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Public reactions to information about genetically engineered foods: effects of information formats and male/female differences

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Developing effective communication strategies to inform the public about genetic engineering applications in food production is critical for the successful commercialization and future development of the technology. However, few existing studies in the United States have examined how communication materials affect public understanding of new technologies. Our survey study examined the effect of two information formats developed according to public issue education principles on the public understanding of, interest in and attitude towards genetically engineered salmon. In addition, we examined male/female differences in attitude. Our results indicated that participants who read the “consequence” information learned more, expressed more interest, and indicated higher level of actual confidence in judgment than those who read the “perspective” information. Women were less approving of genetically engineered salmon than men were both before and after reading the information. Reading information led to a positive change in attitude although the effect size was not different between sexes. The male/female difference was likely due to women’s higher level of concern about effects on humans and greater trust of environmental groups compared to men’s. Suggestions for designing an effective print communication about a specific genetic engineering application are presented.

1. Introduction

Democratic societies want to insure the public can make informed decisions about the acceptability of genetically engineered (GE) foods. Acknowledging that most Americans still have little relevant knowledge (Hallman et al., 2003; Hallman and Metcalfe, 1994; IFIC, 2000; OTA, 1987; Saad, 2001), and have expressed little interest in discussing (Hallman et al., 2002, 2003) and accessing (Saad, 2001) the news about genetic engineering, many surveys have included a brief introduction to genetic engineering before asking about consumer perceptions. The results indicate that US public attitude towards GE foods varies from survey to survey. This fluidity of public attitude has been attributed to

inconsistent survey methodologies or various operational definitions adopted by different stakeholders (Davison et al., 1997; Kolodinsky et al., 2004).

Another cause of the variability in public attitude that attracted our attention is the variations among the information provided (e.g., content differences and choice of words). For example, providing benefit only information reduced the level of perceived risks of GE foods compared to providing risk and benefit balanced information (Kolodinsky et al., 2004) while providing consumer benefit information increased willingness to purchase compared to providing no direct consumer benefits (e.g., environmental benefit) information (Brown and Ping, 2003). The choice of words also affects attitudes. The word "biotechnology" was rated most positively, followed by "genetic engineering," while "genetic modification" was rated most negatively (Hallman et al., 2002, 2003; Levy and Derby, 2000). Although studies on other subjects have shown that information formats (Connelly and Knuth, 1998; Jardine and Hrudehy, 1997; Levin et al., 1998; Siegrist, 1997) also affect attitudes and behaviors, little information is available about the information format effect on consumer attitude towards GE foods. It is therefore important to understand the format effect on public understanding of GE foods in order to inform communication practitioners and possibly to improve public utilization of information in the future.

This study compared the effect of two information formats, developed using public issue education principles, on the public understanding of and attitude towards a controversial technological product, GE salmon. Moreover, we explored the sex differences in attitude. In the following, we firstly review the information format effect. Then, we introduce the two information formats adapted from the public issue education model. Afterwards, male/female differences in attitude are reviewed, and the background of the current study is provided.

Information format effects

Information format affects attitude in various ways. Siegrist (1997) found that presenting probability (e.g., 0.006 probability of dying) would diminish differences between risk levels, while, in contrast, presenting frequency (e.g., 600 in 100,000 die) would emphasize relative threats more. Connelly and Knuth (1998) found that a cajoling tone was more likely to persuade recipients to accept a recommendation than a commanding one. Many studies in various domains, such as health-risk communication (see review of Moxey et al., 2003), consumer judgment (e.g., Levin, 1987; Levin and Gaeth, 1988), and persuasion (e.g., Maheswaran and Meyers-Levy, 1990; Meyers-Levy and Maheswaran, 2004; Rothman et al., 1993), have systematically studied a specific type of information format effect, called information framing effect.

Information framing refers to the positive and negative presentation of a subject (Levin et al., 1998). In a classic risk choice example, participants were asked to choose from one of two options, sure vs. risk outcome, framed either positively or negatively. For example, a positive frame could consist of a choice of a) a sure saving of 1/3 of lives or b) a one-third chance of saving all lives and a 2/3 chance of saving no lives. A negative frame would offer a choice of c) a sure loss of 2/3 of lives vs. d) a 1/3 chance of losing no lives and a two-thirds chance of losing all lives (Tversky and Kahneman, 1981). Consumers are more likely to choose sure gain (a) over a risk outcome (b) when a task is positively framed, and more likely to choose the risk option (d) over sure loss (c) when a task is negatively framed (Tversky and Kahneman, 1981, 1986), although a careful analysis of any of these two options would reveal that they are essentially the same.

Public issue education strategy and perspectives vs. consequences information

An information sheet is usually constructed based on the communicators' best knowledge (Morgan et al., 2002: 3–5), and to accommodate public concerns¹ (Wolfe, 1993). However, helping consumers develop informed opinions and make informed decisions about complicated issues like whether GE foods should be introduced into the food system requires a public issue education strategy (Barrows, 1984; Hahn, 1988). For over 20 years, land grant professionals have used this model in public education around issues such as food security, economic and environmental impacts of large-scale livestock operations, school violence and cultural and ethnic conflicts (Grudens-Schuck, 2003).

