Identifying Key Attributes in Decisions About Protein Consumption

by

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ABSTRACT

Food production and consumption directly impact the environment and human health. Protein in particular has significant cultural and health implications, and how people make decisions about what type of protein they eat has not been studied directly. Many decision tools exist to offer recommendations for seafood, but neglect livestock or plant protein. This study attempts to address these shortcomings in food decision science and tools by asking the questions: 1) What qualities of a dietary protein-based decision tool make it effective? 2) What do people consider when making decisions about what type of protein to consume? Using literature review, meta-analysis, and surveys, this study attempts to determine how the knowledge gained from answering these questions can be used to develop an electronic tool to engage consumers in making sustainable and healthy decisions about protein consumption. The data show that, given environmental and health information about the protein types, people in the sample of farmers market shoppers are more likely to purchase wild salmon and organically grown soybeans, and less likely to purchase grain-fed beef. However, the order of preference among the six types of protein did not change. Additional results suggest that there is a disconnect between consumers and sources of dietary protein, indicating a need for improved education. Inconsistency in labeling and information regarding protein types is a large source of confusion for consumers who participated in the survey, highlighting the need for transparency. Results of this study suggest that decisions tools may help improve decision making, but new ways of using them need to be considered to achieve this.

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INTRODUCTION

Food has come to play such a central role in society that it is no longer just a necessary part of survival, but also has significant economic, cultural, and social roles (Rozin 1996). Individuals in different ethnic groups or religions can identify themselves based on what food they eat, meals are often seen as social experiences, and meetings or social gatherings are usually accompanied by the presence of food. As pervasive as food is, the impacts of different types of food on the environment, human health, and socioeconomic factors are not always apparent, for a number of reasons. Protein foods in particular, as I focus on in this paper, intensify these food-related impacts (Walker, et al. 2005). Protein is an essential macronutrient, and in the Western diet is most often provided by animal products. Many specialized diets are defined by how much protein is consumed, what types of protein are consumed, and why certain types of protein are excluded. Poor labeling and conflicting information, a lack of public attention to these problems, and overall lack of interest in the subject has led to a confused and frustrated public, as evidence by numerous popular media articles on the subject (Brody 2015, Atkinson 2014, Gustafson 2015, Caffrey 2015, Rhodes 2015). In response to the complexity of information, a number of electronic decision tools have been developed, which attempt to help consumers make more informed decisions, or decision that are better aligned with their values. The goal of the following literature review, meta-analysis of existing decision tools, and survey is to determine how the knowledge gained from this research can be used to develop an electronic tool to engage consumers in making sustainable and healthy decisions about protein consumption. A synthesis of these methods indicates that large scale changes in consumer behavior is not likely, however decision tools can help concerned consumers make choices that are more consistent with their values, which tend to be oriented toward health issues more than environmental issues. There is also an indication that their values may be influenced more by health risk aversion than by health promotion. Ultimately, a greater variety of tools is needed in order to determine if they are truly effective.

The Problems

A variety of concerns regarding health, environmental, and socioeconomic factors are associated with any kind of protein source, and some are unique to certain kinds of proteins. These concerns demonstrate why it is critical to consider the way protein is consumed and finding methods to improve decision making.

Environmental Impacts

Studies have found that meat based diets are highly resource consumptive, and that plant-based diets tend to have lower overall environmental impacts (Pimental and Pimental 2003, Baroni, et al. 2007). Overfishing has historically been a major issue for commercial fisheries, and in 2007, 41 of the 243 stocks monitored by the National Marine Fisheries Service were still overfished (Tromble, Lambert and Benaka 2009). In addition, as agriculture becomes increasingly industrialized, new chemical pesticides and fertilizers, as well as genetically modified crops, enter the food production system. Combined with methods like monocropping and tilling, these industrialized methods pose a threat to biodiversity (Benton, Vickery and Wilson 2003, Lu 2004). Production of these fertilizers and pesticides also creates climate changing emissions and pollution, as does the machinery that accompanies an industrialized agricultural system (Vermeulen, Campbell and Ingram 2012). The grain grown using industrialized methods often feeds livestock. Animals are less efficient at providing energy to humans, meaning a lot of grain is required to feed livestock, magnifying these impacts. The scale of impacts from our current food production systems frequently leads to negative consequences for the environment.

Different types of protein have different environmental impacts. Studies have shown that beef requires a large amount of land and water and produces high levels of the potent greenhouse gas methane (Eshel, et al. 2014, de Vries and de Boer 2010). Many of the resources that go into raising cattle go directly to feed production, however livestock animals (and cattle in particular) are not very effective at turning produce into energy for humans, cattle in particular (Pelletier, Pirog and Rasmussen 2010, Cassidy, et al. 2013). The alternative to producing grain for cattle feed is allowing cattle to graze on grasslands, which can drastically alter ecosystems (Asner, et al. 2004, Fleischner 1994). While cattle and other livestock are resource intensive and contribute to climate change-inducing greenhouse gas production, much seafood production leads to heightened levels of biotic depletion, through overharvest of wild populations for human consumption and feed production for aquaculture (Naylor, et al. 2000). The majority of the world's fisheries are already depleted, overfished, or recovering from being overfished (FAO, The State of World Fisheries and Aquaculture 2012).

Seafood production can also have ecological impacts on the habitat. Raising fish in coastal pens, the aquaculture method used for farmed salmon, leads to waste buildup and an excess of nutrients in the water. These nutrients can cause eutrophication to occur, which creates eutrophic coastal zones, harming both marine species and the fisheries that rely on them.

Although plants generally do not require much land or water per unit to produce when compared to the same amount of farm raised animal protein, and plant-based food production systems do not raise the same overharvesting concerns as seafood, they have their own set of environmental impacts. For example, fertilizer production can be a resource intensive process, and poor application and farming practices lead to extensive fertilizer run-off, also contributing to eutrophication and the creation of dead zones (Diaz and Rosenberg 2008), and erosion from methods like tilling allow for more runoff.

Human Health

The protein decisions that people make not only have effects on the environment, but have a direct impact on human health as well. Animal products have a higher protein content than do plant sources of protein, and other nutrient deficiencies have been a documented problem in vegan populations (Larsson and Johansson 2002, Craig 2009, American Dietetic Association 2003). However, the average American diet contains far more protein that the official Recommended Dietary Allowance suggests is necessary (Fulgoni III 2008, Institute of Medicine of the National Academies 2005), and when well maintained, vegetarian and vegan diets may be far healthier when managed well (American Dietetic Association 2003, Levine, et al. 2014). Much of the protein in the Western diet comes from meat or other animal products, and often at portion sizes that have grown larger over time (Young and Nestle 2002). When considering the amount of animal protein in the Western diet, it is important to consider that animal protein sources are also the main contributors of saturated fat in the human diet, whereas plant products contain no saturated fat at all. Although recent research has indicated that sugar may be playing a larger role in the current obesity epidemic than fat (Chowdhury, et al. 2014), and it is accepted that a certain amount of fat is necessary in the human diet (Institute of Medicine of the National Academies 2005), nutrition research indicates that saturated fat is still not necessarily healthy, and that unsaturated fats are a better source of dietary fat (Yi, et al. 2015).

Even though different sources of protein fill different essential nutrient requirements, contaminants can also be transferred to humans via protein foods. Ailments like salmonella, *E. coli* bacteria, and bovine spongiform encephalopathy (BSE) are just a few of the things that humans can be exposed to through protein sources. Although some diseases are specific to certain types of protein, like BSE and beef, other diseases like salmonella can come from animal or plant proteins. There are also chemicals that may be added into production intentionally or accidentally. Chemical fertilizers and pesticides are often sprayed on crops, and there is concern that the residue from pesticides may negatively affect human health (Gilden, Huffling and Sattler 2010). Hormones are often given to livestock so they will put on more weight and therefore provide more meat (Johnson 2015). Antibiotics are also given in mass to animals on factory farms and aquaculture operations, creating antibiotic waste in the environment, which may contribute to increasing amounts of antibiotic resistant infections for humans (Burridge, et al. 2010, FDA 2012). Seafood is not free from its own unique human health concerns, either. Many fish and shellfish accumulate heavy metal toxins, dioxins, flame retardants, and other chemicals that cannot be broken down by the organism (Hites, et al. 2004, Shaw, et al. 2006, Hamilton, et al. 2005). Because of the effects of bioaccumulation, much of the higher trophic level seafood that humans consume has elevated levels of these contaminants in their tissue.

