  $P = 0.25$ ,  $\eta_p^2 = 0.001$ ) (scale: 1 [extremely bad], 2 [moderately bad], 3 [slightly bad], 4 [neither good nor bad], 5 [slightly good], 6 [moderately good], and 7 [extremely good]). The participants also reported that they were “moderately” interested in tasting both products, though they were slightly more interested in tasting “Cell-Based” ( $M = 3.12$ ,  $SD = 1.49$ ) than “Cell-Cultured” Atlantic Salmon ( $M = 2.94$ ,  $SD = 1.52$ ) ( $F(1, 1198) = 4.499$ ,  $P = 0.034$ ,  $\eta_p^2 = 0.004$ ) (scale: 1 [not at all interested], 2 [slightly interested], 3 [moderately interested], 4 [very interested], and 5 [extremely interested]).

Both products were equally rated as “neither natural nor unnatural”; “Cell-Based” ( $M = 4.22$ ,  $SD = 1.87$ ) and “Cell-Cultured” Salmon ( $M = 4.07$ ,  $SD = 1.96$ ) ( $F(1, 1197) = 2.033$ ,  $P = 0.154$ ,  $\eta_p^2 = 0.002$ ) (scale: 1 [very unnatural], 2 [moderately unnatural], 3 [somewhat unnatural], 4 [neither natural nor unnatural], 5 [somewhat natural], 6 [moderately natural], 7 [very natural]). However, “Cell-Cultured” Salmon ( $M = 5.62$ ,  $SD = 1.43$ ) was seen as slightly more likely to have been genetically modified than “Cell-Based” Salmon ( $M = 5.42$ ,  $SD = 1.52$ ) ( $F(1, 1198) = 5.395$ ,  $P = 0.02$ ,  $\eta_p^2 = 0.004$ ) (1 [extremely unlikely], 2 [moderately unlikely], 3 [slightly unlikely], 4 [neither likely nor unlikely], 5 [slightly likely], 6 [moderately likely], and 7 [extremely likely]).

Overall, the participants believed that pregnant women should probably not consume “either” of the salmon products. Using weighted data, 53.6% of the participants seeing either name indicated that pregnant women should probably or definitely not eat this salmon. Coded as 1 (definitely not), 2 (probably not), 3 (probably yes), and 4 (definitely yes), the median for both “Cell-Based” and “Cell-Cultured” was 2.00. By contrast, the majority in both conditions indicated that children “should” eat the salmon depicted using the same scale. The median for both “Cell-Based” and “Cell-Cultured” was 3.00. About seven-in-10 of those who saw “Cell-Based” (70.6%) and “Cell-Cultured” (69.1%) indicated that children should probably or definitely eat the salmon. Kruskal–Wallis tests indicated no statistically significant differences between the two names with respect to either dependent measure.

### 3.4 | Criterion E: Be seen as an appropriate term

After viewing the description of the meaning behind “Cell-Based” or “Cell-Cultured,” two thirds of the participants (68%) reported that they were “not familiar at all” “with the idea of producing just the parts of seafood that people eat, instead of catching or raising them whole.” The remaining participants indicated that they were “slightly” (10.7%), “moderately” (11.1%), “very” (6.5%) or “extremely familiar” (3.5%) with the idea (all percentages reported using weighted data). Coded on a scale of 1 (not at all familiar) to 5 (extremely familiar), there were no statistically significant differences between the two names with regard to participant familiarity with the concept ( $M = 1.68$ ,  $SD = 1.12$ ). Similarly, using a scale of 1 (extremely inappropriate) to 7 (extremely appropriate), both of the names were seen identically as “slightly appropriate” ( $M = 4.97$ ,  $SD = 1.81$ ) “for describing this new way of producing just the parts of salmon that people eat, instead of catching or raising them whole.”