In the most current version of this model (for the model evolution, see review of Dale and Hahn, 1994), Hahn (1988) identified eight stages in a public issue evolution process: concern, involvement, issue identification, alternatives, consequences, choice, implementation and evaluation. Ideally, this is carried out in a series of group meetings where all relevant stakeholders are involved. The land grant professional (i.e. communicator) plays the role of discussion facilitator and provider of balanced information. Hahn suggested that, at the issue stage (where the relevant issue emerges from public or group discussion of concerns), communicators should document and disseminate alternative views on the issue (perspectives) and at the consequences stage, assemble and distribute objective information on the consequences of each alternative (consequences).

When a single communication piece about an issue is the only option (as opposed to the ideal setting of multiple group meetings), either "perspective" or "consequence" could frame construction of a communication piece to deliver necessary factual information. These two formats differ in that the perspective information is organized by different stakeholders' viewpoints about the issue (usually on a range of consequences), while the consequence information is organized by the potential outcomes that are projected by various stakeholders. However, the public issue education strategy does not advocate either format per se. Hence, we felt a test of the effects of these two ways to format information was necessary.

Male/female differences

Attitudinal differences between men and women have been documented in many areas. When facing a risk (i.e. environmental health risk, behavioral and technological risks), men and women perceive different type of risks (e.g., women were much more concerned about sexual assault, while men feared physical violence), and women worry more than men in most circumstances (Connell, 1987; Flynn et al., 1994; Greenberg and Schneider, 1995; Gustafson, 1998). Men and women also differ in their attitude towards genetic engineering (Hoban et al., 1992), but these differences seem application-dependent. In the medical area, women were found to be more interested in taking genetic testing than men (e.g., Evans et al., 1997; Holloway et al., 1994; Tibben et al., 1993). Considering applications of genetic engineering in food, women are more likely than men to believe the risk of genetic engineering is greater than the benefit (National Science Board, 2000; Hallman et al., 2001, 2002).

Within studies of GE foods, two plausible explanations for male/female differences in attitude have been proposed. First, male/female differences in educational attainment (Sheehy et al., 1998) or knowledge (Davidson and Freudenburg, 1996; Moerbeek and Casimir, 2005) may relate to male/female differences in attitude. However, Moerbeek and Casimir (2005) reported that the positive relationship of knowledge and acceptance seemed more salient for

men than for women. Inconsistent support of the so called “knowledge support” hypothesis (“it holds that men are likely to be more knowledgeable about risk-related issues and that people who are better informed will be less concerned about risks to health and the environment”) was also documented by Davidson and Freudenburg (1996: 317). Previous studies examined male/female differences in attitude by controlling education or knowledge as a non-intervening variable. Further testing of this hypothesis might involve controlling the level of relevant “knowledge” by providing information before attitude is surveyed. If male/female differences disappeared, this hypothesis is supported. Otherwise, other explanations should be pursued.

Another possible explanation of male/female differences is that men and women perceive different risks associated with the technology. Our earlier focus group study found that men and women emphasized different types of concerns about GE salmon. Men expressed more concern about the unknown effects on the environment, while women stressed the unknown effects on human health. In contrast, Heffernan and Hillers (2002) found women were more likely than men to agree with the statement that “biotechnology should not be used because of potential risks to the environment.” A PEW (2002) survey found that, after hearing more environmental benefits, men’s perception of genetic engineering changed in the positive direction, while there was little change in women’s perception, implying that women might have more concern about environmental risks than men (Davidson and Freudenburg, 1996).

In sum, male/female differences in attitude towards GE foods have been well documented, but a consistent explanation has not been identified. This study aimed to answer two sequential questions about male/female effects: 1) whether male/female differences exist when both sexes receive the same information about a genetic engineering application, and 2) if so, what are the causes of male/female differences in attitude that emerge?

The current study

The communication topic of this study was GE salmon and opinions about its approval by the Food and Drug Administration (FDA) for use in the food system. The selection of GE salmon as a case study was the result of the following three considerations. First, previous studies have demonstrated that consumer perceptions of GE foods vary according to the type of application (animal vs. plant) (Frewer et al., 1997b; Frewer and Shepherd, 1995; Hallman et al., 2003; Hoban et al., 1992) and even according to the specific applications within the same type (e.g., herbicide resistant rice vs. golden rice) (Frewer et al., 1997a; Hallman et al., 2002; Lusk and Sullivan, 2002). Therefore, examining a specific GE application would be more meaningful in understanding the information effect on attitude than studying GE foods in general. Second, using an animal application among many available GE applications should inspire a spectrum of opinions because consumers generally disapprove of animal applications more than plant applications (Frewer et al., 1997b). Third, the purpose of this study was to develop an effective communication strategy to inform the public. We did not want to impose any fabricated benefits or risks on a given GE application, while we wanted to limit the influence of previous knowledge on new information. An application not yet in the market would be a suitable choice. GE salmon is under current review by FDA, and a considerable amount of information is available with which to construct a factual piece about it.

For this study, the public issue was “should GE salmon be approved to enter the US food system?” We chose to consider the solution of FDA approval since the solution of “disapproval of GE salmon” seemed unlikely.