Socio-Economic Issues

Feeding a population of 7 billion and growing has been a primary concern of food security discussions (FAO, WFP and IFAD 2012, World Bank 2009). As mentioned in the section on the environmental impacts of protein sources, a large amount of resources goes into producing smaller quantities of meat. There is research indicating that the resources used to feed cattle and other livestock could feed significantly more people if the products used for animal feed went directly to human consumption (Cassidy, et al. 2013, Pelletier, Pirog and Rasmussen 2010). The Western diet, which is high in meat, is increasingly emulated by developing countries as they gain wealth, and with an increasing global population, even more strain will be put on the food system (FAO, WFP and IFAD 2012, World Bank 2009).

A prominent societal concern in the food system is the lack of good information available to the consumer. Poor or incorrect labeling can result in concerned consumers making decisions that unknowingly go against their values. For example, studies have shown that a portion of seafood is mislabeled as wild when it was in fact farmed, or as the wrong species altogether (Warner, et al. 2013). Many producers also use phrases such as “natural”, “all-natural”, “free range”, “humane”, or other similar buzzwords to make something sound healthier or more environmentally friendly than it may be, and the multitude of labels causes a great deal of consumer confusion (Kolodinsky 2012, Parasidis, Hooker and Simons 2015, Verbeke 2005). Even when used responsibly by producers, it is difficult for consumers to remember and understand the numerous labels, because the use of many of these labels are not regulated. The ones that are regulated, such as the USDA organic label, have caveats that are not explained on the label (i.e.

some pesticides are permissible, product may have been grown near a location where synthetic fertilizers are or have been used) (Kolodinsky 2012, National Organic Program 2000). Organic certification is expensive, and often it is only large agricultural business that can afford to have it. It is unreasonable to think that the general consumer would be able to research every potential food label or they may encounter or learn all of the caveats to the USDA organic certification and store these to memory. All of these factors lead to a food system where the consumer is uninformed or misled, and unable to make decisions based on his or her values, even for those consumers who put a great deal of effort into learning about the type of food they buy.

Protein Decision Theory

Several studies have been conducted looking into how individuals make decisions about food (Furst, et al. 1996, Connors, et al. 2001, Devine 2005, Keller and Siegrist 2015), and the motivations of vegetarians and vegans (Jabs, Devine and Sobal 1998, Ruby 2012, Bilewicz, Imhoff and Drogosz 2011, Dietz, et al. 1995), however general protein decision making on the basis of consumer values has not been well studied in academia. The complexities associated with protein food decisions, however, have not escaped the attention of the public (Brody 2015, Gustafson 2015, Rhodes 2015, Atkinson 2014), which is demonstrated by the prevalence of vegetarianism and veganism, as well as a host of other specialized diets with varying foci on protein, despite conflicting studies arguing that high protein diets are effective to varying degrees, or not even effective at all (Halton and Hu 2004, Clifton, Keogh and Noakes 2008, Sacks, et al. 2009). Technology has given way to hundreds of online and mobile application decision tools that all aim to help the consumer make a more informed decision (Roheim 2009).

To determine what aspects make an impactful decision tool, I will consider concepts in both decision science and decision support systems, which are described below.

Decision Science

Howard (2007) describes decision analysis as a "logical procedure for balancing of the factors that influence a decision," discussing that decision making consists of three parts: what you can do, what you know, and what you want (Howard 2007). In the context of protein, what a consumer can do is limited by certain constraints such as price, health complications, special diets, religion, location, what is available, etc. What the consumer knows depends on the information the consumer has available, which may be very little and is complicated by the lack of transparency in the food system. The last part, what the consumer wants, is where discussions of personal values and personal value systems become most relevant. Generally, a set of values is shared by a culture, but individuals may balance and prioritize these values differently (Verplanken and Holland 2002). A variety of factors, from limitations like the ones already mentioned, to family history, culture, and personal experiences, impact these value negotiations for each individual (Furst, et al. 1996).

In the context of protein, a high quality decision would be one made in full understanding of the alternatives. This depends on a multitude of factors aside from information available, such as an adequate education in nutrition and environmental science. Providing information on protein options cannot lead to an absolutely informed decision because it cannot provide the necessary complete education, but it is a crucial step toward informed decision making, thereby allowing consumers to more clearly consider their values. With this in mind, relying on Howard's (2007) definition of a good decision being one that is "based on the uncertainties, values, and preferences of the decision maker."

It is important to consider individual values when making recommendations about protein. For example, studies have found that a vegan diet is more environmentally sustainable than a diet containing animal products (Reijnders and Soret 2003). This would imply that promoting a vegan lifestyle for everyone would be best for the environment. Trying to enact this measure, however, would be unsuccessful and strongly opposed because it disregards the values and limitations of individuals and certain groups, an outcome that has been seen in many conservation endeavors that neglect the values of the communities they work with (Dowie 2005).

Decision Tools

Recently, decision tools have been developed in response to the plethora of publicly available information to help consumers make informed decisions. This influx of readily available information should lead to a generally more informed consumer, however the presence of different sources providing often conflicting information has led to a more confused public (Bharati and Chaudhury 2004), especially when it comes to food choices.

Perceived usefulness of recommendations and ease of use of technology, including Decision Support Systems (DSS), are noted as two important factors in determining attitudes toward a technology under the theory of the technology adaptation model (TAM) (Davis, Bagozzi and Warshaw 1989). A DSS is a computer-based application that allows the user to manage a large amount of complex information, and has traditionally been used in a business management system (Power 2002), however it has been applied to consumer use systems (Bharati and Chaudhury 2004). Perceived usefulness and ease of use for a tool fall into the topics of Information Quality (IQ: the quality of the output provided by a tool, determined by factors such as importance or usability of information) and System Quality (SQ: the performance of a DSS, such as convenience, reliability and flexibility) (Bharati and Chaudhury 2004). Studies have found both of these qualities to have an impact on satisfaction from using the DSS, however IQ generally has more of an impact on satisfaction than SQ (Davis, Bagozzi and Warshaw 1989, Delone and McLean 1992, Bharati and Chaudhury 2004, Yang, et al. 2005). Expecting users to rely on their impressions of IQ to assess the overall quality of DSS satisfaction poses a problem: the tools are made under the assumption that users have difficulty determining the quality of the information they hear. If people judge a protein decision tool's recommendations based on faulty or incomplete previously learned information, they may disregard what is actually an effective tool. Confusion caused by different DSS giving different recommendations can also impact the way users assess the information output, as will be discussed more below. The current study focuses on the information presented, since it seems to have more of an impact on user attitudes, and information is a necessary precursor to developing a decision tool. Rather than using satisfaction as a measure of success, a change in likelihood of purchasing a type or multiple types of protein, ideally toward more sustainable choices, is seen as a success.

Much of the literature that exists on the functionality of DSS examines tools that directly result in a product or transaction of some sort, so long term satisfaction resulting from the DSS use is a factor used to assess the DSS itself. This is difficult to apply to DSS that make recommendations on food, as each individual food item is not a long-term purchase, however food purchasing habits develop on a very long term scale. An unsatisfactory purchase based on a recommendation from a food DSS can be corrected relatively quickly and easily by adjusting the way the tool is used or purchasing a different product, but the perception from such an experience could have lifelong impacts.

The most prominent protein DSS model is the Monterey Bay Aquarium's Seafood Watch program, which began with a paper pamphlet distributed to millions of aquarium visitors, and is now available online and as a mobile device app. The Marine Stewardship Council has also developed a well-recognized system to assess seafood sustainability, and award MSC Certification labeling to that seafood that fits their criteria. The awareness these guides raise in society has contributed to a broad interest in sustainable seafood, and some industries have changed their purchasing choices due to consumer demand (Roheim 2009). While raising awareness about the sustainable seafood movement, the actual impact directly on consumer purchasing has been shown to be quite small if any change exists at all. This is due to a number of factors, including consumer confusion between different guides and traceability issues of seafood sourcing (Jacquet, et al. 2009). These guides, however, have been mostly focused on environmental sustainability, with some more recent tools incorporating health factors into their recommendations (Table 1). Many of the more widely distributed guides, such as the Monterey Bay Aquarium's Seafood Watch program or the Marine Stewardship Council's certification, are recommendations, providing a list or certification on the label to indicate that it is deemed sustainable. This model, while informative, may not be very engaging to the average consumer, making this list or certification process seem like a fairly esoteric decision made by an unidentified group of individuals, and has little direct relevance to their daily lives. Bringing health factors, both short term and long term, into the equation for consumers may make it easier to apply these recommendations to their own lives. Additionally, people who do have very specific environmental concerns may not trust the recommendations or certification to tell them what best fits their own hierarchy of values. This is reinforced by the fact that guides considering seafood compared to other protein options are virtually nonexistent (Table 1).

