# CONSUMERS' WILLINGNESS TO PAY FOR THE COLOR OF SALMON: A CHOICE EXPERIMENT WITH REAL ECONOMIC INCENTIVES

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In most retail markets, sellers post the price and consumers choose which products to buy. We designed an experimental market with posted prices to investigate consumers' willingness to pay for the color of salmon. Salmon fillets varying in color and price were displayed in twenty choice scenarios. In each scenario, the participants chose which of two salmon fillets they wanted to buy. To induce real economic incentives, each participant drew one binding scenario; the participants then had to buy the salmon fillet they had chosen in their binding scenario. The choice data were analyzed with a mixed logit model.

*Key words*: choice experiment, color, mixed logit, salmon, willingness to pay.

During the past decade, economists have used experimental markets to investigate consumer preferences and willingness to pay (WTP) for food quality attributes. The most popular method has been the second-price sealed-bid Vickrey auction (Vickrey 1961) where participants submit sealed bids for the product and the price is determined by the second-highest bid, see, for example, Shogren et al. (1994); Alfnes and Rickertsen (2003). The Vickrey auction is an incentive-compatible method for eliciting WTP. However, it is an unfamiliar market mechanism for most consumers. Consumers are more familiar with markets where the seller posts prices and they, as consumers, have to choose which products to buy.

Lusk and Schroeder (2004a) designed an experimental market with posted prices to investigate consumers' WTP for food quality attributes. Starting with five types of beef, they asked participants to choose which they would prefer to buy in seventeen pricing scenarios. To induce real economic incentives, one of the price scenarios was randomly drawn as binding. The participants had to buy the type of beef they had chosen in the binding scenario and pay the respective price posted in that scenario. The choice task in such an experiment is relatively close to that faced by consumers in grocery stores every day. Furthermore, it is in the participants' own interest to choose the alternative they prefer in each scenario, and their incentive to reveal true preferences is relatively transparent. An earlier application of a nonhypothetical choice experiment is Carlsson and Martinsson (2001), who investigated consumers' marginal WTP for donations to public goods. We will refer to such nonhypothetical choice experiments with posted prices as real choice (RC) experiments.

We conducted an RC experiment to investigate consumers' WTP for salmon with various degrees of flesh redness, and to investigate whether information on the origin of the color influences consumers' WTP. We use a modified version of Lusk and Schroeder's (2004a) RC design. Lusk and Schroeder (2004a) used the same five types of beef in all seventeen price scenarios and used a fractional factorial design to vary only the prices of the five alternatives among the scenarios. In addition, they drew only one binding scenario for the entire group of participants. With this design, the choices

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The authors would like to thank seminar participants at the Annual Meeting of American Agricultural Economics Association, Providence, July 2005 for useful comments, and Mia Bencze Rørå, Ingrid Olesen, Hans Jørgen Whist, and Juan Francisco Aldunce Meyer for useful discussions and assistance in the data collection. The authors are also grateful to two reviewers, whose comments and suggestions significantly improved the article. The Research Council of Norway, grant nos. 143045/140 and 159523/110, financed this research.

*Amer. J. Agr. Econ.* 88(4) (November 2006): 1050–1061

are not between specific packages, but between types or labels of products. We used scenario-specific products and a fractional factorial design to vary both product attributes and prices among the scenarios. In each scenario, we displayed two salmon fillets with varying colors and prices and the participants chose which of the two salmon fillets they wanted to buy. To induce real economic incentives, each participant drew a unique binding scenario. The participants then had to buy the salmon fillet chosen in the binding scenario. The modified RC design with scenario-specific products, and the use of a fractional factorial design to vary both product attributes and prices between the scenarios, is very flexible and can easily be expanded to include more product attributes and/or attribute levels.

Salmon are recognized for their pink-red flesh color, which distinguishes them from other species. Consumers use intrinsic cues such as color to infer the quality of food products. In surveys, as well as focus groups, consumers have stated that they see the color of salmon as an indicator of flavor and freshness, and it has been shown that redness contributes significantly to the overall enjoyment of salmon, see, for example, Anderson (2000); Steine, Alfnes, and Rørå (2005); Sylvia et al. (1995). To our knowledge, there are no previously published consumer WTP studies using experimental markets to investigate preferences for seafood attributes, however there are a few studies using surveys (Holland and Wessells 1998; Johnston et al. 2001; Steine, Alfnes, and Rørå 2005; Wessells, Johnston, and Donath 1999).

Consumers' WTP for the color of farmed salmon is interesting for at least two reasons. First, that while wild salmon obtain their characteristic red color from the crustaceans they eat in the sea, farmed salmon acquire their color from synthetically produced feed additives. However, feed additives are expensive, and the marginal return in terms of color is decreasing and varies considerably between individual salmon. Improved information on consumer WTP for salmon with various degrees of redness will help producers optimize coloring. A second issue is the ongoing debate about the "color added" label on farmed salmon. In recent years, consumer focus on food safety, ethical production, and animal welfare has increased, and food additives used partly or purely for cosmetic reasons are subject to considerable debate. The U.S. Food and Drug Administration, for example, requires grocery stores to label farm-raised salmon so that consumers are aware of the presence of artificial coloring. The fish should be labeled in the retail case and in individual packages with the words "color added" or "artificially colored."