2. Methods

Information format design

Relevant information was collected from various stakeholders, including a) the company producing the GE salmon (Aqua Bounty Technologies), b) government agencies (FDA, US Department of Agriculture (USDA), Environmental Protection Agency (EPA)), c) fishermen involved in fish farming (the National Fisheries Institute), d) scientific review panels (National Academy of Sciences, Royal Society of Canada, Royal Society of London), and e) semi-independent research groups (PEW Initiative on Food and Biotechnology, Institute for Social, Economic and Ecological Sustainability at the University of Minnesota, Union of Concerned Scientists), environmental groups (Environmental Defense, Friends of the Earth and Greenpeace), consumer groups (Consumers Union and Center for Science in the Public Interest) and an international group (Food and Agriculture Organization (FAO)).

Our information sheets included two sections, one of invariant background, and a second section that differed in format. In the invariant section, factual data were presented on traditional selective breeding and the technique of genetic engineering, how GE fish were created, how fish farming is done and the current status of FDA review.

The second section presented either a) perspectives on or b) possible consequences of the introduction of GE salmon into the food system. Development of the information documents required first gathering the stakeholders' *perspectives* on GE salmon introduction. Among the many environmental and consumer groups, the ones chosen offered their perspective on GE salmon on their websites while other groups expressed no opinions about GE fish. The perspectives summary developed for each group represents that found in the documents used so the group opinions defined the content.

These individual group perspectives were linked together into the *perspective* section, which clearly identified each stakeholder. For example,

The *National Fisheries Institute*, representing the fishing industry, feels that farming of Atlantic salmon replaces a diminishing natural resource, helps conserve wild salmon populations and produces protein efficiently. It takes less than 2 pounds of feed to produce one pound of farmed salmon compared to 5 pounds of wild feed to produce one pound of wild salmon. They acknowledge that salmon do escape from ocean pens, and some escapees have spawned in nearby rivers and interbred with wild salmon ...

Each of these stakeholder perspectives usually addressed a number of consequences of the introduction of GE salmon. To produce the *consequence* section, all the consequences embedded in these perspectives were identified. We used verbatim sentences and paragraphs from the perspectives summaries to construct explanations of each of these consequences. Stakeholders were not identified by name in these consequence summaries. For example, "National Research Council scientists" were cited in the perspective section but "others" was used in the consequence section. This list of consequences and their explanations became the *consequences* section. For example, using sentences from the National Fisheries Institute statement above, we produced,

- *Production of GE salmon may spare wild fish populations.*

Farming of Atlantic salmon replaces a diminishing natural resource, helps conserve wild salmon populations and produces protein efficiently. It takes less than 2 pounds of feed to produce one pound of farmed salmon compared to 5 pounds of wild feed to produce one pound of wild salmon.

The resulting perspective and consequence sections used 96 percent identical sentences and phrases and differed only in the omission of stakeholder names and the addition of a consequence title, i.e., Production of GE salmon may spare wild fish populations. Thus, length, content, and reading level did not differ between information pieces.

To ensure both information pieces were factual and unbiased, these were reviewed by an expert in fish genetics and the environmental impact of GE salmon and an expert in public issue education. Both information pieces had 12th grade reading levels.

Questionnaire design and administration

Two versions of the questionnaire were used to collect data. In addition to the difference in information formats, a few questions regarding information necessity were customized to reflect the format differences. The information piece was sandwiched between pre and post questions. To improve question clarity, we tested each questionnaire version with eight individuals (total $N = 16$) prior to the survey using cognitive interviewing (Harris-Kojetin et al., 1999; Jabine et al., 1984; Subar et al., 1995), and comments from these interviews were used to improve the final questionnaires.

Attendees of an annual art festival in a small college town completed the questionnaires in 2004. Participants were selected randomly from one point in the line of festival booths and interviewed to determine those meeting the following criteria: 1) 21–65 years old, 2) eat fish at least once a month, and 3) not a college student from the authors' university. The sample was also stratified by age and sex to match the most recent census in the authors' state. Two questionnaire versions were alternated by two-hour blocks. Of those meeting the criteria, half completed the perspective questionnaire and half completed the consequence questionnaire. In order to reduce the number of missing values, a survey administrator checked the instrument, except for the demographic questions, when the questionnaire was completed. Once missing data had been supplied, the participant received a cash gift.

Measurements

All the following questions except demographics are measured using 7-point scales. The attitude scale ranged from -3 (strongly disapprove) to 3 (strongly approve), with 0 as "neutral." Information length scale ranged from -3 (too short) to 3 (too long), with 0 as "just about right." Other scales ranged from 1 to 7, with a score of 1 indicating not important, not at all confident etc., 7 indicating extremely important, extremely confident, etc.

Pre and post measures

Attitude was measured by a single item, "how [do] you feel about the use of fast growing genetically engineered salmon in fish farming to produce fish for human consumption?"

Personal interest was measured by three questions: 1) how important to you personally is information on genetically engineered salmon? 2) How interested are you personally in learning about genetically engineered salmon? 3) How interested are you personally in finding information on genetically engineered salmon? An additional item, "how interested are you personally in receiving more information about genetically engineered salmon?" was measured only in the post test.