Other tools similar to the Seafood Watch Program have been created to help consumers make better decision for their health and the environment. Most of these tools, as discussed previously, have been exclusively for seafood, with over 200 seafood decision guides existing internationally (Roheim 2009). This abundance of seafood decision tools may imply that seafood is an ideal protein sourcein all situations. An excess of guides for seafood with little acknowledgement of other protein types overemphasizes the benefits of consuming seafood while downplaying the impacts of other proteins.

While the potential benefits of comparing all categories of protein and both the impacts on environment and human health are clear, discerning what type of interface and output are desirable is not so straightforward. Interactivity allows the consumer to decide which categories are more important, leading to a more informed decision that is also consistent with consumer values. Ideally, this will lead not only to better recommendations, but will hopefully translate to practice while the consumer is actively making purchasing decisions. On the other hand, by relying on consumer values, consumers are given the opportunity to disregard factors that may not be directly relevant to them, environmental impacts in particular. It is also difficult to determine whether giving recommendations as general protein types or specific products or sources would be more useful. By giving specific products, consumers can be sure that the product they are purchasing is verified as a good product. There are a lot of specific products to verify, and if a consumer is trying to make a purchase, and none of the options at the store or restaurant match product recommendations made by a tool, then the individual is left guessing at the best option. In this case, providing recommendations for a general protein type may be most beneficial, as the consumer can make a decision that will be the best choice in most situations. This, however, runs the risk of aligning individually responsible producers with destructive or harmful overall industries (Roheim 2009). This paper will try to address these conflicting arguments via qualitative survey, contributing to a theory on best methods for electronic decision tools.

The role of decision tools in the decision making process is illustrated in Figure 3. This shows the three components of making a decision (what you can do, what you know, and what you want) discussed above. It also shows the disconnect between consumer understanding or knowledge and the decision being made, due to the multitude of factors that make having complete information difficult. This lack of full understanding leads to a disconnect between consumer values (what you want) and the decision. The decision tool, as shown in the diagram, helps to rebuild these connections between knowledge, understanding, and values and the decision being made.

RESEARCH QUESTIONS

Given the impacts of various types of protein productions on both the environment and health, the potential of decision tools focused on protein to help consumers make more informed choices, it is clearly important to consider decision-making surrounding protein options. The goal of this paper is to determine how best to develop an electronic tool to engage consumers in making decisions about protein consumption that are better for the environment and human health. To achieve this, I have asked two research questions: 1) What qualities of a dietary protein-based decision tool make it effective? and 2) What do consumers consider when making decisions about what type of protein to consume? The following meta-analysis and survey attempt to answer these questions in order to make recommendations about how a decision tool should be made and used.

METHODS

To address the two research questions above were addressed using two types of analyses. The first is a meta-analysis of existing decision tools for protein sources, where I examine what qualities these tools exhibit, such as the information they base recommendations on, user input, and the kind of recommendations they make. The second study is a survey completed at farmers' markets in the Phoenix area to determine what kind of decisions the consumers surveyed made, and how they made these decisions when given different amounts of information to rely on.

Meta-Analysis

Only North American tools were evaluated in this study due to great regional differences in the environmental impacts of protein types, as well as language barriers for some international tools. A snowball sampling method was used to locate decision tools, meaning that I started with a couple of tools I was aware of from personal experiences and literature (Environmental Working Group Meat Eater's Guide and Incofish

International Seafood Guide) and followed references made by these tools to locate new ones. I continued this until the references offered by different tools were not returning any new websites. The decision tools were evaluated on the categories of protein type, input method, value categories, and output.

Protein type refers to which of the seafood, livestock, or plant protein categories the tool evaluates. Input method refers to the way that the user interacts with the tool, specifically, if the tool is interactive. Interactive is defined as having some sort of interface where the user can input their values or personal information to receive more personalized recommendations. The value categories the tools were assessed for were environmental and health values. The output refers to the type of information given to the user of the tool. If a tool offers recommendations by protein type, it means that there is a recommendation for a particular type of protein food or from where it is originally sourced (i.e. Atlantic salmon, grass-fed beef, organic soy, general protein type, etc.). Purchasing source/product output means that the tool does not give a general type of protein, but rather a specific location (Fry's, Sprouts, farmers' market, a specific farm, etc.) or product (Starkist tuna, Hebrew National hotdogs, etc.). A tool offering information either gave additional information to accompany recommendations, or provided only information about different types of protein sources, rather than giving recommendations.

Survey

Study Area

Surveys were conducted at three different farmers markets in Arizona: Mesa (May 8, 2015), Old Town Scottsdale (May 9, 2015), and Ahwatukee (May 10, 2015).

Participation was voluntary and anonymous, and anyone who completed the survey was given a small gift. An undergraduate student assistant and I approached shoppers that passed by our tent and explained the survey procedure, at which point they either decided to participate or not participate. We attempted to approach as many passers-by as possible, without targeting any particular demographic.

Surveying at farmers markets provides a relatively narrow representation of the population, and the potential impacts of this on the results are discussed later. This decision was made due to the fact that none of the numerous local, regional, or national grocery stores approached would allow surveys to be conducted on their premises. The reason for focusing on food-purchasing locations was that participants would be in a "hot state," meaning that they were in a state of mind to actually be making decisions about food. People make purchasing decisions differently whether they are in a "hot state" or "cold state" (Loewnestein 2000), and the surveys given under the assumption that people most often make food purchasing decisions in a hot state. Grocery stores and farmers' markets were focused on over other establishments (i.e. restaurants) because grocery purchases depend on other elements, such as food preparation and considerations of family or other household members.

Surveys

This is a qualitative study, designed to develop a theory about how individuals or groups make decisions about protein sources and what issues are most important to consider in consumer education and decision tool design.

The survey included four sections. Section one assessed how the participant already made decisions between protein sources by giving them only the information generally available at the time of purchase. This included nutrition information and prices (Appendix A, Tables 3 and 4). Section two attempts to understand consumer knowledge of potential contaminants, certain nutrients, and environmental impacts related to the given protein types. Section three revisits the questions in section one, but with added information on environmental impacts and potential contaminants (Appendix A, Table 5) and questions related to this new information. The final set of questions in section four gathers demographic information. The entire survey can be viewed in Appendix A. The survey went through eleven revisions and two test runs before the actual survey was administered at the target sites.

This survey uses wild and farmed salmon to represent the seafood category, grass-fed and grain-fed beef to represent livestock, and organically-grown and non-organically-grown soybeans/tofu for the plant protein category. There are a multitude of other options with widely varying health and environmental measurements, however salmon, beef, and soy are prominent protein types that represent all three protein categories of concern here, and in general have more complete and comparable data on environmental impacts than other protein types.

In the first section of the survey, I attempted to recreate the information that shoppers would have readily available in a grocery shopping situation by giving only price and nutrition information. Although farmers' markets do not generally provide nutrition information on their products, this survey was designed to simulate a supermarket experience as much as possible. Prices were based on non-sale prices at Safeway in April 2015, and nutrition information came from the National Nutrient Database (United States Department of Agriculture 2014). Environmental and contaminant information were collected from the literature and published reports. A full breakdown of these sources can be found in Appendix C. Generally, the environmental data came from studies that completed life cycle analyses, and contaminant data came from published literature and disease outbreak reports. High/moderate/low rankings for contaminant data were made by comparing each protein source to each other, unless the level is so low across all protein categories that it is not an issue (for example, the possibility of synthetic pesticides show that salmon and non-organic soy both have a "high" ranking compared to other protein types, but footnotes indicate that these levels still do not go above the EPA tolerance levels; mercury, on the other hand, is ranked "low" for all protein options, as mercury is virtually unreported in all categories).

