Marine Resource Economics, Volume 20, pp. 211–219
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0738-1360/00 $3.00 + .00

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The Effect of Color on Consumer WTP for Farmed Salmon

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Abstract *Atlantic salmon is recognized for its pink-red color. The color is due to deposition of color pigments in the muscles. Wild salmon absorb the pink-red color pigment astaxanthin from the crustaceans they eat. To impart the pink-red color in farmed salmon, synthetically produced astaxanthin is added to their feed. The more astaxanthin, the redder the flesh becomes. In conventional salmon farming, the relatively expensive astaxanthin constitutes approximately 15% of the total feed costs. In this study, we use a stated choice experiment with pictures to investigate consumer willingness to pay (WTP) for salmon with different degrees of redness. The results show that consumer WTP increases with the redness of the salmon. However, when consumers were informed about the origin of the color, the WTP for the above-normal-red salmon was reduced.*

Key words Choice experiment, color, mixed logit, salmon, WTP.

JEL Classification Codes Q13, Q22.

Introduction

Atlantic salmon, rainbow trout, and other salmonids are recognized for their pink-red color. This characteristic color is caused by the deposition of carotenoids in the muscles (Khare *et al*. 1973; Schiedt, Leuenberger, and Vecchi 1981; Schiedt, Vecchi, and Glinz 1986). Carotenoids are biosynthesized by plants, algae, some bacteria, and fungi. In the wild, salmon absorb carotenoids from the crustaceans they eat (Goodwin 1984). Salmonids are unable to biosynthesize carotenoids and must eat

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The authors would like to thank Atle Guttormsen, Kari Kolstad, Ingrid Olesen, and Bjarne Gjerde for valuable discussions. The Research Council of Norway financed this research, Grant Nos. 143045/140 and 159523/110.

them as a part of their diet to get the pink-red color (Davis 1985). In farmed salmon production, carotenoids, mainly astaxanthin and canthaxanthin,[1] are added to the salmon feed. Increasing the amount of carotenoids in the diet will, within biological limits, increase the redness of the flesh.

Consumers seem to prefer red-colored products of salmon and trout (Ostrander *et al*. 1976; Gormley 1992; Rounds, Glenn, and Bush 1992; Skonberg *et al*. 1998; Anderson 2000; *Fish Farming International* 2003). In a test of smoked salmon colors, consumers chose pink salmon before orange or dark, kipper-like colored salmon (Gormley 1992). Consumers use the redness as an indicator of quality traits, such as freshness and flavor (Sylvia *et al.* 1996; Anderson 2000), and it has been shown that the redness contributes significantly to the overall enjoyment of cooked salmon (Sylvia *et al*. 1995). Furthermore, a study conducted by *Roche Vitamins*[2] found that consumers expect to pay more for extreme red salmon than for normal red salmon (*Fish Farming International* 2003). Salmon producers recognize that color is one of the most important characteristics of salmon, and use large amounts of money to impart the natural pink-red color. In conventional Norwegian salmon farming, the cost of astaxanthin accounts for approximately 15% of the feed costs. Feed costs account for 50% of the total production costs at farm level (Guttormsen 2002). Hence, coloring is a relatively significant cost in salmon farming. In 2003, the total cost of producing 1 kilogram slaughtered and gutted salmon in Norway was approximately NOK 20,[3] and the cost of producing a one kilogram fillet was approximately NOK 34.

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 a part of the ongoing debate. Consumer groups in the US have complained about the lack of color additive labeling of farmed salmon. In 2003, they filed a lawsuit against three major grocery chains which had not been labeling farmed salmon to force them to label the farmed salmon as "color added." Consumer groups argue that consumers have the right to know what is added to the feed (Smith & Lowney, PLLC 2003). Now, most big US grocery stores have some form of color information on the label of farmed salmon. One of the most common is, "the feeding process enhances the color," written in small print.

In this paper, we present the results of a stated choice (SC) experiment conducted to investigate consumer WTP for salmon with various degrees of redness.[4] We explore consumer preferences for both normal and extreme colors, and we investigate consumer reactions to *color-added* information. The remainder of the paper proceeds as follows: first, we explain the design of the SC experiment, followed by description of the data, presentation of the empirical model, the results, and conclusion.