In 2003, consumers in the United States filed a lawsuit against three major grocery chains to force them to label the farm salmon as color added (Smith and Lowney 2003). In a class action complaint, it was stated: "As a result of Defendant's misbranding, concealment and nondisclosure, consumers are misled to purchase the artificially colored salmon and/or to pay a greater price than they would otherwise pay. Defendant has been unjustly enriched at the expense of these consumers" (Smith and Lowney 2003). Hence, Smith and Lowney (2003) argue that consumers' WTP for farmed salmon would decrease if they knew the origin of the color.

In a check of grocery stores in the United States in 2005, we found that many stores still sold farmed salmon that were not labeled with color added and we found very few with color added labeling in the retail cases. Furthermore, of the stores that did label farmed salmon, several used less negative expressions such as "the feeding process enhances the color" instead of color added.

The remainder of the article proceeds as follows: first, we give some background information on farmed salmon, followed by a presentation of the experimental procedure, products, design of choice scenarios, sample, econometric model, results and discussion, and last, summary and conclusions.

## Background

During the past few decades, the production of farmed salmon has experienced a growth surpassed by few other primary production commodities. Global production increased from about 12,000 metric tones in 1980 to well above one million metric tones in 2003. The increase in production has been accompanied by a substantial decline in prices. The large increase in production and decline in prices have significantly altered the structure of several markets, and affected the pattern of the international salmon trade (Asche et al. 2005). One of the biggest losers is the salmon fishing industry in Alaska (Eagle, Naylor, and Smith 2004). The changes have led to a series of trade disputes, and the largest producers of farmed salmon, Norway and Chile, have been subject to dumping complaints in both the United States and the EU. See Anderson and Fong (1997), Asche, Bremnes, and Wessells (1999) and Asche (2001) for discussion of some of the salmon trade dispute cases.

The main factors behind reduced production costs are improved productivity and technological change. Today, fish farmers can, to a greater extent, control growth and sexual maturity, and such quality parameters as fat content, texture, taste, and color. However, while better controls have reduced costs and improved the final product, the industrialization of the salmon farming industry has at the same time led to criticisms from some researchers, consumer groups, and environmentalists, see for instance, Naylor et al. (2000).

One of the more controversial issues is the use of synthetically produced colorants in the salmon feed. The characteristic color of salmon is caused by depositions of carotenoids in the muscles. In the wild, salmon absorb carotenoids from the crustaceans they eat. The most important carotenoid for the color of salmon is astaxanthin. Salmon are unable to biosynthesize astaxanthin, and thus, without astaxanthin in their diet, the salmon's flesh would range from gray or khaki to pale yellow or pale pink.

Many types of fish and crustaceans, including trout, salmon, red sea bream, shrimp, and lobster, accumulate astaxanthin in their tissues and skin. Astaxanthin is a powerful antioxidant, and studies suggest that astaxanthin has a series of biological and nutritional functions in the species that accumulate it. Astaxanthin has, for example, been found to increase fertilization, and increase survival and growth rates in these species.[1]

Farm-raised salmon, of course, do not have access to the natural sources of astaxanthin. To impart the pink-red color in farmed salmon, synthetically produced carotenoids, mainly astaxanthin, are added to their feed. However, astaxanthin is expensive, and in conventional salmon farming astaxanthin accounts for approximately 15% of the feed costs. Feed costs in turn account for nearly 50% of total production costs (Guttormsen 2002). Hence, coloring is a relatively important cost in salmon farming. In 2003, the total cost of producing 1 kg of slaughtered and gutted salmon in Norway was approximately NOK 20, and the cost of producing 1 kg of salmon fillet was approximately NOK 34 (February 4, 2004).[2]

The internationally recognized method for salmon color measurement is by comparing the salmon fillet flesh with the colors in the *SalmoFan*™. The SalmoFan is a color fan developed on the basis of the color of salmonid flesh pigmented with astaxanthin. The color of conventional farmed salmon fillets sold in the Norwegian market normally range from twenty-three to thirty on the SalmoFan, and most common are fillets ranging from twenty-five to twenty-seven. In a consumer study conducted by Roche Vitamins,[3] the producer of astaxanthin for the salmon-farming industry, they used color twenty-six as their base product (Fish Farming International 2003).

## Experimental Procedure

The experimental session included a survey,[4] a stated choice experiment, and an RC experiment. The RC experiment consisted of three-times ten choice scenarios. In each choice scenario, the participants chose between two salmon fillets with posted prices. If none of the alternatives was of interest, they could also choose a *none-of-these* (NOT) alternative. See table 1 for an example of the choice experiment questions. In this article, we analyze the first twenty RC scenarios that focused on the color of salmon.[5]

The RC experiment had nine steps. Step 1: The experimental procedure was explained to the participants. Step 2: The participants studied the alternatives in scenarios one to ten, and marked on a questionnaire which of the alternatives in each scenario they wanted to buy. Step 3: The participants were informed about the origin of the color, see table 2. Step 4: The participants studied the alternatives in scenarios eleven to twenty, and (as in Step 2) marked on a questionnaire which of the alternatives in each scenario they wanted to buy. Step 5: The

[1] For a summary of the research on the connection between astaxanthin and animal health, see Astaxanthin (2006).