Questions on clarification were answered at any part of the survey, however certain questions about content, particularly definitions of terms regarding the environment and substances/potential contaminants were generally not answered until the third section, as Section 2 was intended to reveal consumer knowledge and misconceptions.

Analysis

To analyze questions regarding how likely respondents were to purchase each type of protein at the beginning and end of the survey, I used a Likert scale. In order to use these questions to determine the general order of preference for the six types of protein in the survey, I first calculated the average of the Likert scale responses, which ranged from 0 (would not purchase) to 5 (very likely to purchase) for each protein type and compared the averages from the first part to the averages in the third. I then used a Wilcoxon non-parametric test to look for a difference within individual responses between the beginning of the survey and the end of the survey (α=0.05). Questions about the impact that price and nutrition data had on decisions were asked in both the first and third section, so I also compared these responses by Wilcoxon test.

To assess potential difference among demographic groups I separated the responses based on this demographic data (i.e. male vs. female, below/the same as/above mean household income, etc.) and performed Wilcoxon tests.

To test the null hypothesis that that the 8 categories were ranked equally, I used a Chi square goodness-of-fit test to analyze the ranking data (question 30). As a post-hoc test, I compared each category in the ranking to the combined ranks of the remaining seven categories in a Chi-squared goodness-of-fit test. A Bonferroni alpha correction was used for eight comparisons, resulting in a corrected alpha of 0.006.

To test the hypothesis that respondents rated certain factors as having different levels of impact on the likelihood that they make different protein choices in the third part of the survey (questions 38-45), I used a Friedman test, with alpha equal to 0.05. For post hoc tests, I utilized Wilcoxon signed rank tests with a Bonferroni correction of 0.05/28=0.0018.

Finally, descriptive statistics were used on responses related to human health and environmental status of various substances (e.g. questions 11 and 12) to determine what substances respondents thought were concerns.

RESULTS

Decision Tools

Table 1 shows a synopsis of North America based protein decision guides available online, and Table 2 shows all of the food decision guides and tools considered in this assessment. Out of 23 decision guides considered, 87.0% of guides considered seafood, yet only 21.7% considered livestock protein, and 8.7% used plant protein in their guide. A mere two of the guides considered included all three forms of protein in their guides, the Environmental Working Group's Meat Eater's Guide and the Eat Well Guide. 82.6% of the guides considered environmental issues in their recommendations, while only 56.5% used health issues. Only 26.1% of the guides were interactive. 56.5% of the tools considered gave protein type output, and 17.4% of the tools offered purchasing source/product output. 52.2% of the tools included in this review offered information in some form beyond simple recommendations.

There is not a single tool found that fills all of the categories mentioned above (livestock, seafood, plant, health, environment, interactive, and protein type output). The Environmental Working Group's Meat Eater's Guide covers all categories, however it is not interactive. The Eat Well Guide likewise covers all of these categories, however it provides output as a specific product or source, rather than a general protein types. The Environmental Working Group's Consumer Guide to Seafood offers protein type options using an interactive tool that takes into account both human health and environmental impacts, but does not include livestock or plant protein in its assessment.

Decision Making

Approximately one in six people approached completed the survey. With 66 surveys administered and 62 completed, this means that about 400 people were approached across all of the farmers' markets. Table 3 shows the average Likert scale rating given by respondents for each type of protein at the beginning of the survey in part 1, and later in the survey after seeing the additional environmental and health information in part 3. In part 1, grass fed beef was the most popular choice, followed by wild salmon, organic soybean, grain fed beef, farmed salmon, and non-organically grown soybean. When looking at all complete responses (n=62), no change was found for farmed salmon (Z=-0.639, p=0.523), grass-fed beef (Z=-1.086, p=0.278), or non-organically grown soybean (Z=-0.411, p=0.681) from the first part of the survey to the third. Our results suggest that consumers prefer to purchase wild salmon (Z=-2.222, p=0.026) and organically grown soybean (Z=-2.598, p=0.009) and less likely to purchase grain-fed beef (Z=-2.876, p=0.004) after seeing the additional environmental and health data. The order of preference did not change, but the magnitude of difference between the ratings showed some change. Preferences within the beginning section of the survey differed significantly between grain-fed beef and farmed salmon, creating an upper group of grass-fed beef, wild salmon, organic soybeans, and grain-fed beef, and a lower group of farmed salmon and non-organic soy. Due to the increase in preference for wild salmon and organic soy and the decrease in preference for grain fed beef from the beginning to the end of the survey, the significant split moved between organic soy and grain fed beef, separating the preferences into two parallel groups of 1) grass-fed beef, wild salmon, and organic soy, and 2) grain-fed beef, farmed salmon, and non-organically grown soy, respectively.

When separated by male (n=19) and female (n=42) respondents, males showed no significant change from the first to second time answering these questions, however women showed a significant difference in three types of protein: an increase in preference for wild salmon (Z=-2.043, p=0.041) and organic soybeans (Z=-2.377, p=0.017), and a decrease in preference for grain fed beef (Z==2.179, p=0.029),.

No significant change was found in households earning less or about the same as the Arizona mean household income ($45,000), however households earning more than the Arizona mean showed a significant increase in willingness to purchase organically grown soy (Z=-2.303, p=0.021). No significance was found in those who chose to not report their income (n=4).

Respondents less than 30 years (n=13) old showed a significant decrease their willingness to purchase grain-fed beef (Z=-2.599, p=0.009), however no significance in any category was found for respondents between 30 and 60 (n=36) or aged 60 and up (n=8). There was no significant differences in college-aged respondents (25 and under, n=4) or retirement-age respondents (65+, n=2), both groups with a very small representation in these survey responses. Respondents 40 years of age or younger (n=29) showed a significant decrease in willingness to eat grain-fed beef (Z=-2.881, p=0.004) and increase in willingness to eat soybeans (Z=-2.598, p=0.009). An increase in willingness to purchase wild salmon was found in respondents over the age of 40 (n=29, Z=-1.983, p=0.047).

Household composition (i.e. individual only, individual and non-related roommate, individual and family without children, individual and family with children) had little impact on any change from initial to final response. Significance was found for an increase in willingness to purchase wild salmon for those providing food to family with no children (Z=-2.06, p=0.039). Additionally, those providing food for themselves and family with children showed a significant increase in willingness to purchase organically grown soybeans (Z=-2.271, p=0.023).

Responses that indicate the participant has “no special diet” (n=40) showed significance in several areas. Their willingness to purchase wild salmon (Z=-2.565, p=0.01), grass-fed beef (Z=-1.752, p=0.08), and organically grown soy (Z=-2.294, p=0.022) all increased, while willingness to purchase grain fed beef decreased (Z=-2.500, p=0.012). None of the other categories (vegetarian, vegan, or other) showed any significant correlations. Only three respondents were vegetarian, and one on was vegan.

Consumers that described themselves as “average weight” (n=43) showed a decrease in willingness to purchase grain fed beef (Z=-3.143, p=0.002) and an increase for organically grown soybeans (Z=-2.626, p=0.009). Those who described themselves as “overweight” (n=13) showed an increase in willingness to purchase both wild salmon (Z=-2.232, p=0.026) and grass-fed beef (Z=-1.997, p=0.046). No change was shown in the group reporting themselves as “underweight” (n=5).

Consumers who reported that they ate at restaurants a few times a week (n=19) showed a significant decrease in willingness to purchase grain-fed beef (Z=-2.092, p=0.036). None of the responses for those who eat out a few times a year or a few times a month showed any significant correlation.

For the entire sample (n=62), no significant change in impact of price or nutrition information was found when separating response into groups, however overall, participants reported that the impact of nutrition increased (Z=-1.979, p=0.048). This significance was not explained by income level or any of the age categories explored above.