Experimental Design

The experimental session included a survey, a non-hypothetical choice experiment, and an SC experiment with pictures. In this paper, we will analyze the SC experiment, which consisted of 10 hypothetical choice scenarios that focused on the color of salmon.

[1] The Norwegian salmon farming industry uses mainly astaxanthin.
[2] 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 1 October 2003.
[3] NOK 100 = EUR 11.44 = USD 14.34. February 4, 2004 (www.oanda.com).
[4] For a thorough survey of SC methods and applications, see Louviere, Hensher, and Swait (2000). For a resent review of SC applications in food marketing, see Alfnes (2004).

We used the SAS macro *%mkdes* to generate a fractional factorial design with 40 choice scenarios (Kuhfeld 2001). Each scenario had two alternatives described by color and price. The scenarios were distributed into four blocks of 10 scenarios randomly arranged within the blocks. Each block of 10 scenarios constituted a version of the SC experiment. SAS reported a D-optimality of 95.70 for the design.

Each version of the SC experiment had 10 scenarios. Each scenario was represented by a poster with two 18 cm x 13 cm pictures of salmon fillets. The pictures were labeled as *Alternative 1* and *Alternative 2*, and the price for 400 grams of salmon fillet was printed below each picture. The color and price of the fillets differed from scenario to scenario according to the fractional factorial design. In addition to the salmon alternatives, each scenario also had a *none-of-these* (NOT) alternative. See table 1 for an example of the choice scheme.

We took two pictures of salmon fillets from six different color categories. We used the *Salmo*Fan™ (Roche Vitamins 2000) to determine the color of the fillet pictures after they were developed. The *Salmo*Fan™ is a color fan developed on the basis of the color of salmonid flesh pigmented with astaxanthin. Comparing the fillet flesh with the *Salmo*Fan™ is the internationally recognized method for salmon color measurement. The colors of the fillet pictures were determined to be 21, 23, 25, 27, 29, and 32 on the *Salmo*Fan™. We will hereafter refer to the colors as alternative R21, R23, R25, R27, R29, and R32, respectively. The color of the salmon fillets sold in the Norwegian market normally range from 23 to 30 on the *Salmo*Fan™. Fillets as pale as 21 are never seen in the Norwegian market, whereas fillets as red as 32 are usually seen only for rainbow trout. Most common are fillets between 25 and 27 on the *Salmo*Fan™.[5]

Price was a five-level attribute, with the levels NOK 24, 30, 36, 42, and 48 per 400 grams. This corresponds to NOK 60, 75, 90, 105, and 120 per kilo. The week before the SC experiment, the price of salmon fillets in the three largest grocery stores in the area were NOK 79, 89, and 119 per kilo.

In half of the sessions the participants were informed about the origin of the salmon color before the SC experiments, in the other half they were not. See table 2 for the information given to participants.

Sample

The data collection was conducted at MATFORSK, the Norwegian Food Research Institute on four nights in the first week of February 2004. We conducted two ses-

Table 1
Example of Choice Scheme

	400 Grams of Farmed Salmon		
Scenario 1	Alternative 1 NOK 36	Alternative 2 NOK 48	None of these
I would choose (check one)	☐	☐	☐

[5] In a consumer study conducted by Roche Vitamins, the producer of astaxanthin for the salmon farming industry, they use R26 as their base product (*Fish Farming International* 2003).

Table 2
Information Given 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 substance common in both fresh water and marine organisms. Wild salmon gets carotenoids from eating crustaceans, or small fish who themselves have recently eaten such animals.
In order to impart similar color to farmed salmon, synthetically produced astaxanthin is added to their feed. No negative side effects have been reported from the use of astaxanthin.

sions each night, and each session lasted approximately one and a half hours. In total, 115 participants were recruited through various local organizations in southeastern Norway. Between 13 and 16 persons participated in each session. The organizations were given NOK 200 for each participant they recruited, and the participants were given NOK 300 to take part in the experiment.

Descriptive statistics for the survey sample are presented in table 3. The participants' ages ranged from 20 to 63 years with an average of 39 years. Fifty-eight percent of the participants were women. The average household income of the sample was NOK 562,000. One participant who said he did not eat fish, and six participants who chose the *none-of-these* alternative in all choice scenarios, were excluded from the analysis.