[2] NOK 100 = EUR 11.44 = US$ 14.34. February 4, 2004. (www.oanda.com).

[3] DSM Nutritional Products, formerly Roche Vitamins and Fine Chemicals, is the world's leading supplier of vitamins and carotenoids to the feed, food, pharmaceutical, and cosmetic industries. Roche Vitamins and Fine Chemicals became part of DSM on October 1, 2003.

[4] The survey was divided into four parts. The participants answered most questions before the choice experiment, some questions after ten choice scenarios, others after twenty choice scenarios, and the remaining questions after all thirty choice scenarios had been completed. We do not use the survey responses in this article.

[5] The last ten scenarios, focusing on organic and ecolabeled salmon, are to be analyzed in another article.

**Table 1. Example of Choice Experiment Question**

| | 400 g of farmed salmon | | |
|---|---|---|---|
| Scenario 1 | Alternative 1 | Alternative 2 | None of these |
| | NOK 36 | NOK 48 | |
| I would choose (check ✓ one) | ☐ | ☐ | ☐ |

**Table 2. Information Provided to Participants**

The fillets from wild salmon are usually pink red or orange. The strength of the color can vary from salmon to salmon. The color originates from carotenoids in the fish's diet. Carotenoids are widespread in living organisms.
The most important carotenoid for the color of salmon is astaxanthin. Astaxanthin is a common substance in both freshwater and marine organisms. Wild salmon obtain carotenoids from eating crustaceans or small fish that themselves have recently eaten such animals.
To create similar color in farmed salmon, synthetically produced astaxanthin is added to their feed. No negative side effects have been reported from the use of astaxanthin.

participants were informed about organic and eco-labeled salmon. Step 6: The participants studied the alternatives in scenarios twenty-one to thirty, and (as in Steps 2 and 4) marked on a questionnaire which of the alternatives in each scenario they wanted to buy. Step 7: After all participants had completed all scenarios, each participant drew one card determining his or her binding scenario. The draw was done without replacement, so that only one participant was assigned to each scenario. Step 8: Each participant received the salmon fillet he or she had chosen in his or her binding scenario. Step 9: The participants went to the cashier and paid for their salmon fillets. For the instructions, see Alfnes et al. (2006).

The design of our experiment follows Lusk and Schroeder (2004a) with some important modifications. First, we used scenario-specific products. We had thirty boxes filled with ice on three large tables. Each of the boxes represented one scenario. In each box we displayed two consumer packages of salmon fillets. The prices of the two alternatives were posted on laminated paper in the back of the box. This setup is very flexible and allowed us to vary not only the price, but also the products, among the scenarios. Second, the participants chose between the exact product packages they could obtain. Each participant randomly drew his or her exclusive scenario, and the participant who drew scenario four would obtain the fillet he or she had chosen in box number four. The salmon fillets they evaluated were the exact same fillets they would buy. For this to be possible, the number of participants in each session had to be smaller than or equal to the number of choice scenarios.

Third, the two alternatives in each box were referred to as *Alternative 1* and *Alternative 2*. The only information that was posted in the first twenty choice scenarios was the price. The consumers had to infer the quality from intrinsic quality cues such as the color. Extending the design to include other types of information such as labeling is straightforward. Fourth, the color, as well as the price, was a part of the fractional factorial design, as was the positioning of the products as *Alternative 1* or *Alternative 2*. Any left- or right-hand-side bias would therefore have no effect on the relative utility of the alternatives. Fifth, before the first ten scenarios we did not give the participants any information about how the salmon fillets differed. We said that we had various types of farmed salmon fillets, and asked the participants to study the alternatives and choose the alternative they would like to buy, given the price. Only after the first ten scenarios, did we inform the participants about the origin of the color. Sixth, to reduce any systematic ordering effects, the participants could start at any of the ten scenarios on each table. This also speeded up the process and we avoided a queue in front of the first scenario.

Our modification of the design was inspired by the growing literature on stated choice surveys. Lusk and Schroeder (2004a) include all alternatives in every scenario, and varied only the prices among the scenarios. This limits the number of alternatives that can be included in the experiment. In the stated choice literature, consumers choose among alternative product descriptions in hypothetical scenarios. In stated choice surveys it is common to include a large number of quality attributes, both existing and nonexisting. To elicit consumer preferences for the attributes efficiently, fractional factorial design is used to vary all attributes among the scenarios. To lessen the cognitive burden on the participants, only two or three alternatives are usually included in each scenario. For a thorough survey of stated choice methodology and applications see Louviere, Hensher, and Swait (2000).