When asked to rank 8 categories from highest to lowest importance (question 30), the Chi square goodness-of-fit test was found to be highly significant at an alpha level

0.05 (χ^2, p=5.53344E-19), meaning that at least one of the categories was ranked at a similar level more frequently than expected. “Nutrition” was highly significantly different at the corrected alpha level (χ^2, df=7, p=3.7x10^{-13}), with 47% of respondents listing it as their highest priority item. “Chemical fertilizer” was the next most significant category at the corrected alpha level (χ^2, df=7, p=6.0x10^{-5}), with 49% of respondents ranking it in the top two positions, and 25% ranking it as their first priority. The “antibiotics” associated with protein choices also showed significance at the corrected alpha (χ^2, df=7, p=2.1x10^{-4}). 56% of the participants ranked this category in their top three priorities, and 27% named it as their second choice. “Nutrient emissions” was also found to differ from the expected frequencies at the corrected alpha level of significance (χ^2, p=0.0016), however it was relegated to the lowest three priority choices 60% of the time, with it falling as the lowest priority for 24% of participants. Significance was also found for the “greenhouse gas emissions” category (χ^2, p=0.0021), with 29% of respondents ranking it as their 5th priority, and another 44% placing it in one of the lowest three ranks. No significance was found for “water use” (χ^2, p=0.35) or “land use” (χ^2, p=0.13) categories. Figure 1 depicts the ranking of each category.

Friedman tests on questions 38 through 45 (n=62) regarding the impact that different factors had on respondents preferences found a significant difference between at least one impact category ($\chi^2(7)$=81.2, p=0.000). Post hoc tests found a significant difference between 12 of the 28 comparisons: price and nutrition (Z=-4.271, p=0.000), price and contaminants (Z=-3.979, p=0.000), nutrition and water use (Z=-4.906, p=0.000), nutrition and land use (Z=-5.190, p=0.000), nutrition and greenhouse gas emissions (Z=-5.078, p=0.000), nutrition and nutrients emissions (Z=-5.007, p=0.000), nutrition and animal welfare (Z=-3.448, p=0.001), contaminants and water use (Z=-5.-023, p=0.00), contaminants and land use (Z=-5.355, p=0.000), contaminants and greenhouse gases (Z=-5.068, p=0.000), contaminants and nutrients emissions (Z=-5.232, p=0.000), and contaminants and welfare (Z=-3.642, p=0.000). In every comparison, the health factor nutrition or contaminants had the bigger impact.

A series of questions asked if participants thought the water use, land use, greenhouse gas emissions, and nutrient emissions associated with protein production were issues that humans should be concerned about. Over 60% of responses either strongly agreed or agreed that these were important issues for human concern (water use 67%, land use 66%, greenhouse gas emissions 67%, nutrient emissions 63%), while over a quarter of the responses for each question indicated that respondents had no opinion on the choice (water use 27%, land use 27%, greenhouse gas emissions 25%, nutrient emissions 30%). Only 6-8% of respondents for each of the four questions were in disagreement or strong disagreement with the need for concern for these issues. Additionally, survey participants were asked to specify which substances from a list were concerns for human health and which were concerns for the environment. The responses to these questions can be found in Table 4.

DISCUSSION

The survey responses provide a great deal of information on how people may prioritize different impacts when they make food purchase decisions, however the small sample size and farmers' market demographic means that the responses most likely do not reflect the decisions and priorities of the general population. Despite being a stated preferences rather than a revealed preferences study, some inconsistencies were revealed through comparing responses to different questions. The results of the meta-analysis and survey have implications in areas of environmental concerns, health and nutrition factors, and limitations to the survey. This section will cover all of these topics in order to demonstrate how decision tools may be able to help improve dietary protein decision making.

Environmental Concerns

An overwhelming minority of respondents showed disagreement with the statements that the land use, water use, greenhouse gas emissions, and nutrient emissions associated with protein production are issues that humans should be concerned about, while over 60% of responses indicated agreement or strong agreement with these statements. However, when asked to rank environmental impacts with health impacts, the health impacts were significantly higher ranked than environmental ones (Figure 2). Similarly, participants indicated that nutrition and contaminant information played a larger role in their stated willingness to purchase each type of protein than environmental or animal welfare issues, demonstrating that humans have inherent anthropocentric interests. Health factors were even considered more important that price, which is consistent with research on consumer preference for organic foods for contaminant and nutritional reasons, despite having a higher price (Winter and Davis 2006). This is most likely indicative of the farmer's market demographic, as 60% of the respondents reported household incomes higher than the Arizona mean income.

Nutritional and Health Preferences

The fact that the ranking order of protein choices did not change, but the relative preference for particular options did, and that wild salmon preference increased while grain-fed beef preference decreased indicates that people may not be willing to reduce their animal protein consumption, but rather redirect a reduction of one choice to an increase in another. In both the grass-fed beef/wild salmon/organic soy group and the grain-fed beef/farmed salmon/non-organic soy group, the plant protein comes in as the least desirable option. Soy has lower saturated fat content, cholesterol, and sodium, and greater amounts of nearly every other vitamin and mineral than the animal protein options, as well as having low risks of mercury, hormones, antibiotics, and pathogens. If people were truly prioritizing nutrition, soy should have appeared as the first choice. However, 100kg of soy (the measurement used for comparison) had more calories than beef, and less protein than both beef and salmon, which may mean that respondents prioritized these nutrition categories over the others. 49% of respondents also stated that they believed phytoestrogens were a human health concern, and soybeans were the only proteins considered that contain it. Many people concerned with phytoestrogen may have selected against it for this reason. Contaminants were the next highest concern for participants after nutrition, and non-organic soy was most likely to have synthetic pesticides, potentially explaining its spot as least desirable protein option. Explicitly including taste in the ranking (question 30) and impact level (questions 38-45) may have helped to explain some of these differences. While respondents were given space to write in other impacts on their decisions, such as taste, not enough responses were received to make this comparison.

Not all health factors were considered equal by respondents, however. The importance of omega-3 fatty acids, which are not typically included on nutrition labels, has been emphasized in scientific and popular literature recently (Kris-Etherton, Harris and Appel 2002), but this category was consistently considered a lower priority than nutrition and potential contaminants issues. This discrepancy indicates that people are either more driven by fear of potential contaminants than by an interest in actively improving their health, or not well informed on the benefits of omega-3 in the diet, which is supported by literature indicating that people are more motivated to action by risk or negative information (Verbeke, Frewer, et al. 2007).

Table 4 shows how many people consider certain substances to be bad for human health or for the environment, and there are some important discrepancies in some of these responses. For example, 22% more people think that mercury is only a human health concern, and 38% of responses think the same of hormones. This supports the idea that there is a disconnect in people's minds between human health and the environment (Barry 2010), and that even when shown the data, people may not see how their choices impact the environment. If individuals do have environmental concerns, but cannot draw a connection between these substances and negative environmental impacts, then they are still not making decisions that are completely consistent with their values. This supports the previous argument that a high quality decision is one made in full understanding of the alternatives, but due to a lack of education, in this case in the environmental sciences, can prevent this from being possible even given complete information on the options (Barry 2010). The disconnect also demonstrates two themes in human-environment interactions: further support for the prevalence of anthropocentric values which prevents the participants from seeing past their personal interests, and that terms such as "the environment" and "nature" are vague and can be interpreted differently by different people or groups. This not only has negative implications for the environment, since participants prioritized these issues as low concerns, but it means that people don’t recognize that their health is inherently connected to the state of the environment (Sala, Meyerson and Parmesan 2009).

There were participants who believe that zinc, Vitamin A, and omega-3 fatty acids are detrimental to human health (Table 4). Additionally, only 52% of participants think that trans-fats are bad for people (Table 4), when in fact, trans-fat is the only fat that is largely agreed upon by nutrition science to be bad for human health (FDA, FDA cuts trans fat in processed foods 2015). These results reveal a lack of nutrition knowledge and indicate a need for better education in this area.

Somewhat surprisingly, income level was not correlated with a change in preferences, however this is most likely due to my small and biased sample. Some factors did correlate with a change in preference though. Women’s change in stated preferences paralleled the overall change in preferences. Women were more represented in survey responses than men, however, at 68% (42 out 62) out of respondents, giving a more reliable representation of actual purchasing habits. Those respondents with no special diet also showed similar change in preferences, as well as showing an increasing preference for grass-fed beef. This is not surprising, however, as those individuals with no restrictions on their diet have more dietary freedom to act on new information. One way that dietary restrictions could have been controlled for was to tell participants to replace any protein source that they were unable to consume with one that they could eat, and to imagine that the nutrition and other information represented the replacement protein instead.