Empirical Models

We analyzed the SC data with a mixed logit model (see e.g., Hensher and Greene 2003). Let us assume that the individual's utility from each alternative can be decomposed into a non-stochastic and linear-in-parameters part that depends on observable variables, a stochastic part that is triangularly distributed,[6] heteroskedastic, and perfectly correlated over choices made by the same person, and a second stochastic part that is independently and identically extreme value distributed. Given these assumptions, the utility of individual *n* from alternative *i* in choice situation *s* is denoted by:

$$U_{nis} = \beta_i' x_{nis} + \left[\eta_{ni} + \varepsilon_{nis} \right], \tag{1}$$

where x_{nis} is the vector of observed non-stochastic variables including attributes of alternative *i* in individual *n*'s choice situation *s*; β_i is a vector of structural parameters; η_{ni} is a triangularly distributed error term that is heteroskedastic and perfectly correlated over choices made by one individual, and ε_{nis} is an extreme value error term that is independently and identically distributed over individuals, alternatives,

[6] The main reason to choose the triangular distribution over the normal distribution is 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.

Table 3
Descriptive Statistics for the Sample

Variable	Definition	Mean	St. Dev.[a]
Gender	Gender of participant Female = 1; Male = 2	1.43	0.49
Age	Age of participant	38.81	10.29
Income	Total income of household[a] (in NOK 100,000)	5.62	2.63
Education	Highest completed education Elementary school =1 High school = 2 College/university = 3	2.54	0.67

[a] The income question had six classes. The midpoints of the classes were used in the estimation.

and choices by the same individual. In the rest of the discussion, we suppress the subscript *s*.

In the SC experiment, the participants were asked to make 10 choices between varieties of salmon fillets offered at various prices. The choices were analyzed with the following mixed logit model:

$$U_{nis} = (\beta_{0i} + \beta_{1i} Id_i) \quad Weight + \beta_2 Price_{nis} + \beta_3 Price24_{nis} + [\eta_{nis} + \varepsilon_{nis}], \qquad (2)$$

where β_{0i} is the alternative specific constant for alternative *i*, ASC(*i*), in other words there is a constant for each color; β_{1i} is the effect of color information on alternative *i*; Id_i is a dummy variable taking the value one if the participants were given information about the origin of the color, and zero otherwise; *Weight* is 1 for the NOT alternative and 0.4 for all the fillets, this normalizes β_{0i} and β_{1i} to be the utility for one kilogram of salmon fillet; β_2 is the price sensitivity parameter; $Price_{nis}$ is the price of alternative *i*; and $Price24_{nis}$ is a dummy taking the value one if the price is NOK 24, and zero otherwise.[7] For identification, the utility of the palest alternative, R21, was normalized to zero.

The mean WTP for alternative *i* relative to the WTP for alternative R21 can be calculated by estimating the utility difference between alternative *i* and the R21 alternative, and dividing by the negative of the price sensitivity parameter. Since the price sensitivity parameter measure the utility of the price in NOK 100, we must multiply the result with 100 to get the WTP in NOK:

$$WTP_{ni} = -100 \quad \frac{(\beta_{0i} + \beta_{1i} Id_n) - (\beta_{0,R21} + \beta_{1,R21} Id_n)}{\beta_2}, \qquad (3)$$

where WTP_{ni} is the estimated mean WTP of alternative *i* and all other variables and parameters are as described under equation (2).

[7] We inspected the data and found that the choice probability increased as we reduced the price down to NOK 30. However, from NOK 30 to NOK 24 the choice probability significantly decreased. Since we were mainly interested in the price sensitivity for prices higher than NOK 30, we have included a dummy for the NOK 24 price.