As the number of product attributes or attribute levels increases, the difference between the number of products needed in the Lusk and Schroeder (2004a) design, and the number of products needed in a design with scenario-specific products, increases considerably. In a choice experiment where all products are available in each choice scenario, it is possible that all participants end up with the same product. Assuming that we have $n$ alternatives and $m$ participants, we would then need $m$ products of each of the $n$ alternatives, that is, $m \times n$ products. Including only two alternatives in each choice scenario and allowing each participant to draw his or her exclusive scenario, reduces the total number of products necessary to $2 \times m$, or $2 \times m/n$ products of each alternative.

## Products

To ensure wide variation in color, we bought salmon from four different production sites: three conventional salmon farms that utilize synthetically produced astaxanthin and an organic salmon farm that uses astaxanthin only from natural sources. We did not request specific colors, and the color variation we obtained is largely a result of the producers' inability to produce salmons with a homogenous color. The salmon fillets were cut into portions weighing approximately 400 g,[6] put into packaging familiar to consumers and precisely weighed. We also recorded if the fillet portions were from the front or tail of the fillet. The fillets were categorized into color categories using the internationally recognized method for color measurement for salmon, the SalmoFan. Fillets from the conventional salmon farms ranged in color from twenty-three to thirty on the SalmoFan, and those from the organic salmon farm ranged from twenty to twenty-two. The fillets were grouped into five color categories, hereafter referred to as alternatives R21, R23, R25, R27, and R29.

The price attribute had the levels NOK 24, 30, 36, 42, and 48. This corresponds to a price per kilogram of NOK 60, 75, 90, 105, and 120, respectively. The week before the experiment, the prices of salmon fillets in the three largest grocery stores in the area were NOK 79, 89, and 119 per kilogram. Thus, all prices except for that of NOK 24 per 400 g/NOK 60 per kilogram were within a familiar price range for salmon fillets in the area.

Nonprocessed food products, such as salmon fillets, are heterogeneous in so many ways that we cannot normally obtain products that are uniform across all characteristics. Allowing the color categories to be represented by more than a single product gives a better representation of the categories than selecting one product from each category. In our experiment, we had eight sessions, and each session had twenty color scenarios. Each color category was included eight times in each session. We replaced the fillets each day, and the fillets sold in the first session every night were replaced with new fillets. The total number of fillets displayed in the color experiment was 197, divided into five color categories. On average, each color category was represented by almost forty salmon fillets in the experiment. This relatively high number of salmon fillets in each color category reduced the effect on the WTP estimates of any unrecorded attributes of one specific salmon fillet.

## Design Choice Scenarios

We used the SAS macro described in Kuhfeld (2001) to generate a fractional factorial design with forty choice scenarios.[7] Each scenario had two alternatives described by color and price, both five-level attributes. To avoid clearly dominated alternatives, we limited the design to scenarios where the color of the two alternatives differed. There were, however, no limitations on the price attribute, and several scenarios had the same price for both alternatives. The scenarios were divided into four blocks, and randomly arranged within the blocks. SAS reported a D-efficiency of 96.85 for the design. Each block of scenarios was used once as scenarios one to ten, and in another session as scenarios eleven to twenty. Other product-specific attributes such as the fillet thickness, visible fat, exact weight, and fillet cut were not included in the design, but were randomized in the drawing of the products. For a further discussion of fractional

[6] The mean weight was 400.28 g with a standard deviation of 40.25 g. To avoid weight playing an important role in choice, we imposed a 10% upper limit on how much choice pairs were allowed to differ.

[7] Notwithstanding the statistical advantages possessed by a complete factorial, such designs are practical only for choice experiments with very few attributes and levels. In our case, the full factorial design without (with) restrictions had $5^4 = 625(5^3 \times 4 = 500)$ choice sets.

**Table 3. Descriptive Statistics for the Sample**

| Variable | Definition | Mean[a] | Std. dev. |
|---|---|---|---|
| *Gender* | Gender of participant<br>Female = 1; Male = 2 | 1.43 | 0.49 |
| *Age* | Age of participant (in years) | 38.81 | 10.29 |
| *Income* | Total income of household[b]<br>(in NOK 100,000) | 5.62 | 2.63 |
| *Education* | Highest completed education<br>Elementary school = 1<br>High school = 2<br>College/University = 3 | 2.54 | 0.67 |

[a] Corresponding figures for the population between twenty and sixty years old in the Oslo area are 1.49, 39.80, 5.89, and 2.41, respectively.
[b] The income question had six classes. The midpoints of classes are used in the estimation.

factorial design, see Louviere, Hensher, and Swait (2000).

## Sample

The experiment was conducted at MATFORSK, The Norwegian Food Research Institute, across four nights in February 2004. We conducted two sessions each night, and each session lasted approximately one and a half hours. Each session had between thirteen and sixteen participants. In total, 115 participants were recruited through various local civic organizations, including choirs and soccer teams, in southeastern Norway. In each organization, the contact person was instructed to provide a sample of regular consumers, between twenty-five and sixty-year old, with an approximately equal division of sexes. The organizations were given NOK 200 for each participant they recruited, and the participants were given NOK 300 to take part in the experiment.[8]

Table 3 presents the descriptive statistics for the sample. The participants' ages ranged from twenty to sixty-three years, with an average of thirty-nine years. Fifty-eight percent of the participants were women. The average household income was NOK 562,000. One participant who said he did not eat fish, and fifteen participants who chose the NOT alternative in all choice scenarios were excluded from the analysis. The sample used in the estimation comprises the remaining ninety-nine respondents.