Considering the seemingly random distribution of significance in weight, age groups, incomes, who participants were providing food for, and how often they ate at restaurants, it is likely that a combination of these factors as well as a number of personal experiences and history play a combined role in preferences and concerns. This is supported by a previous study on vegetarianism, which interviewed people in an affluent suburban neighborhood, similar to the sample in the present study, and found that those who hold traditional values are less likely to be vegetarian, while those holding more altruistic values have a higher likelihood of being vegetarian (Dietz, et al. 1995)

Study Design Limitations

There are several limitations to the survey and interpreting the results. One limitation has to do with the actual types of protein used as options in the survey. Only four of the 66 people surveyed were vegetarian or vegan, meaning a large number of respondents are likely unfamiliar with using plant-based proteins in many ways. Because of lack of information for tofu, soybeans were used as an example, which are less versatile than tofu. Tofu and soy products are well known alternatives to animal products, however it also does not have a great reputation as a food source. Using a more neutral type of plant protein could have led to different results.

A number of changes to the survey could have helped provide better representations of true purchasing habits. For example, giving definitions or short descriptions of each category prior to the ranking question could have changed the way people responded to this question, as well as how they responded in the third section of the survey. Many of the questions in the second part of the survey, asking which protein source respondents thought had the highest and lowest impacts in each environmental category, could not be easily used, as it was not specified to choose only one option. As a result, many people chose one from each column, or chose anywhere between two choices to marking all of the choices if they were not sure which to choose. For the questions asking participants to indicate which options in a list of substances they thought were bad for the environment or human health, it would have helped to clarify that these substances were to be considered in moderation, such as the amount that would be associated with one serving of food.

The process of choosing locations to survey also revealed one source of lack of transparency in the food system. By not allowing me to survey shoppers, the grocery stores I approached were implying that they would rather their patrons be uninformed about their choices than to allow me to collect surveys. The explanations that I received were that the grocery stores did not want to inconvenience their shoppers by having someone asking for their voluntary participation in a survey. This indicates that society, or at least the producers, value convenient consumption over informed consumption.

RECOMMENDATIONS

Although the sample population is not representative of the population as a whole, it is still a useful sample group for the purposes of this study. Many of the more responsibly produced protein types are also more expensive. Any attempt to create consumer driven change in behavior would have to rely on those with greater individual purchasing power to create initial changes. Once those who have the financial means to buy higher priced food items start changing their purchasing behavior, the increase in demand can begin to drive prices down, making these products more accessible to a wide range of consumers.

The survey results suggest that this dominantly affluent group's decisions can be altered, but the lack of change in overall ranking of protein choices from the first part of the survey to the third show that this change is only to a certain extent. The added information, given in the form of table 3 in the survey, likely confirmed the somewhat more environmentally- and health-conscious decisions that the people surveyed were already making. This indicates that a decision tool based on this information may help people make choices more consistent with their values, but does not indicate that these tools can get people to make drastically different choices. This information combined with the relative lack of change in consumer behavior observed in previous studies of seafood decision tools shows that widespread behavior change on the part of the consumer in making protein choices is not likely.

This does not mean that decision tools are useless, however. Having consumers' values validated is an important step toward increased transparency in the food system, and can begin to address the social justice concerns mentioned at the beginning of this paper. This can also contribute to the observed change in corporate behavior due to consumer pressure that has been found with existing seafood decision tools. Unsynthesized and restricted to academic literature, the environmental and health information used in this study would be useless to consumers, as many of them cannot access academic journals or would not know how to interpret it even if they could. The ability to easily see the real impacts that a protein source has on health and the environment can help consumers transition from general demands for more transparency on the part of food providers to demanding specific changes in production processes. The lack of decision tools that consider protein options beyond seafood, and therefore the lack of research on the effectiveness of such tools, means that we cannot dismiss the potential impacts that such a decision tool would have in society.

Based on the results of the survey it is important that any decision tool that may be created include all protein categories. One of the motivations of this study was an observed bias against plants as a viable source of protein, which is reinforced by the severe lack of decision tools considering plant protein. Excluding plant protein from future tools simply because it is one of the least preferred choices would only bolster this bias. As plant protein generally has lower environmental impacts than the other types of protein, it can't be ignored as a protein option. However, the clear preference for animal protein exhibited in this study means that these types of protein must not be excluded. Retaining the more environmentally destructive forms of protein in a decision tool would also provide opportunities to learn about the impacts.

Both health and environmental impacts are important to include. Environmental concerns must be a component of the tool, because the impacts that certain animal protein types have on the environment cannot be ignored in the face of biodiversity loss and climate change. However, as health concerns were higher priorities of the survey participants, they must be a factor in decision tools both in consideration users' values as well as for potential environmental gain. Research has shown that seafood that is considered more environmentally friendly also contains less harmful mercury contamination, making it healthier for human consumption as well (Gerber, Karimi and Fitzgerald 2012). This trend may prove true for other types of protein, such as beef. Grass-fed beef has more omega-3 fatty acids, fewer calories, and less saturated fat than grain-fed beef, making it the healthier option. Although grain-fed beef has lower impacts in the greenhouse gas and land use categories, switching to grass-fed operations would drastically decrease the amount of cattle that could be raised, meaning less feed production and methane emissions, and the combined impacts would likely be smaller than they currently are, despite being higher per 100 grams of meat produced. This kind of tool would support a definition of sustainability based not only on environmental factors, but human health factors as well.

This survey was designed to determine which factors were most important to people when they were actually choosing a type of protein. In decision tools, however, the user would input information related to their values, and the tool would provide a recommendation. Unless the tool included some way to include preference for taste, the recommendations would likely be far more in line with the consumers' stated values. In this study the participants were associating the protein types with known experiences of that type of protein. In future studies of this topic, the names of the protein types should be hidden, or an actual tool should be designed and tested, so that the decisions are actually being made based purely on values. The survey lacked detailed questions about animal welfare, however in the one question regarding this concept, it was rated equally as important as the environmental factors. A tool should ideally consider animal welfare, as this is a major reason that many people choose to follow vegetarian and vegan diets (Jabs, Devine and Sobal 1998, Ruby 2012, Dietz, et al. 1995)

The types of tool targeted by existing studies of DSS focus on "transaction-based or retail orienting websites" rather than information presenting (IP) websites, which is the type of DSS that protein decision tools are (Yang, et al. 2005). None of the protein decision tools investigated in the meta-analysis directly result in purchasing a product or service, but rather they offer recommendations on purchases to be made. However, adding the option to purchase food directly from a protein decision tool, a complex but not altogether impossible task, may increase the success of these protein decision tools. Indeed, the convenience of online shopping would attract more customers who do not wish to spend added time finding the particular types of protein a tool would recommend. It would also decrease the confusion that consumers often face when making decisions in supermarkets, and could include only food items where the source is verified, eliminating the issue of traceability. Tools that are localized to allow home delivery purchase, or allow consumers to preorder food and pick it up pre-assembled at one location would likely make the additional environmental and health information easier to act on and more likely to be used, especially if protein choices can be combined with all grocery products for a more convenient shopping experience. It would also likely decrease impulse purchasing that often occurs in supermarkets (Peck and Childers 2006).

Decision tools for protein foods as they currently exist are not as effective as those creating and promoting them may hope for, as the literature review discussed previously indicates, however this does not mean that they have no impact on consumer purchasing and society. By reimagining the way these tools are developed to include more health measures and protein options beyond seafood, and even adding purchasing options, we could produce tools that lead to purchasing decisions that are better for people and the environment.