Knowledge was measured by a single item, "how much factual information could you tell someone wanting a verbal explanation of development and use of genetically engineered salmon in the food system?"

Post-only measures

Information quality was measured by nine questions, including three questions regarding the ease of reading, and six questions regarding participants' judgment on the information appeal, fairness, stance, factualness, trustworthiness and length.

Actual confidence was measured using one overarching question, "overall, how confident are you in understanding all the concerns surrounding the introduction of genetically engineered salmon into our food system?," and five detailed questions listed in Table 2.

Information needed to increase actual confidence was measured using one overarching question, "overall, how much more information would you need to feel completely confident in understanding all the concerns surrounding the introduction of genetically engineered salmon into our food system?," and seven detailed questions listed in Table 2.

Information necessity measurements reflected the organization of two information formats. Participants were asked to evaluate "how necessary is the following information for you to be well informed about this issue?" A complete list of the questions is in Table 3.

Trust was defined as the trustworthiness of a given information source in providing information about genetically engineered salmon. Five information sources were evaluated: government agencies, scientific organizations, environmental organizations, industry organizations and consumer organizations.

Demographic information was collected at the end of the questionnaire, including sex, ethnic group, age, marital status, household income, whether have children, the frequency of salmon consumption, education, political and religious bent.

Data analysis

SPSS 10.0v was used to analyze the results. For within format effects and within sex effects (pre vs. post measurement), paired-sample t-tests were used. For the between format effects, analysis of covariance (ANCOVA) with salmon consumption level as a covariate was used because the participants reading the consequence information ate significantly more salmon than the participants reading the perspective information, and higher level of salmon consumption contributed to a bigger format effect. When the between format effect was tested among the repeated (post) measures of attitude, personal interests and self-assessed knowledge, the variance due to the prior assessments was also removed from the corresponding post assessments. Hence, ANCOVA using information formats as a factor, and salmon consumption and appropriate pre-test scores as covariates was used to examine these post "between format" effects.

Owing to the small sample size, sex effects were explored by combining those who read each information piece. To simplify the analysis, indexes for participants' personal interest (pre and post) were calculated because of the high correlations among these three personal interest questions ($r_{pre} > 0.75$, $r_{post} > 0.82$).

Owing to imbalanced level of religiosity between sexes, male/female differences were examined using ANCOVA with the level of religiosity as a covariate. For the repeated (post) measure of attitude, personal interest and self-assessed knowledge, ANCOVA using sex as a factor, and the level of religiosity and corresponding pre-scores as covariates was used.

To examine male/female's influence on attitude, regression analysis was used. Post-attitude was used as the dependent variable because most of the explanatory variables were collected after reading the article. Sex was used as an independent variable in the basic model, and religiosity was added as a control variable (equation (1)). Stepwise regression was used to detect the variable(s) that explained the male/female differences. If the added independent

variable(s) remove the significance of sex in the model, male/female differences in attitude are explained by that variable.

$$\text{Post-attitude} = a + b (\text{sex}) + c (\text{religiosity}) \quad (1)$$

The following tables report original means based on the analysis of all the participants. However, *F*-tests of ANCOVA were based on the analysis of reduced cases owing to missing data points in the control variables (i.e., salmon consumption level and religiosity). Considering the differences between modified and original means are small (± 0.03), modified means were not reported.

3. Results

Respondents

A total of 205 questionnaires were completed. Nearly equal numbers of males ($n = 102$) and females ($n = 103$) participated in the study. The mean age was 40.90 ± 13.30 years. About 90 percent of the sample was white. Over 90 percent had completed some college or earned a college degree. More than half of the participants (53 percent) were married. Two thirds (63 percent) did not have children in the household. The median household income was \$60,000. They were somewhat to moderately religious and their political stances were slightly liberal to neutral. About 60 percent of the sample was not aware of GE salmon, and only 15 percent had heard of it more than three times. Participants receiving perspective ($n = 103$) and consequence ($n = 102$) information had no significant difference in demographic background, except that participants who read the consequence information ate salmon significantly more times per year ($p = 0.026$) than those who read the perspective information (31.70 ± 27.89 vs. 23.26 ± 23.36 respectively).

Male and female participants did not differ significantly in demographic background, except that women were significantly more religious ($p = 0.006$) than men (4.01 ± 1.81 vs. 3.32 ± 1.71 respectively).

Format effects

To examine the information effect, we first determined if the participants perceived both information pieces similarly. There were no significant differences in information quality. Overall, both information pieces were rated moderately to rather easy to read, moderately to rather interesting, a little biased, slightly favorable to the issue, rather factual, rather trustworthy and just about right in length (data not shown).

Since participants did not differ significantly in perceptions of information quality, we could compare the overarching information format effects on attitude, knowledge and personal interest assuming these underlying information attributes would not affect the results. In terms of *within format effect* (Table 1), reading perspective information significantly reduced the negative pre-attitude so that, afterward, those participants held a slightly more positive post-attitude (0.16 ± 1.66). In contrast, reading consequence information led to a small, non-significant positive change and participants' post-attitude remained negative (-0.36 ± 1.77). Reading either information format significantly ($p < 0.05$) increased self-reported knowledge and increased personal interests in the topic. A post-information measurement of "interest in receiving more information about GE salmon" indicated that participants were "moderately interested" to "rather interested" in doing so.