Results and Discussion

Table 4 contains the estimated parameters and WTP with standard errors and *p* values. The *ASCs* represent the average utility of the alternatives relative to the utility of R21 for participants who were not informed about the origin of the color. The *ASC* for the alternatives R23, R25, R27, R29, and R32 were all positive and significant at the 10% level. Furthermore, the ASC for R25, R27, R29, and R32 were all significantly larger than the ASC for R23 (R25-R23: *Wald*=8.82, *p* value=0.00; R27-R23: *Wald*=14.42, *p* value=0.00; R29-R23: *Wald*=16.85, *p* value=0.00; R32-R23: *Wald*=27.70, *p* value=0.00). This means that, on average, the consumers preferred the redder alternatives to the two palest alternatives, R21 and R23. Furthermore, the marginal utility of increased redness was positive, but decreasing. The increase in utility is significant when the redness goes from R21 to R23 and from R23 to R25. However, for the alternatives most commonly seen in the market, R25, R27, R29, the utility of the alternatives were not significantly different (R27-R25: *Wald*=1.00, *p* value=0.32; R29-R27: *Wald*=0.14, *p* value=0.70; R29-R25: *Wald*=1.47, *p* value=0.23). The utility of the extreme red R32 was significantly higher at the10% level than the utility of R25 (*Wald*=6.58, *p* value=0.01) and R27 (*Wald*=3.05, *p* value=0.08), but not higher than the utility of R29 (*Wald*=1.57, *p* value=0.21).

Table 4
Estimated Parameters for the Mixed Logit Model

Variable	Parameter	Std. Err.	*p*-value	Mean WTP	Std. Err.	*p*-value
Generic Variables						
Price[a]	–3.16	0.94	0.00			
Price24	–0.38	0.22	0.08			
Alternative Specific Constant for Color *i*, *ASC(i)*						
ASC(R23)	3.03	0.87	0.00	95.89	38.60	0.01
ASC(R25)	5.08	0.84	0.00	160.84	53.15	0.00
ASC(R27)	5.71	0.81	0.00	180.78	56.62	0.00
ASC(R29)	5.94	0.85	0.00	187.99	58.20	0.00
ASC(R32)	6.78	0.81	0.00	214.60	69.23	0.00
ASC(NOT)	–0.99	0.57	0.08	–31.25	14.17	0.03
Information Dummies, Id_i						
Id(R23)	0.54	1.17	0.65	16.99	37.74	0.65
Id(R25)	–0.30	1.13	0.79	–9.38	35.98	0.79
Id(R27)	–0.28	1.12	0.80	–8.99	35.25	0.80
Id(R29)	–0.68	1.15	0.55	–21.67	37.02	0.56
Id(R32)	–1.52	1.13	0.18	–48.03	37.72	0.20
Id(NOT)	–1.21	0.57	0.03	–38.41	21.02	0.07
Summary Statistics						
Number of choice observations					1,077	
Number of participants					108	
Log likelihood no coefficients					–1,183.20	
Log likelihood of corresponding multinomial logit					–943.45	
Log likelihood of the model at convergence					–882.10	

Notes: Estimated with Nlogit 3.0. Halton draws. Replications for simulated probability = 250.
[a] Price in NOK 100.

ASC plus *ID* represents the utility of the alternatives for the participants who were informed about the origin of the color. None of the utilities differed significantly between the groups. The utility of the alternatives R23, R25, R27, R29, and R32 were still significantly higher than the utility of R21. The average consumer preferred the redder alternatives to the pale R21 and R23 (R25-R23: *Wald*=2.85, *p* value=0.09; R27-R23: *Wald*=8.93, *p* value=0.00; R29-R23: *Wald*=6.16, *p* value=0.01; R32-R23: *Wald*=7.45, *p* value=0.00), even when they knew the origin of the color. For the informed participants, the alternative with the highest utility was alternative R27. This indicates that a "color-added" label is unlikely to have a large effect on demand for normal pink-red salmon. However, the demand for extreme red salmon is likely to decrease. We can see that the color information has the largest negative impact on the reddest alternative, and utility of R32 is significantly reduced by the color information compared to the utility of the paler R23 (*Wald*=4.87, *p* value=0.03).

ASC(NOT) and *ID(NOT)* refer to the utility of the *none-of-these* alternative. Some authors interpret the utility of the *none-of-these* alternative as the baseline for the WTP estimation. Lusk and Schroeder (2004) compared WTP estimates from a hypothetical SC experiment and a non-hypothetical choice experiment using the *none-of-these* alternatives as a baseline for their WTP estimation. They found that the WTP estimates from the hypothetical SC experiment were significantly higher than the estimates from the non-hypothetical choice experiment. However, they found only small and insignificant differences in marginal WTP from changes in product quality between the two methods. These results are likely caused by fewer *none-of-these* choices in the hypothetical setting. In this paper, we concentrate our discussion on the marginal WTP for color.