TABLES AND FIGURES

Table 1 A synopsis of the qualities of 23 existing decision guides that focus on at least one form of protein

Class	Function	Occurrence of function
Protein type	livestock	5
	seafood	20
	plant	2
Input	interactive	6
Values	health	13
	environment	19
Output	protein type	13
	purchasing source/product	4
	information	12

Table 2 shows the qualities exhibited by each decision guide/tool considered in the analysis of existing tools

Name of Decision Tool	Protein type			Impacts		function	output		
	livestock	seafood	vegetable	health impacts	env. impacts	interactive	protein type	source/ product	info
EWG Consumer Guide to Seafood		X		X	X	X	X		
EWG Meat Eater's Guide	X	X	X	X	X		X		
Eat Well Guide	X	X	X	X	X	X		X	
EatWild	X				X	X		X	
Fix Antibiotics	X			X		X		X	
Fix Food: Antibiotics	X			X	X				X
Safina Center Online Seafood Guide		X		X	X		X		
EDF Seafood Selector		X		X	X		X		
Greenpeace Seafood Red List		X			X		X		
MBA Seafood Watch		X			X		X		
NOAA FishWatch Fish Finder		X		X	X				X
Sea Choice		X			X		X		
MSC Sustainable Seafood Product Finder		X			X			X	
Mercury Calculator		X		X		X			X
Fishchoice Seafood Buying Guide		X		X	X				X
Fishchoice Sustainable Seafood Calculator		X			X	X			X
New England Aquarium Ocean-friendly Seafood		X			X				X
Incofish		X			X		X		X
Green American		X		X	X		X		X
EarthEasy		X			X		X		X
Fish Consumption Advisories		X		X			X		X
National Resources Defense Council: Mercury in Fish		X		X			X		X
Marine Conservation Society Good Fish Guide		X			X		X		X

Table 3: Average stated likelihood of purchasing each type of protein in part one of the survey and later in the survey at part three, with associated standard deviations.

Protein type	Part 1 (stdev)	Part 3 (stdev)
Farmed salmon	1.5 (1.6)	1.4 (1.8)
Wild salmon	3.4 (1.8)	3.7 (1.7)
Grass-fed beef	3.6 (1.5)	3.7 (1.5)
Grain-fed beef	2.4 (1.6	1.9 (1.5)
Organic soybean	2.6 (2.0)	3.0 (2.0)
Non-organic soybean	1.2 (1.5)	1.3 (1.7)

Table 4: Percentage (and number) of participants who believe the substances in the left column are bad for human health and for the environment

Substance	Bad for human health	Bad for environment
Mercury	89% (59)	67% (44)
Omega-3 fatty acids	6% (4)	0% (0)
Pesticides	89% (59)	85% (56)
Trans-fat	52% (34)	9% (6)
Isoflavone	11% (7)	6% (4)
Zinc	5% (3)	2% (1)
Flame retardants	74% (49)	74% (49)
Antibiotics	58% (38)	49% (32)
Iron	3% (2)	3% (2)
Chemical fertilizer	82% (54)	86% (57)
Riboflavin	3% (2)	0% (0)
Vitamin A	2% (1)	0% (0)
Microplastics	74% (49)	74% (49)
Hormones	79% (52)	41% (27)
Phytoestrogen	49% (32)	33% (22)

Figure 1: The distribution of ranking for the eight categories participants were asked to rank. Ranked from highest (1) to lowest (8).

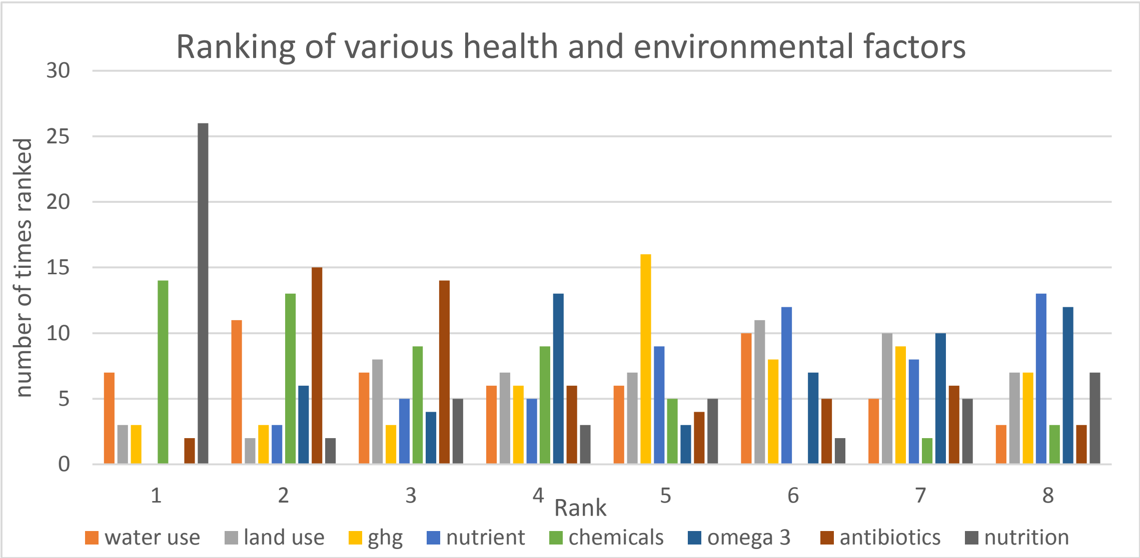


Figure 2: The distribution of response to the statement that each of the four factors associated with protein production processes (water use, land use, greenhouse gas emissions, nutrient emissions) are a concern for humans

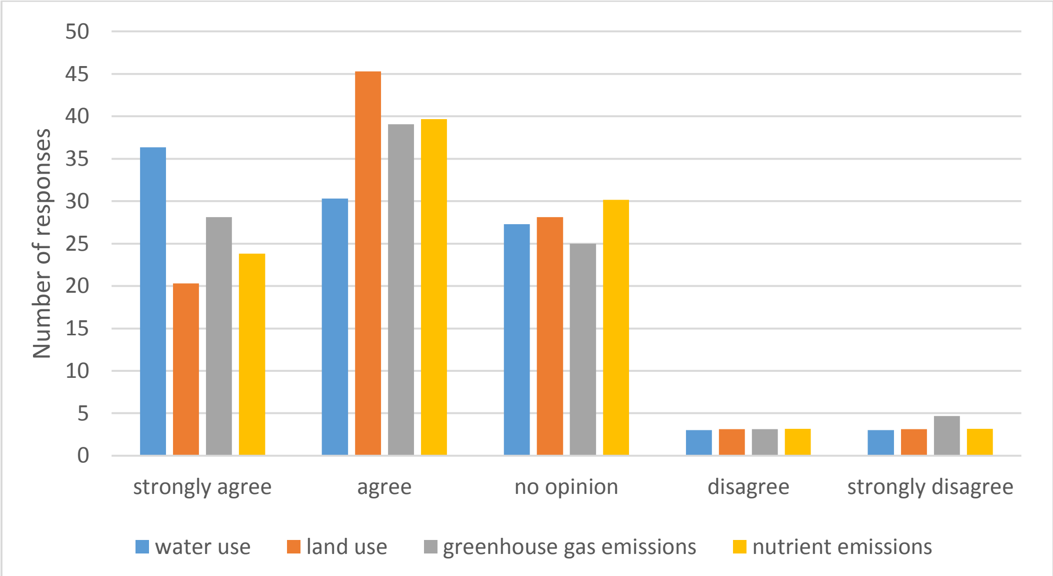
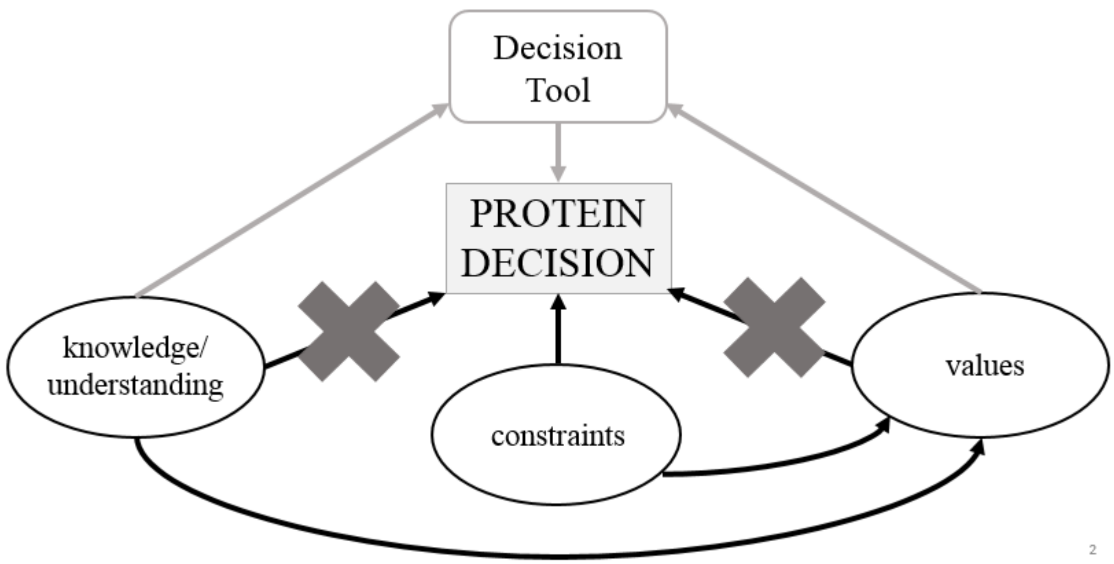


Figure 3 A depiction of the decision making process for a protein choice and the role that a decision tool plays. A lack of complete understanding on the part of the consumer creates a disconnect between the decision and the knowledge and values components. The decision tool can facilitate these connections if the consumer is unable to research the options.