Table 1. Information effect on attitude, knowledge and personal interests

	Perspective (n = 103)	Consequence (n = 102)	F
Pre-attitude	-0.11 ± 1.60	-0.45 ± 1.75	2.155 ^a
Post-attitude	0.16 ± 1.66	-0.36 ± 1.77	2.096 ^b
	Paired-t	2.394*	0.785
Pre-knowledge	1.69 ± 1.03	1.96 ± 1.19	1.864 ^a
Post-knowledge	3.70 ± 1.18	4.20 ± 1.17	5.417 ^{b, *}
	Paired-t	14.984***	19.064***
Personal interest in information			
Pre-importance of GE salmon related information	4.07 ± 1.54	4.49 ± 1.79	1.403 ^a
Post- importance of GE salmon related information	4.54 ± 1.33	5.0 ± 1.53	1.488 ^b
	Paired-t	3.933***	5.041***
Pre-interested in learning	4.06 ± 1.48	4.39 ± 1.76	0.697 ^a
Post-interested in learning	4.28 ± 1.29	4.80 ± 1.59	4.334 ^{b, *}
	Paired-t	2.073*	4.084***
Pre-interested in finding	3.57 ± 1.43	4.14 ± 1.82	3.505 ^{a, †}
Post-interested in finding	4.17 ± 1.37	4.65 ± 1.77	0.070 ^b
	Paired-t	5.094***	5.352***
Post-interested in receiving more	4.16 ± 1.58	4.64 ± 1.74	2.264 ^a

^a ANCOVA test for format effects (consequence vs. perspective) controlling for salmon consumption. The degree of freedom is (1, 201).

^b ANCOVA test for format effects (consequence vs. perspective) on post (attitude/knowledge/personal interests) controlling for salmon consumption and pre (attitude/knowledge/personal interests). The degree of freedom is (1, 200).

[†] $p < 0.1$. * $p < 0.05$. *** $p < 0.001$.

For *between format effects* (Table 1), the result showed no significant differences for pre-attitude, pre-knowledge and pre-personal interest level before the articles were read. Participants prior to reading either information format had slightly negative attitude, knew little about GE salmon, and were somewhat to moderately interested in the topic. Afterward, those who read consequence information reported a significantly higher level of gained knowledge ($p = 0.021$) than those reading perspective information, and were more interested in learning about GE salmon ($p = 0.039$).

There were no significant differences between formats for post-attitude when pre-attitude was controlled. However, pre-attitude and post-attitude were highly correlated ($r = 0.783$, $p = 0.000$). Since participants had little awareness of GE salmon prior to reading the information, pre-attitude is likely to reflect the opinions about genetic engineering in general. If so, the strong correlation between pre-attitude and post-attitude suggests that (pre-) attitude about genetic engineering in general may have influenced (post-) attitude towards GE salmon.

After reading the information, participants also reported how much confidence they had in their understanding of the concerns surrounding GE salmon and how much more information they would need to make them feel completely confident (Table 2). Overall, participants were somewhat to moderately confident in understanding all the concerns presented (Mean_{perspective} = 3.44, Mean_{consequence} = 3.81). For both formats, they have the highest confidence about the effects on environment and consumer choice, and the lowest confidence about the effect on consumer health (Mean_{perspective} = 2.86, Mean_{consequence} = 3.48). Note that participants reading the consequence information had significantly higher level of actual confidence in understanding the effect on consumer choice ($p = 0.01$) and consumer health ($p = 0.009$) than those reading the perspective information.

Table 2. Effect on confidence

	Perspective (<i>n</i> = 103)	Consequence (<i>n</i> = 102)	<i>F</i> ^a
Actual confidence (overall)	3.44 ± 1.18	3.81 ± 1.31	2.459
Effect on the environment	3.94 ± 1.48	4.27 ± 1.54	1.834
Effect on consumer choice	3.76 ± 1.47	4.29 ± 1.39	6.743*
Making GE salmon	3.60 ± 1.36	3.92 ± 1.42	1.602
Regulation	3.32 ± 1.21	3.61 ± 1.50	1.303
Effect on consumer health	2.86 ± 1.43	3.48 ± 1.81	6.781**
Information needed to increase confidence (overall)	4.50 ± 1.43	4.43 ± 1.46	0.208
Long-term effects on human health	5.48 ± 1.46	5.19 ± 1.70	1.686
Short-term effects on human health	5.27 ± 1.56	4.94 ± 1.80	2.067
Nutrient composition	4.59 ± 1.69	4.42 ± 1.73	0.411
Effects on wild fish population	4.49 ± 1.54	4.26 ± 1.91	0.881
Results of animal feeding studies	4.41 ± 1.62	4.32 ± 1.76	0.068
Effects on salmon physiology	4.29 ± 1.71	4.25 ± 1.84	0.003
Effects of fish pens on environment	4.24 ± 1.61	4.08 ± 1.76	0.225

^a ANCOVA of information format effect controlling for salmon consumption. The degree of freedom is (1, 201).

* $p < 0.05$. ** $p < 0.01$.