Participants were also asked how clear the term they viewed is, “in communicating that the salmon was not caught in the ocean,” and in communicating that it was not “Farm-Raised,” responding using the scale: 1 (extremely unclear), 2 (moderately unclear), 3 (slightly unclear), 4 (neither clear nor unclear), 5 (slightly clear), 6 (moderately clear), and 7 (extremely clear). The participants who saw “cell-cultured” indicated that the term was slightly clearer in communicating that, “the salmon was not caught in the ocean” ( $M = 4.52$ ,  $SD = 2.07$ ), than those who saw “Cell-Based” ( $M = 4.12$ ,  $SD = 2.18$ ) ( $F(1, 1198) = 10.48$ ,  $P = 0.001$ ,  $\eta_p^2 = 0.009$ ). Similarly, “Cell-Cultured” was seen as slightly clearer in communicating that “the salmon was not farm-raised” ( $M = 4.38$ ,  $SD = 2.09$ ), than “Cell-Based” ( $M = 4.09$ ,  $SD = 2.16$ ) ( $F(1, 1198) = 5.315$ ,  $P = 0.021$ ,  $\eta_p^2 = 0.004$ ).

It should be noted that these responses were given “after” reading the explanation of the meaning of the terms. Yet, when seeing the terms “Cell-Based” and “Cell-Cultured” on the packages at the beginning of the experiment (prior to explaining their meaning), both were seen equally as “Neither Wild Caught nor Farm Raised.” Moreover, a greater proportion of those who saw the name “Cell-Cultured” assumed that the product was farm-raised than those who saw the name “Cell-Based,” whereas a greater proportion of those who saw the name “Cell-Based” thought that the product was “Wild-Caught.” On its own (without explanation), therefore, “Cell-Cultured” does not appear to be clearer than “Cell-Based” in demonstrating that the salmon was not produced using traditional methods.



The participants were asked to indicate their level of agreement that the “Cell-Based” and “Cell-Cultured” salmon they viewed should be sold in the same section of the supermarket as “Wild-Caught” and “Farm-Raised” seafood, using a scale of 1 (*strongly disagree*) to 7 (*strongly agree*). The mean responses for both terms were identical ( $M = 4.31$ ,  $SD = 1.90$ ) (4 = *neither agree nor disagree*).

### 3.5 | Consumer perceptions post-explanation of the meaning of the term

The participants who saw packages labeled as “Cell-Based” had slightly more positive overall reactions ( $M = 4.24$ ,  $SD = 1.93$ ) than those who saw packages labeled as “Cell-Cultured” ( $M = 4.01$ ,  $SD = 1.93$ ) ( $F(1, 1198) = 4.164$ ,  $P = 0.042$ ,  $\eta_p^2 = 0.003$ ) (scale: 1 [*extremely negative*] to 7 [*extremely positive*]). Those who saw “Cell-Based” also expressed slightly more interest in tasting the salmon ( $M = 2.83$ ,  $SD = 1.47$ ) than those who saw “Cell-Cultured” ( $M = 2.65$ ,  $SD = 1.51$ ) ( $F(1, 1198) = 4.397$ ,  $P = 0.036$ ,  $\eta_p^2 = 0.004$ ) (scale: 1 [*not interested at all*] to 5 [*extremely interested*]). Those who saw “Cell-Based” also indicated greater likelihood of purchasing the salmon in the next 6 months ( $M = 3.77$ ,  $SD = 2.22$ ) than those who saw “Cell-Cultured” ( $M = 3.45$ ,  $SD = 2.26$ ) ( $F(1, 1198) = 6.308$ ,  $P = 0.012$ ,  $\eta_p^2 = 0.005$ ) (scale: 1 [*extremely unlikely*] to 7 [*extremely likely*]). However, they were equally unlikely to recommend that pregnant women buy the salmon; “Cell-Based” ( $M = 3.34$ ,  $SD = 1.97$ ), “Cell-Cultured” ( $M = 3.26$ ,  $SD = 2.03$ ) ( $F(1, 1198) = 0.488$ ,  $P = 0.485$ ,  $\eta_p^2 = 0.000$ ) (scale: 1 [*extremely unlikely*] to 7 [*extremely likely*]).