[8] Norway has a high organizational participation rate. In the Oslo area, for example, 49% of the population actively participates in at least one organization (Statistics Norway). Recruiting through organizations can then yield a representative sample of the population.

## Econometric Model

We analyzed the RC data with a mixed logit (also known as a random parameter logit) model. The mixed logit obviates three of the limitations of the standard logit model by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time (Train 2003). Furthermore, McFadden and Train (2000) show that under mild regularity conditions, any discrete choice model derived from random utility maximization has choice probabilities that can be approximated as closely as one pleases by a mixed logit model.

Let us assume that the individual's utility from each alternative can be decomposed into a linear-in-parameters part that depends on observable variables, and an error term that is an independently and identically distributed (iid) extreme value. Given these assumptions, the utility of individual $n$ from alternative $i$ in choice scenario $s$ is denoted by

$$(1) \qquad U_{nis} = \boldsymbol{\beta}' \boldsymbol{x}_{nis} + \boldsymbol{\eta}_n' \boldsymbol{z}_{nis} + \varepsilon_{nis}$$

where $\boldsymbol{x}_{nis}$ and $\boldsymbol{z}_{nis}$ are vectors of observed variables relating to alternative $i$; $\boldsymbol{\beta}$ is a vector of fixed coefficients; $\boldsymbol{\eta}$ is a vector of random terms with mean zero; and $\varepsilon_{nis}$ is an iid extreme value error term. The terms in $\boldsymbol{\eta}$ are error components that, along with $\varepsilon_{nis}$, define the stochastic portion of the utility. The standard logit is a special case of the mixed logit where $\boldsymbol{\eta}$ has zero variance.

The density of $\boldsymbol{\eta}$ is denoted by $f(\boldsymbol{\eta} \mid \boldsymbol{\Omega})$, where $\boldsymbol{\Omega}$ is the fixed parameter of the distribution. For a given $\boldsymbol{\eta}$, the conditional choice probability is a standard logit

$$(2) \qquad L_{ni}(\boldsymbol{\eta}) = \frac{e^{\boldsymbol{\beta}' x_{ni} + \boldsymbol{\eta}'_n z_{ni}}}{\sum_{j \in J} e^{\boldsymbol{\beta}' x_{nj} + \boldsymbol{\eta}'_n z_{nj}}}.$$

Consequently, the unconditional choice probability, $P$, in the mixed logit model is the logit formula integrated over all values of $\boldsymbol{\eta}$ with the density of $\boldsymbol{\eta}$ as weights

$$(3) \qquad P_{ni} = \int L_{ni}(\boldsymbol{\eta}) f(\boldsymbol{\eta} \mid \boldsymbol{\Omega})\, d\boldsymbol{\eta}.$$

This integral cannot be solved analytically and is approximated through simulation (Brownstone and Train 1999).

In the RC color experiment, the participants were asked to make twenty choices between salmon fillets offered at various prices. The choice data were analyzed with the following mixed logit model

$$(4)$$
$$U_{nis} = (\beta_{0i} + \beta_1 Tail_{nis} + \beta_{2i} ID_s + \eta_{ni}) Weight_{nis} + \beta_3 Price_{nis} + \beta_4 Price24_{nis} + \varepsilon_{nis}$$

where $\beta_{0i}$ is the alternative specific constant for alternative *i,* ASC(*i*) (in other words, there is one constant for each color); $Tail_{nis}$ is a dummy variable taking the value of one if the product is a tail fillet, and zero otherwise; $ID_s$ is a dummy variable taking the value of zero before the color information was given and one afterwards; $\eta_{ni}$ is an error term that is triangularly distributed, heteroskedastic, independent between alternatives, and perfectly correlated over choices made by the same individual;[9] $Weight_{nis}$ is the exact weight of the alternative *i* in kilograms; $Price_{nis}$ is the price of alternative *i*; $Price24_{nis}$ is a dummy taking the value of one if the price is NOK 24, and zero otherwise. For the estimation purposes, the weight of the NOT alternative is set to one. For identification, the alternative-specific parameters for the palest alternative, R21, is normalized to zero.

Multiplying the alternative specific constants (ASCs) the tail variable and the information dummies (IDs) with the weight, implies a linear increase in utility with an increase in weight for all varieties of fillets. For example, the utility of a 420-g fillet is assumed to be 5% higher than the utility of a 400-g fillet with the same color, and the utility of a 420-g tail fillet is assumed to be 5% higher than the utility of a 400-g tail fillet with the same color. The Price24 dummy is included to capture any adverse effects of offering the salmon fillets at a price below that normally seen in the market.