To increase their confidence, participants needed “moderately more” to “quite a bit more” information on all the impacts presented ($\text{Mean}_{\text{perspective}} = 4.50$, $\text{Mean}_{\text{consequence}} = 4.43$). They especially want more information on long-term and short-term effects on human health. No significant differences were found between information formats on the information needed to increase judgment confidence.

To improve the focus of our information pieces, we asked participants to evaluate the necessity of each topic presented in the respective formats. In Table 3, the information needed is listed in descending order of necessity. Within the background information, participants who read either format of information rated the description about making GE salmon as most necessary ($\text{Mean}_{\text{perspective}} = 5.43$, $\text{Mean}_{\text{consequence}} = 5.60$), while the description of selective breeding was rated least necessary ($\text{Mean}_{\text{perspective}} = 3.89$, $\text{Mean}_{\text{consequence}} = 4.18$). However, those who read the consequence information thought fish farming was significantly more necessary ($p = 0.009$) than those who read the perspective information.

Participants reading the perspective information (Table 3) thought the viewpoints from US scientific review groups, environmental groups, governmental regulatory agencies, US independent scientific study groups, and consumer groups were “rather to very necessary,” and the viewpoints of international organizations, fishery representatives, the company, the Royal Society of Canada Expert Scientific Panel, and the Council of the Royal Society, London were only “moderately to rather” necessary. Participants reading the consequence information (Table 3) thought almost all topics were “rather to very necessary,” with environmental impact the most necessary ($\text{Mean}_{\text{consequence}} = 6.09$), and impact on other countries the least ($\text{Mean}_{\text{consequence}} = 4.93$). Although “perspective of different groups” was not a title topic in the consequence information, participants felt this was very necessary ($\text{Mean}_{\text{perspective}} = 5.76$).

Regardless of the different topics covered in both formats, a common pattern was that environmental impact or environmental groups’ viewpoint was most necessary, and impact on other countries or the viewpoints of the Royal Society of Canada Expert Scientific Panel, and the Council of the Royal Society, London were least necessary.

At the end of the questionnaire, participants also evaluated the trustworthiness of different information sources. Overall, participants trusted scientific (5.23 ± 1.25 for perspective vs. 4.87 ± 1.38 for consequence) and consumer groups the most (4.51 ± 1.40 vs. 4.60 ± 1.45),

Table 3. Information necessity^a

Perspective (<i>n</i> = 103)		Consequence (<i>n</i> = 102)	
	Mean ± std.		Mean ± std.
Background information			
Making GE salmon ^b	5.43 ± 1.65		5.60 ± 1.56
Current situation ^b	5.23 ± 1.65		5.56 ± 1.48
Genetic engineering technique ^b	5.07 ± 1.49		5.28 ± 1.63
Fish farming ^{b**}	4.69 ± 1.57		5.29 ± 1.45
Description of selective breeding ^b	3.89 ± 1.58		4.18 ± 1.88
US scientific review groups			
Environmental groups	5.48 ± 1.43	Environmental impact	6.09 ± 1.20
Government regulatory agencies	5.34 ± 1.53	Impact on wild fish	5.87 ± 1.35
US independent scientific studies	5.29 ± 1.57	Perspective of different groups	5.76 ± 1.48
Consumer groups	5.23 ± 1.68	Impact on regulatory framework	5.32 ± 1.54
International organization (FAO)	5.21 ± 1.54	Impact on fish farming	5.20 ± 1.59
Fisheries representative viewpoint	4.91 ± 1.69	Impact on salmon availability	5.05 ± 1.63
Company viewpoint	4.83 ± 1.69	Impact on other countries	4.93 ± 1.79
Royal Society of Canada Expert Scientific Panel viewpoint	4.65 ± 1.77		
Council of the Royal Society, London viewpoint	4.22 ± 1.83		
	4.16 ± 1.86		

^aAll questions were measured on a 7-point scale, range from 1: "not necessary at all" to 7: "extremely necessary."

^bANCOVA of information format effect controlling for salmon consumption. The degree of freedom is (1, 201).

***p* < 0.01.

followed by government agencies (4.45 ± 1.39 vs. 4.09 ± 1.64) and environmental groups (4.29 ± 1.43 vs. 4.19 ± 1.51), and they trusted industry the least (3.25 ± 1.33 vs. 3.01 ± 1.65). However, participants reading the perspective information trusted scientific groups significantly more (*p* = 0.035) than participants reading the consequence information.

Male/female differences

We examined the effect of sex on attitude and other attributes. The significant differences are reported in Table 4. Before reading the information, women held slightly negative attitudes (−0.63 ± 1.64), while men were neutral (0.08 ± 1.65), and women's viewpoints were significantly more negative (*p* = 0.002) than men's. After reading the article, although both men's and women's attitude became more positive, the mean change in perception did not differ between sexes (*p* = 0.858).

Women (4.28 ± 1.63) had significantly (*p* = 0.033) higher personal interest before reading the information than men (3.95 ± 1.48). After reading the information, personal interest level increased for both sexes (*p* < 0.001), and this increase was greater for women than that for men (*p* = 0.045 when pre-personal interest is controlled).

Self-reported knowledge did not differ between sexes before reading the information. Reading the information led to a significant increase in self-reported knowledge (*p* < 0.001) that did not differ between sexes (*p* = 0.854).