### 3.6 | Discussion: Determining the best performing common or usual name

It should be noted that a common or usual name is required by U.S. law as a “statement of identity,” and must communicate “on its own” (i.e., free from other supporting statements) that the product is different in some substantial way from the existing products with which it might be confused. It must also communicate this to all shoppers who read the label, and not just to those who regularly shop for seafood or to consumers who are already inclined to purchase cell-based seafood. It must also appropriately communicate the identity of the product to those who would wish to avoid it. Therefore, this study employed a representative sample of adult American consumers, rather than targeted samples of likely seafood consumers only. The logic of the study design also assumes

that although most consumers are likely already familiar with both “wild-caught” and “farm-raised” seafood products, initially, most will be unfamiliar with cell-based products prior to encountering them in the supermarket. That nearly 80% of the participants said they were unfamiliar with the “idea” of producing just the parts of Salmon that people eat instead of catching or raising them whole suggests that this is currently the case. Given this, seeing a seafood product with an unfamiliar common or usual name will not automatically cue the fact that there is a new “third-way” of producing seafood that is neither “wild-caught” nor “farm-raised.”

Much of the prior research designed to address the issue of appropriate nomenclature for these products has focused mainly on issues of consumer acceptance (Bryant & Barnett, 2018, 2020). This approach makes sense from a marketing perspective because the promised benefits of cell-based meats, poultry, and seafood (Stephens et al., 2018; Tomiyama et al., 2020) can only be realized if consumers are willing to purchase them. However, the term ultimately used to label cell-based products must meet regulatory criteria as well as marketing criteria. Names chosen solely to maximize potential consumer acceptance (Szejda, 2018) may fall short of regulatory requirements or may be viewed as false or misleading by regulators or as lacking transparency by consumers. Therefore, the study assessed five criteria to determine the name that best meets the requirements of producers, consumers, and regulatory agencies.

The results of this study confirm the findings in Hallman and Hallman (2020). On their own, both “Cell-Based Seafood” and “Cell-Cultured Seafood” signaled to 60% of consumers that the novel product differs from conventional “wild-caught” and “farm-raised” salmon (meeting criterion A). Without any additional explanation, more than 40% also directly understood that the products were made from the cells of salmon. Both terms were equally able to signal potential allergenicity, with 72.6% of those who saw “Cell-Based Seafood” and 75.4% of those who saw “Cell-Cultured Seafood” indicating that those allergic to seafood should “probably” or “definitely not” consume the product (meeting criterion B). Therefore, both terms tested meet the key regulatory criteria.

Both terms are also seen as appropriately descriptive “for describing this new way of producing just the parts of Salmon that people eat, instead of catching or raising them whole” (meeting criterion E). This should be of importance to producers. Because of the purported environmental, ethical, health, and other benefits associated with cell-based meat, poultry, and seafood, companies should want to transparently differentiate their cell-based products from their conventional counterparts. They may also find such differentiation necessary to justify the price

premium likely needed to be charged when cell-based products initially make it to market.

Producers of cell-based meat will also want to avoid repeating the errors made in introducing GM (genetically modified) foods to consumers (Hallman, 2018). One of the mistakes made by producers of GM foods was to send unlabeled GM products into Europe and other markets where they faced significant resistance. The resulting backlash created longstanding consumer mistrust of producers of GM products and of Genetically Modified Organisms (GMOs) in general (Mohorčič & Reese, 2019). In choosing to voluntarily differentiate their products using a transparent common or usual name, producers of cell-based meat, poultry, and seafood would also likely preempt efforts to mandate labeling of their products using terms they may find limiting or pejorative.

Products labeled with either term are seen as equally safe and nutritious and are presumed to taste equally as good. Neither is seen as unnatural, although the products labeled as “Cell-Cultured” were seen as slightly more likely to have been genetically modified.

From a marketing perspective, packages of Atlantic Salmon Fillets with the common or usual name “Cell-Based Seafood” were rated by participants as slightly more positive than those with the common or usual name “Cell-Cultured Seafood.” Both before and after reading the description of the meaning of the terms, participants reported slightly more positive overall impressions, slightly greater interest in tasting, and slightly greater likelihood of purchasing the products labeled as “Cell-Based Seafood” than those labeled as “Cell-Cultured Seafood.”