The mean WTP per kilogram of alternative *i* can be calculated by dividing the utility difference between 1 kg of alternative *i* and the NOT alternative, with the negative of the price sensitivity parameter. Because the price sensitivity parameter measures the utility of the price in NOK 100, we multiply the result by 100 to get the WTP in NOK

$$(5)$$
$$WTP_{is} = -100 \times \frac{(\beta_{0i} + \beta_1 Tail_{is} + \beta_{2i} ID_s) - (\beta_{0NOT} + \beta_{2NOT} ID_s)}{\beta_3}$$

where $WTP_{is}$ is the estimated mean WTP per kilogram of alternative *i* in scenario *s*; and all other variables and parameters are as described in equation (4).

## Results and Discussion

In our design, there was no correlation between color and price and no correlation between the price of alternative 1 and the price of alternative 2. Therefore, one would expect that, on average, the choice probability for an alternative increased as the price decreased. This was the case as long as the price was within the familiar range of NOK 30 to NOK 48 per 400 g. However, when the price was reduced from NOK 30 to NOK 24, the average choice probability for an alternative was reduced. On average, the percentage of the participants who chose an alternative with a price of NOK 48 was 30.76. This increased to 35.98 for NOK 42, 37.71 for NOK 36, and 42.86 for NOK 30, but decreased to 36.78 for NOK 24. The NOK 24 price lies below that normally seen in the market, and it appears that this low price was viewed as a signal of lower quality.[10] Not controlling for this would give a price sensitivity parameter that was closer to zero, and thereby higher WTP values.

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[9] The main reason we chose the triangular distribution over the normal distribution was that the former is a limited distribution. Hence, the triangular distribution does not imply that anyone has an unlimited high WTP for salmon. See Hensher and Greene (2003) for a discussion of various distributions on the non-iid error term in mixed logit models.

[10] An alternative explanation is that respondents are reluctant to choose the lowest priced product when there is quite a large price range. NOK24 was the lowest price included in the market experiment and as such may be perceived as a signal of lower quality. In other words, the NOK24 effect might be a result of the price range used in the experiment, and not the price range found in the outside market.

**Table 4. Estimated Parameters for the Mixed Logit Models**

| | Model 1 (with Price24 dummy) | | | Model 2 (without Price24 dummy) | | |
|---|---|---|---|---|---|---|
| Variable | Para. | Std. err. | *p*-value | Para. | Std. err. | *p*-value |
| Generic variables | | | | | | |
| *Price*[a] | −3.55 | 0.63 | 0.00 | −1.94 | 0.44 | 0.00 |
| *Price24* | −0.49 | 0.14 | 0.00 | | | |
| *Tail*[b] | −0.20 | 0.33 | 0.54 | −0.46 | 0.33 | 0.16 |
| Alternative specific constants | | | | | | |
| *ASC(R23)* | 3.16 | 0.53 | 0.00 | 3.06 | 0.52 | 0.00 |
| *ASC(R25)* | 3.57 | 0.52 | 0.00 | 3.65 | 0.52 | 0.00 |
| *ASC(R27)* | 3.45 | 0.54 | 0.00 | 3.44 | 0.53 | 0.00 |
| *ASC(R29)* | 4.26 | 0.56 | 0.00 | 4.41 | 0.56 | 0.00 |
| *ASC(NOT)*[c] | −1.20 | 0.41 | 0.00 | −0.50 | 0.36 | 0.16 |
| Information dummies | | | | | | |
| *ID(R23)* | −0.59 | 0.72 | 0.41 | −0.73 | 0.71 | 0.31 |
| *ID(R25)* | −0.10 | 0.72 | 0.88 | −0.45 | 0.71 | 0.53 |
| *ID(R27)* | 1.00 | 0.72 | 0.17 | 0.92 | 0.72 | 0.20 |
| *ID(R29)* | −1.15 | 0.70 | 0.10 | −1.24 | 0.70 | 0.07 |
| *ID(NOT)* | −0.14 | 0.43 | 0.75 | −0.22 | 0.44 | 0.61 |
| Summary statistics | | | | | | |
| Number of observations | 1,977 | | | 1,977 | | |
| Number of participants | 99 | | | 99 | | |
| LL[d] standard logit | −2,051 | | | −2,058 | | |
| LL mixed logit | −1,808 | | | −1,814 | | |

Note: Estimated with Nlogit 3.0.
[a] Price in NOK 100.
[b] Tail is one if tail, zero otherwise. The variable is centralized before the estimation.
[c] NOT stands for None of These.
[d] LL stands for Log-Likelihood.

Table 4 shows the estimated parameters, standard errors, and $p$ values for the mixed logit model, with and without the Price24 dummy. The Price and NOT parameters change considerably when we exclude the Price24 dummy. The Price parameter changes because the adverse reaction to the NOK 24 price is not accounted for with a dummy, but instead is interpreted as a lack of price sensitivity. Furthermore, with a reduced absolute value on the Price parameter, the NOT parameter must increase to compensate for the loss in the NOT alternatives' relative utility resulting from its zero price.