Figure 1 presents the mean WTP for R23, R25, R27, R29, and R32 relative to the WTP of R21. The WTP for R23, R25, R27, R29, and R32 were NOK 96, 161, 181, 188, and 215, respectively, without information, and NOK 113, 151, 172, 166, and 167 with information. The figure clearly illustrates the concave nature of the WTP graph and illustrates the difference between the *with* and the *without* information groups with respect to their WTP for the reddest alternatives. The effects are the same as discussed for the parameters. In both groups, the WTP for the reddest alter-

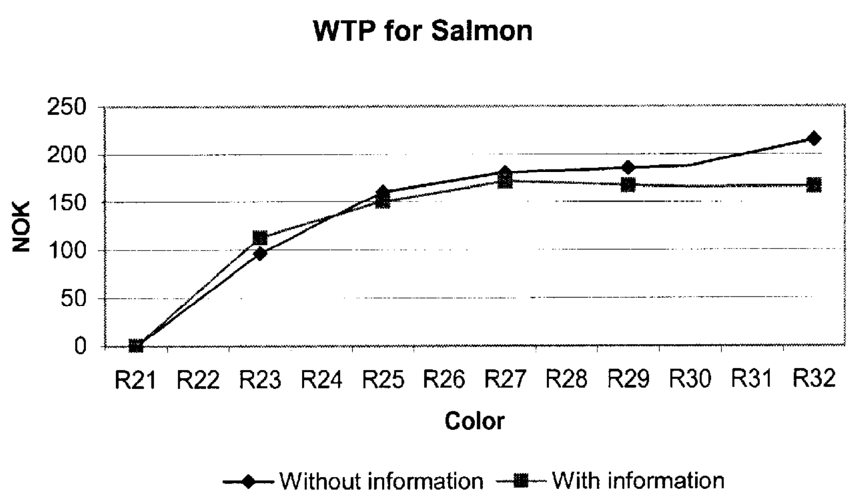

Figure 1. Willingness to Pay for Salmon Color Without and With Information

natives, R25, R27, R29, and R32, were significantly higher than the WTP of the palest alternatives, R21 and R23. For the group without information, the WTP for R32 was significantly higher than the WTP for the paler R25. The color information has the largest negative impact on the WTP for the reddest alternative, and WTP for R32 is significantly reduced by the color information compared to the WTP for the paler R23.

These results are consistent with previous studies that have found that consumers prefer redder salmon (Ostrander *et al*. 1976; Gormley 1992; Rounds, Glenn, and Bush 1992; Skonberg *et al*. 1998; Anderson 2000). However, the WTP estimates, the concave nature of the WTP graphs, and the effect of "color added" information could not be found with the techniques used in the previous studies.

Last, we note the negative *Price24* parameter. In our design, there was no correlation between color and price. Therefore, one would expect the choice probability to increase as price was reduced. This was the case as long as price was within the familiar price range of NOK 30 to NOK 48 per 400 grams. However, when price was reduced from NOK 30 to NOK 24 the choice probability was significantly reduced. The NOK 24 is below what is normally seen in the market, and the negative *Price24* parameter indicates that the low price is seen as a signal of low quality. Not controlling for this would have given a price sensitivity parameter that was closer to zero, resulting in higher WTP.

We estimated a variety of discrete choice models on the responses to the SC experiments. We found that the level of the WTP estimates varies within a few percent between the models. However, the ranking of the alternatives, the concave nature of WTP, and the effect of the "color added" information are very robust and independent of model specification.

Conclusions

The pink-red color is one of the most important characteristics of Atlantic salmon. Consumer WTP for salmon increases with the redness of the fillets. Salmon fillets that are redder than R23 are acceptable to most consumers and can command reasonably high prices, while salmon that are paler than R23 are difficult to sell at any price.

Information about the origin of the salmon color had no effect on the WTP for the pale and the normal pink-red salmon. However, this information reduced the WTP for the above-normal-red salmon. A "color added" label is likely to have little effect on the WTP and the prices one can ask for normal pink-red salmon.

These results indicate that consumers want pink-red salmon, even when they know the origin of the color. The market segment for pale salmon without cosmetic feed additives seems to be small. The use of synthetically produced cosmetic feed additives is, therefore, likely to continue in conventional salmon production.

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