Although the mean differences and associated effect sizes in these measures are small, the pattern of those differences is consistent. They also add to those of Hallman and Hallman (2020), who found that the pattern of results associated with “Cell-Based” was similar to those of “Wild-Caught” and “Farm-Raised” seafood products, whereas the pattern of those associated with “Cell-Cultured” was dissimilar. In that study, initial reactions to “Cell-Based Seafood” were as positive as they were to both “Wild-Caught Seafood” and “Farm-Raised Seafood.” The products labeled as “Cell-Based Seafood” were also judged to be as nutritious as both “Wild-Caught” and “Farm-Raised” seafood, whereas “Cell-Cultured” products were not. Participants imagined that “Cell-Based Seafood” tasted as good as both “Wild-Caught” and “Farm-Raised” seafood. They were also equally interested in tasting and likely to purchase “Cell-Based Seafood” as they were seafood that was either “Wild-Caught” or “Farm-Raised.” In contrast, those who saw “Cell-Cultured Seafood” products were only as interested in tasting and purchasing them as they were in tasting and purchasing “Farm-Raised” seafood products. Thus, the overall pattern of results from

this study combined with those of Hallman and Hallman (2020) suggests that “Cell-Based” is currently the better choice for a common or usual name for seafood made from the cells of fish, based on measures of likely consumer acceptance and purchase of these innovative products.

## 4 | CONCLUSION

This study confirms that “Cell-Based Seafood” is the best candidate for a common or usual name for seafood made from the cells of fish. It meets the regulatory requirements to signal (on its own) that the novel products are not the same as conventional wild-caught and farm-raised seafood. At the same time, combined with the product name, “Atlantic Salmon Fillets,” it indicates to consumers that the products are made from the cells of fish, and therefore, those who are allergic to fish should not eat them. From a marketing perspective, “Cell-Based” is viewed as an appropriate term for describing the process for producing the products, meeting the need for transparency in labeling. Additionally, consumers indicate that they perceive “Cell-Based Seafood” products more positively than “Cell-Cultured” and are slightly more inclined to want to taste and purchase “Cell-Based” products. Therefore, the term “Cell-Based Seafood” should be considered the best common or usual name to be used to label seafood products produced from the cells of fish.

### 4.1 | Limitations

As with any online experiment, there are limitations to this study. This study only examines the terms “Cell-Based” and “Cell-Cultured” with respect to seafood. Although it builds on an earlier study testing seven potential common or usual names, it provides a comparison of only the two best names derived from that study within a representative sample of American consumers. Other names have been suggested by various stakeholders that might be tested in future research. Additional studies are also needed to assess these terms with respect to cell-based meat, poultry, and other products that also require a similar statement of identity.

The study represents a current snapshot of consumer beliefs, attitudes, and intentions with respect to potential statements of identity for a novel product with which most are unfamiliar. However, common or usual names are established by common use. As consensus is developed with respect to an optimal common or usual name and it is used with greater frequency by companies, regulators, journalists, advocates, critics, and others, consumers will become much more familiar with its connection to

the novel products for which it serves as a statement of identity. Thus, the results of this study serve as a baseline. Future studies may be needed to assess consumer perceptions, particularly as cell-based products enter the marketplace.

The common or usual name is intended to appropriately identify the product as a particular type of food, distinguishable from others. It is not intended to communicate all of the benefits or advantages of the product. Marketers using the common or usual name are able to add truthful but not misleading statements to the label, including claims related to health, sustainability, and the environment, free from claims, and any others that they think may help to sell the product. The testing of such claims on labels bearing the terms “Cell-Based” or “Cell-Cultured” will no doubt be undertaken in future marketing studies.

The ultimate goal of many cell-based seafood companies is to create novel products that will look, taste, cook, and have the same form, texture, and nutritional values as their conventional counterparts. These products are still in their developmental stages, and none have been approved for sale in the United States or elsewhere. Therefore, the image of the cooked salmon fillet presented on the package in this study is aspirational and does not represent a currently available cell-based seafood product. Yet, showing an example of a cooked cell-based salmon product in its future idealized form (matching the essential characteristics of conventional salmon fillets) represents the most difficult test of key regulatory criterion (A). That is, the ability of the common or usual name “by itself” to help consumers distinguish the novel product from the “wild-caught” and “farm-raised” products with which consumers are already familiar. Because the image on the package looks like conventional salmon, consumers had only the common or usual name being tested to distinguish it from conventional salmon.