We now concentrate the discussion on model 1. From the lower part of table 4, we can see that the mixed logit model (log likelihood = –1,808) fits the data significantly better than the more restrictive standard logit model (log likelihood = –2,051). The ASCs represent the utility per kilogram of the alternatives before we informed the participants about the origin of the color. It is worth noting that these color preferences were elicited without telling the participants that they should focus on color. The ASCs for the colors R23, R25, R27, and R29 are all positive and significant. This means that on average the consumers preferred these colors to the paler R21. Furthermore, the alternative with the highest utility is the reddest alternative, namely R29. The utility of R29 is significantly higher than the utility of the paler R23 (Wald, $p$-value = 0.00), and R27 (Wald, $p$-value = 0.02), and is higher, but not significantly, than R25 (Wald, $p$-value = 0.07). No significant differences were found between alternatives R23, R25, and R27. However, the average utility of R25, R27, and R29 is significantly higher than the utility of R23 (Wald, $p$-value = 0.05).

The ASCs plus the IDs represent the utility per kilogram of the alternatives after we informed the participants about the origin of the color. None of the utilities changed significantly after the color information was presented, however the IDs are jointly significant (Wald, $p$-value = 0.00). The utilities of the colors R23, R25, R27, and R29 are still positive and significant. This means that the average consumer prefers redder colors to the paler R21, even after they know the origin of the color. However, the utility of the reddest alternative, R29, decreased significantly relative to the utility of R25 (Wald, $p$-value = 0.05) and R27 (Wald, $p$-value = 0.00), and decreased, but not significantly, relative to the utility of R23 (Wald, $p$-value = 0.26). After the color information was supplied, the utility of R27 is significantly higher than the utility of R23 (Wald, $p$-value = 0.00), R25 (Wald, $p$-alue = 0.01), and R29 (Wald, $p$-value = 0.00). Furthermore, the average utility of R25, R27, and R29 is significantly higher than the utility of R23 (Wald, $p$-value = 0.00). The number of tail fillets was unevenly distributed among the five color categories and was most frequent in the R29 category. The tail parameter was found not to be significant, although the negative value indicated that the participants preferred the thicker front part of the fillet to the tail of the fillet.

Table 5 presents the WTP per kilogram of the five alternatives. As discussed, participants preferred the reddest alternative, R29, when they were uninformed, and the slightly paler R27 when informed about the origin of the color. After receiving the color information, the participants still preferred fairly red salmon, but they seemed to have become a little skeptical with respect to salmon that was redder than usual. This is reflected in figure 1 where the concave nature of the WTP for color is evident.

The effect of the color additives on the individual salmons varies and producers are not able to produce salmon with a homogenous color. The concave nature of the WTP function implies that consumers, on average, are willing to pay less for a batch of salmon with varying color than for a batch with the same mean color, but with no variation in color. Let

**Table 5. Willingness to Pay per Kilogram of Salmon by Color**

| | Before Information | | After Information | |
|---|---|---|---|---|
| Color | WTP | Std. err | WTP | Std. err |
| R21 | 33.87 | 9.33 | 37.87 | 8.96 |
| R23 | 123.11 | 19.37 | 110.55 | 17.39 |
| R25 | 134.44 | 21.46 | 135.49 | 20.13 |
| R27 | 131.11 | 21.02 | 163.33 | 25.05 |
| R29 | 154.14 | 24.97 | 125.81 | 20.71 |

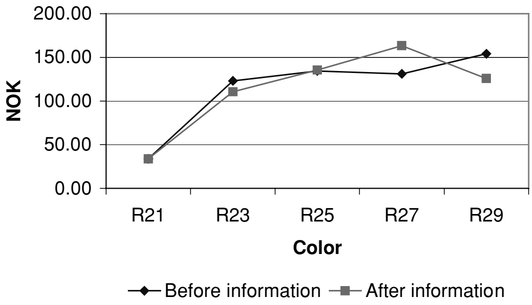


**Figure 1. Willingness to pay per kilogram of salmon by color before and after receiving information**

us, as an example, assume that 25% of salmon end up in a color category lower and 25% in a color category higher, than the category the producer aimed for. On this basis, if the producer aims, say, for R23 he or she can expect to produce 25% R21, 50% R23, and 25% R25.

Before information, the weighted average WTP over the three colors R21, R23, and R25, was NOK103.63, which is significantly lower than the NOK 123.11 reported for R23 in table 5 (Wald, $p$-value = 0.00). Similarly, the weighted average WTP for salmon with mean colors of R25 and R27 were NOK 130.77 and NOK 137.70,[11] respectively. The weighted average WTP for the salmon with mean colors of R25 and R27 were significantly higher than the weighted average WTP for the salmon with a mean color of R23 (Wald, $p$-value = 0.00; Wald, $p$-value = 0.00, respectively). After receiving the information, the weighted average WTP for salmon with mean colors R23, R25, and R27 were, respectively, NOK 98.61, NOK136.21, and NOK 146.99.