In addition, we found that women had less confidence (*p* = 0.020) in their understanding of making GE salmon, requested more information (*p* = 0.023) on long-term effects on human health, and trusted environmental groups more (*p* = 0.016) than men did. For those who read consequence information, women thought information about the impact on other countries

Table 4. Male/female differences

	Male (<i>n</i> = 102)	Female (<i>n</i> = 103)	<i>F</i>
Pre-attitude	0.08 ± 1.65	-0.63 ± 1.64	9.767 ^{a,**}
Post-attitude	0.20 ± 1.67	-0.40 ± 1.75	0.032 ^b
	Paired- <i>t</i>	1.022	2.177 [*]
Pre-personal interest	3.95 ± 1.48	4.28 ± 1.63	4.608 ^{a,*}
Post-personal interest	4.33 ± 1.40	4.82 ± 1.43	4.075 ^{b,*}
	Paired- <i>t</i>	4.562 ^{***}	6.083 ^{***}
Pre-knowledge	1.82 ± 1.11	1.83 ± 1.13	0.007 ^a
Post-knowledge	3.98 ± 1.25	3.92 ± 1.15	0.034 ^b
	Paired- <i>t</i>	17.787 ^{***}	15.888 ^{***}
Actual confidence— Making GE salmon	4.00 ± 1.42	3.52 ± 1.33	5.466 ^{a,*}
Ideal confidence—Long term effects on human health	5.10 ± 1.56	5.56 ± 1.59	5.286 ^{a,*}
Trust environmental groups	4.01 ± 1.44	4.47 ± 1.47	5.902 ^{a,*}
Consequence necessity— Impact on other countries	4.53 ± 1.77	5.33 ± 1.74	5.883 ^{a,*}
Perspective necessity— Environmental groups	5.04 ± 1.68	5.63 ± 1.31	3.554 ^{a,†}

^a ANCOVA of male/female effect with the level of religiosity as covariate. The degree of freedom is (1, 199).

^b ANCOVA of male/female effect on post (attitude/personal interest/knowledge) controlling for the level of religiosity and pre (attitude/personal interest/knowledge). The degree of freedom is (1, 198).

[†] $p < 0.1$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

was more necessary ($p = 0.017$) than men did. For those who read the perspective information, women thought viewpoints from environmental groups were more necessary ($p = 0.062$) than men did.

To test the “knowledge support” hypothesis, our assumption that both sexes had similar levels of knowledge was supported (Table 4) in that no significant differences were observed in self-reported knowledge between sexes. Since male/female differences in attitudes appeared among equally informed males and females, the “knowledge support” hypothesis is rejected. In addition, we examined the correlation of education and attitude, and compared attitude between sexes as conventional studies would do. We did not find significant correlation of educational attainment and attitude (both pre and post), but women had significantly more negative attitude than men did ($F = 6.428$, $p < 0.05$). Based on this analysis, our data do not support the “knowledge support” hypothesis.

To explore the influence of other factors on this difference, significant predictors of sex differences, including post-personal interest, actual confidence in understanding how GE salmon is made and its long-term effects on human health, trust of environmental groups and religiosity, were used as explanatory variables in regression analysis (Table 5). Model I is the basic model as given in equation (1). Models II–V are the regression models with these explanatory variables added individually to the basic model. The results showed that post-personal interest, trust of environmental groups and long-term effects on human health reduced the significance of sex’s effect on attitude, but these individual factors do not explain all the male/female differences found. Stepwise regression indicated that long-term effects on human health and trust of environmental groups (Model VI) make the effect of sex on attitude non-significant. This suggested that women’s higher level of trust of environmental groups and higher level of concerns about long-term health effects could contribute to their more negative attitude towards GE salmon.

Table 5. Regression analysis to explore male/female differences in attitude (dependent variable = post-attitude)

	Model I	Model II	Model III	Model IV	Model V	Model VI
Constant	0.697 [†]	1.833**	1.317*	2.337**	1.770**	3.288***
<i>Independent variable</i>						
Sex	-0.622*	-0.460 [†]	-0.685**	-0.445 [†]	-0.476 [†]	-0.315
Religious	0.04	0.008	0.04	0.02	0.02	0.0005
Post-personal interest		-0.275**				
Actual confidence in making GE salmon			-0.137			
Long-term effect on humans				-0.343***		-0.331***
Trust environmental group					-0.285**	-0.269**
Significance	0.042	0.001	0.033	0.000	0.000	0.000
Adjusted R ²	0.022	0.066	0.029	0.113	0.075	0.160

[†] $p < 0.10$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

4. Discussion

One of the objectives of this study was to examine the effect of two information formats, developed using public issue education principles, on the public understanding of and attitude towards GE salmon. These data indicated that an information sheet (either format) designed according to public issue education principles could increase recipients' personal knowledge and motivate recipients to find or learn more information in the future. Searching for new information or reading newly discovered information is a critical step toward making informed decisions about the acceptability of introducing GE applications into the food system.