However, because cell-based seafood products do not yet exist in the marketplace, no consumer has had any experience with such products. Thus, the participants were asked to consider a hypothetical product, with which none could have any real familiarity. The participants viewed an image of a conventional salmon fillet on the package as a stand-in for the hypothetical cell-based product, which likely influenced their perceptions of it. Real cell-based seafood products that finally reach the market may look different, so consumer reactions to those images, and the product packages bearing them may also be different. Future research designed to measure consumer reactions to various forms of cell-based seafood may help marketers better gauge potential receptivity for their products.

Finally, the packaging shown in the experiment was specifically designed as a vehicle for comparing the suitability of common or usual names as a statement of prod-

uct identity. It was not created to test consumer reactions to the packaging design itself, or to test the acceptability of the package for retail purposes in the United States or any other market. Future studies intended to test optimal design elements for packages marketing “Cell-Based” or “Cell-Cultured” seafood products may fill this gap.

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## AUTHOR CONTRIBUTIONS

William K. Hallman—Conceptualization; formal analysis; funding acquisition; investigation; methodology; project administration; supervision; writing original draft; writing review editing. William K. Hallman II—Data curation; formal analysis; investigation; validation; visualization; writing original draft; writing review editing.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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## REFERENCES

- Bryant, C., & Barnett, J. (2018). Consumer acceptance of cultured meat: A systematic review. *Meat Science*, *143*, 8–17. <https://doi.org/10.1016/j.meatsci.2018.04.008>
- Bryant, C., & Barnett, J. (2020). Consumer acceptance of cultured meat: An updated review (2018–2020). *Applied Sciences*, *10*(15), 5201. <https://doi.org/10.3390/app10155201>
- Dolgin, E. (2020). Will cell-based meat ever be a dinner staple? *Nature*, *588*(7837), S64–S67. <https://doi.org/10.1038/d41586-020-03448-1>
- Hallman, W. K. (2018). Consumer perceptions of genetically modified foods and GMO labeling in the United States. In S. Matsumoto & T. Otsuki (Eds.), *Consumer perception of food attributes* (pp. 44–61). CRC Press.
- Hallman, W. K., & Hallman, W. K., II. (2020). An empirical assessment of common or usual names to label cell-based seafood products. *Journal of Food Science*, *85*(8), 2267–2277. <https://doi.org/10.1111/1750-3841.15351>
- Miller, R. K. (2020). A 2020 synopsis of the cell-cultured animal industry. *Animal Frontiers*, *10*(4), 64–72. <https://doi.org/10.1093/af/vfaa031>

- Mohorčič, J., & Reese, J. (2019). Cell-cultured meat: Lessons from GMO adoption and resistance. *Appetite*, *143*, 104408. <https://doi.org/10.1016/j.appet.2019.104408>
- Ong, S., Choudhury, D., & Naing, M. W. (2020). Cell-based meat: Current ambiguities with nomenclature. *Trends in Food Science & Technology*, *102*, 223–231. <https://doi.org/10.1016/j.tifs.2020.02.010>
- Seafood Health Facts. (2018). *Overview of the U.S. seafood supply*. <https://www.seafoodhealthfacts.org/seafood-choices/overview-us-seafood-supply>
- Stephens, N., Di Silvio, L., Dunsford, I., Ellis, M., Glencross, A., & Sexton, A. (2018). Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. *Trends in food science & technology*, *78*, 155–166. <https://doi.org/10.1016/j.tifs.2018.04.010>
- Szejda, K. (2018). *Cellular agriculture nomenclature: Optimizing consumer acceptance*. <https://www.gfi.org/images/uploads/2018/09/INN-RPT-Cellular-Agriculture-Nomenclature-2018-0921.pdf>
- Tomiyama, A. J., Kawecki, N. S., Rosenfeld, D. L., Jay, J. A., Rajagopal, D., & Rowat, A. C. (2020). Bridging the gap between the science of cultured meat and public perceptions. *Trends in Food Science & Technology*, *104*, 144–152. <https://doi.org/10.1016/j.tifs.2020.07.019>
- U.S. Food and Drug Administration. (2019). *Advice about eating fish - For women who are or might become pregnant, breastfeeding mothers, and young children*. <https://www.fda.gov/food/consumers/advice-about-eating-fish>

## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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