Similarly to the situation before information, the weighted average WTP for the salmon with mean colors of R25 and R27 was still significantly higher than the weighted average WTP for the salmon with a mean color of R23 (Wald, $p$-value = 0.00; Wald, $p$-value = 0.00, respectively). Comparing the weighted average WTP for the heterogeneously colored salmon, with the WTP for the homogenously color salmon (as reported in table 5), we can see that the concave nature of the WTP for salmon color gives a higher optimal color in the heterogeneous color case

[11] Although, the WTP function overall has a concave nature, it is not smooth, and has an unexplained dip at R27 before information. This causes the weighted average WTP of R25, R27, and R29 to be higher than the WTP for R27.

than in the homogenous color case. With heterogeneous colors, the weighted average WTP for salmon with mean colors of R25 and R27 is significantly higher than the weighted average WTP for salmon with a mean color of R23, both before and after the information. The higher the variability in color, the more color additives the producer should use to ensure that none of the salmon falls short of R23.

In a companion article to Lusk and Schroeder (2004a), Lusk and Schroeder (2004b) compared WTP estimated from their RC experiment with WTP elicited in four different types of auction mechanisms. They found that the RC experiment gave significantly higher total and marginal WTP estimates than the auctions. Whereas auction participants appear limited by outside options and rarely bid higher than the market price, RC participants often chose high-priced alternatives. The average WTP found in their RC experiment was in line with the market price of the products, suggesting that many of the participants must have been willing to pay more than the average market price in the choice experiment.

Recalling that the price of salmon fillets in local stores ranged from NOK 79 to NOK 119 the week before the experiment, we note that the level of the WTP estimates presented in table 5 is somewhat high. The average WTP for the two most common colors, R25 and R27, was 15.65% and 12.57% higher, respectively, before the information was received, and 14.02% and 37.16% higher after the information was received than the highest market price we found in the local stores. Given the market prices, the price premium of between NOK 73 and NOK 125 for added color implies that the average consumer would not buy R21 salmon at any price.

There are several potential sources of an upward bias in RC experiments. The participants may not take their outside options fully into account, and choose the NOT alternative too infrequently. The participants may also be less price-sensitive in an RC experiment where they are offered only one product and allowed to buy only a single piece of the product than in a real market. The price sensitivity directly affects both the marginal and the total WTP estimates through the denominator in equation (5). A higher percentage of NOT choices would increase the estimated utility parameter for the NOT alternative, and through equation (5), reduce the level of all salmon WTP estimates. However, it is important to realize that including the fifteen participants choosing the NOT alternative in all twenty scenarios would not have helped much. We employed a panel version of the mixed logit model, where all choices made by one participant are clustered together. Including fifteen participants who make the same choice in all twenty scenarios would have little effect on the parameter included in equation (5). However, it would significantly increase the variance of the non-iid error term associated with the NOT alternative. We are still in a very early stage in the use of RC experiments, and further research is necessary before we fully understand how prices, outside options, and other framing effects influence consumers' decisions.

## Summary and Conclusion

In RC experiments, consumers face choices involving real products and money in a series of choice scenarios. The choice task is relatively similar to the choices consumers face in real world grocery stores. The incentives for revealing one's true preferences are transparent. This makes the RC experiments an incentive-compatible method for eliciting WTP for food-quality attributes. The design of the experiments and the analysis of the data are based on methods developed for hypothetical choice experiments. We modified Lusk and Schroeder's (2004a) RC design by using scenario-specific products and a unique binding scenario for each participant. This increases flexibility, allows the use of a fractional factorial design to vary both product attributes and the prices, permits the incorporation of a larger number of product attributes and attribute levels, and gives participants the choice between specific product packages not just product types. The greater the number of attributes and levels, the more important it is to use a fractional factorial design to vary product attributes, which again makes it necessary to use scenario-specific products.

The RC experiment presented in this article focuses on the color of salmon. The pink-red color is one of the most important quality traits for Atlantic salmon. Consumers use color as a quality indicator and are willing to pay significantly more for salmon fillets with normal or above-normal redness, as compared with paler salmon fillets. Without artificial coloring, farm-raised salmon would be difficult to market and would probably command significantly lower prices.

We found that most of the increase in WTP for color is before R25, and that salmon with color below R23 on the SalmoFan are difficult to sell at any price. Because producers are not able to produce a homogenous color, they should aim for R25 or redder to ensure that few salmon fall short of R23. However, consumer WTP for the degree of redness is only one part of the information necessary to find the optimal level of coloring for salmon. In addition, it is necessary to know the cost of increasing the average color, the color variation at different levels of color additives, and the extent to which producers are able to retrieve the consumers' WTP. The concave nature of the WTP for color suggests that average WTP decreases when the spread in colors increases. Therefore, it is important that the concave nature of the WTP for color is taken into account when determining the weight the color spread should have in the salmon-breeding goal.

Informing consumers about the origin of the color does not affect the WTP for pale and normal red fillets. However, this information does influence the WTP for above-normal red fillets, which decreases significantly. These results indicate that color-added labeling would have little effect on the demand for the most common color categories of farmed salmon.

*[Received September 2004; accepted February 2006.]*

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