However, consistent with previous findings about information format effects (Levin, 1987; Levin et al., 1998; Tversky and Kahneman, 1981), we found that these two information formats did exert different effects on recipients' knowledge, personal interest and confidence in their understanding of concerns about the issue. Although both formats shared 96 percent of sentences, participants who read consequence information learned more, expressed more interest in learning, felt the information was more important to them, and indicated a higher level of actual confidence about understanding the effects on consumer choice and on consumer health.

An informed decision requires the decision-maker to consider various viewpoints and the various consequences of a solution to an issue. Our findings suggest that consequence information has a greater impact on the reader and should be considered for future communication to the public about GE foods. Moreover, in future communication about GE salmon, we recommend increasing the depth of information about "long- and short-term effects on human health," which was rated very necessary or needed to improve participants' actual confidence in understanding the issue.

To understand public opinion dynamics, communicators are interested in tracking changes in attitude. Our result showed that provision of information, regardless of format, decreased negativity slightly. This contrasts with previous findings in European countries where provision of information on GE foods led to more negative attitude (Frewer and Shepherd, 1994; Scholderer and Frewer, 2003). This difference may be due to differences in pre-attitude in the two settings. In the US, most people have uncrystallized viewpoints on this issue, while European consumers are strongly against GE applications. Scholderer and Frewer (2003: 148) explained that, in Europe, "pre-existing attitude structures appear to be so strong that they will indeed override any external information that is given," and that additional information served as an activator of previous negative attitudes. The positive, small change in attitude in this

study is probably due to an increase in knowledge. Studies characterizing risks (Slovic et al., 1980) indicated that risk perceptions are positively related to “dread” and “unknown.” Although we did not measure these two dimensions directly, it is likely that the information provided reduced the level of “unknown” to some extent.

The most inexplicable finding is that reading the perspective information led to a significant but small positive change in attitude, while reading the consequence information led to only a small, non-significant but positive change. No significant differences were found between formats when comparing the information quality and the necessity of individual topics. Two tentative explanations seem equally plausible. First, differences in initial attitude between the two groups might be the reason of the difference in attitude change. Although not significantly different, those who read the consequence information had a more negative pre-attitude toward GE salmon than those who read the perspective information. The two formats resulted in the same degree of shift upward in opinions so that post-attitude was more positive but still differed between the groups. This indicates that in future research, it will be important to assess pre-attitude about genetic engineering and GE foods in general as well as attitude towards the specific application in question.

Second, participants who read the perspective information trusted scientific groups more than those who read the consequence information and level of trust in scientific groups may relate to the difference in attitude change. Previous studies (Moon and Balasubramanian, 2004; Siegrist, 1999, 2000; Zimmerman et al., 1994) have reported that trust in regulations, researchers or industries related to favorable attitude towards GE foods. The attribution of positive effects to scientific groups may have overridden any concerns raised by other groups in this piece.

We also examined sex differences in this paper. We found that female participants' interest in the topic increased significantly more than the interest of male participants after reading the information, but we did not find the changes in post-attitude and post-knowledge differed between sexes.

Male/female differences in attitude (Table 4) emerged prior to reading the information, and this relative relationship did not change after reading the information. Since self-reported pre-knowledge was not significantly different and all the participants received nearly identical factual information, this finding was in line with our focus groups' finding that male/female differences in attitude exist exclusive of educational or knowledge differences. Hence, we explored other causes of male/female differences in attitude. The regression analysis suggested that women's more negative attitude might be due to some extent to their higher level of concern about long-term health effects and their higher level of trust of environmental groups. In our focus group studies, we also found that women had more concern than men about the known or unknown effects of eating GE salmon on humans. Similar findings were also reported by Kirk et al. (2002). Women's higher level of trust in environmental groups might be a reflection of their higher level of concerns about environmental issues (Davidson and Freudenburg, 1996; Flynn et al., 1994; Zelezny et al., 2000). However, this was not the case in our focus groups where men expressed more concern than women about unknown effects of GE salmon on the environment. If men do not trust environmental groups as much as women do, this may magnify their concern about environmental impacts whereas women's greater trust may ameliorate their concern relative to their worry about health effects. These data all suggest that concern about different types of risks is more likely to explain male/female differences than the “knowledge support” hypothesis.

However, there may be other explanations for the male/female differences found in this study. For example, trust has been identified as a major determinant of attitude towards new technologies, and proposed as an explanation for male/female differences (Davidson and Freudenburg, 1996). In this study, women regarded environmental groups as a more trusted

source than men did, perhaps predisposing women to negative views and concerns. Further experimental studies are needed to examine reasons for male/female differences.

This study revealed that men and women had somewhat different attitudes towards GE salmon and that this may be due to different concerns. However, the regression analysis used in this study did not exhaust all the possible explanations of male/female difference in attitude. Male/female differences in pre-attitude probably reflect the male/female differences in opinions about GE applications in general and influenced post-attitude. Future studies that examine male/female differences in perceptions to a GE food need to examine initial attitude towards genetic engineering of foods in general and also explore variables, such as naturalness, morality and controllability (Frewer et al., 1998; Sjoberg, 2000) that might explain male/female differences in attitude.

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Note

1 Or the public concerns feedback to the design of information sheets. Bucchi (1998: 11–14) argues that scientific knowledge fed into the public, and in return, the simplified and popularized public knowledge influences the "reproduction" of science.

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