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APPENDIX A

SURVEY QUESTIONS

PROTEIN SOURCE DECISION SURVEY

I am a masters student under the direction of Leah Gerber in the School of Life Sciences at Arizona State University. I am conducting a study to determine how people make decisions about the types of protein they choose to purchase.

I am inviting your participation, which will involve a 10-15 minute online survey. You have the right not to answer any question, and to stop participation at any time. You must be 18 years or older to complete this survey. Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty.

There are no foreseeable risks or discomforts to your participation. Only the researchers will have access to your responses, and your responses will be completely anonymous. The results of this study may be used in reports, presentations, or publications, but your name will not be used.

If you have any questions concerning the research study, please contact the research team at: Leah.Gerber@asu.edu or sgeren@asu.edu. If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788.

Signing below will represent your consent to participate in this study

Part 1:

Imagine that you are at the grocery store deciding which type of food to buy. You are looking at six different options: wild salmon, farmed salmon, grass-fed beef, grain-fed beef, organically grown soybeans (edamame), or non-organically grown soybean (edamame). Mark the number that represents how likely you are to purchase this item. Your responses should reflect how you usually make decisions while grocery shopping. Prices (Table 1) and nutrition information (Table 2) are available for you to refer to, **if this is information you frequently use while making decisions**. Use of these tables is not required. If you do not usually check the prices or the nutrition content before making a purchase, then you should avoid using the tables. However, please use any other information or personal preferences that you would normally consider while making a protein decision.

1) How likely are you to purchase farmed salmon?

   (Would not purchase) 0 1 2 3 4 5 (Very likely)

2) How likely are you to purchase wild salmon?

   (Would not purchase) 0 1 2 3 4 5 (Very likely)

3) How likely are you to purchase grass-fed beef?

   (Would not purchase) 0 1 2 3 4 5 (Very likely)

4) How likely are you to purchase grain-fed beef?

   (Would not purchase) 0 1 2 3 4 5 (Very likely)

5) How likely are you to purchase organically grown soybeans?

   (Would not purchase) 0 1 2 3 4 5 (Very likely)

6) How likely are you to purchase non-organically grown soybeans?

   (Would not purchase) 0 1 2 3 4 5 (Very likely)

7) What impact did the price have on your ranking?

   (No impact) 0 1 2 3 4 5 (High impact)

8) What impact did the nutrition information have on your ranking?

   (No impact) 0 1 2 3 4 5 (High impact)

9) Which part(s) of the nutrition label played a role in your ranking, if any?

☐ Calories	☐ Saturated fat	☐ Potassium (K)	☐ Fiber	
☐ Protein	☐ Cholesterol		☐ Calcium (Ca)	☐ Vitamin C
☐ Total fat	☐ Sodium (Na)	☐ Carbohydrate		☐ Vitamin A
			☐ Iron (Fe)	

10) List any other factors that affected your ranking, with a number between 0 and 5 representing the impact it had on your ranking (see questions 7 and 8), as well as any explanation necessary.

Part 2:

11) Which, if any, of the substances listed below do you believe have a negative effect on human health? (Check all that apply)

☐ Mercury	☐ Zinc	☐ Vitamin A
☐ Omega-3 fatty acids	☐ Flame retardants	☐ Microplastics
	☐ Antibiotics	☐ Hormones
☐ Pesticides	☐ Iron	☐ Phytoestrogen
☐ Trans-fat	☐ Chemical fertilizer	
☐ Isoflavones	☐ Riboflavin	

12) Which, if any, of the substances listed below do you believe have a negative effect on the environment? (Check all that apply)

☐ Mercury	☐ Zinc	☐ Vitamin A
☐ Omega-3 fatty acids	☐ Flame retardants	☐ Microplastics
	☐ Antibiotics	☐ Hormones
☐ Pesticides	☐ Iron	☐ Phytoestrogen
☐ Trans-fat	☐ Chemical fertilizer	
☐ Isoflavones	☐ Riboflavin	

13) Are there any substances that you had heard of before answering the previous two questions? (Check all that apply)

☐ Mercury	☐ Zinc	☐ Vitamin A
☐ Omega-3 fatty acids	☐ Flame retardants	☐ Microplastics
	☐ Antibiotics	☐ Hormones
☐ Pesticides	☐ Iron	☐ Phytoestrogen
☐ Trans-fat	☐ Chemical fertilizer	
☐ Isoflavones	☐ Riboflavin	

14) Are there any substances that you not only have heard of, but are familiar with (i.e. know the function, impacts, source, etc.; check all that apply)

☐ Mercury	☐ Zinc	☐ Vitamin A
☐ Omega-3 fatty acids	☐ Flame retardants	☐ Microplastics
	☐ Antibiotics	☐ Hormones
☐ Pesticides	☐ Iron	☐ Phytoestrogen
☐ Trans-fat	☐ Chemical fertilizer	
☐ Isoflavones	☐ Riboflavin	

15) The amount of water used to grow/raise a source of protein is an issue humans should be concerned about.

☐ Strongly agree ☐ Agree ☐ No opinion ☐ Disagree ☐ Strongly disagree

16) Explain your response

17) The amount of land used to grow/raise a type of protein is an issue humans should be concerned about.
☐ Strongly agree ☐ Agree ☐ No opinion ☐ Disagree ☐ Strongly disagree

18) Explain your response

19) The amount of greenhouse gases produced when growing/raising a type of protein is an issue that humans should be concerned about.
☐ Strongly agree ☐ Agree ☐ No opinion ☐ Disagree ☐ Strongly disagree

20) Explain your response

21) The amount of nutrient runoff produced during production of protein sources is an issue that humans should be concerned about.
☐ Strongly agree ☐ Agree ☐ No opinion ☐ Disagree ☐ Strongly disagree

22) Which type of protein do you believe requires the most water to produce?
☐ Farmed salmon ☐ Grass-fed beef ☐ Organic soy
☐ Wild salmon ☐ Grain-fed beef ☐ Non-organic soy

23) Which type of protein do you believe requires the least water to produce?
☐ Farmed salmon ☐ Grass-fed beef ☐ Organic soy
☐ Wild salmon ☐ Grain-fed beef ☐ Non-organic soy

24) Which type of protein do you believe requires the most space to produce?
☐ Farmed salmon ☐ Grass-fed beef ☐ Organic soy
☐ Wild salmon ☐ Grain-fed beef ☐ Non-organic soy

25) Which type of protein do you believe requires the least space to produce?

☐ Farmed salmon ☐ Grass-fed beef ☐ Organic soy
☐ Wild salmon ☐ Grain-fed beef ☐ Non-organic soy

26) Which type of protein production do you believe results in the most greenhouse gas emissions?

☐ Farmed salmon ☐ Grass-fed beef ☐ Organic soy
☐ Wild salmon ☐ Grain-fed beef ☐ Non-organic soy

27) Which type of protein production do you believe results in the least greenhouse gas emissions?

☐ Farmed salmon ☐ Grass-fed beef ☐ Organic soy
☐ Wild salmon ☐ Grain-fed beef ☐ Non-organic soy

28) Which type of protein production do you believe results in the most nutrient emissions?

☐ Farmed salmon ☐ Grass-fed beef ☐ Organic soy
☐ Wild salmon ☐ Grain-fed beef ☐ Non-organic soy

29) Which type of protein production do you believe results in the least nutrient emissions?

☐ Farmed salmon ☐ Grass-fed beef ☐ Organic soy
☐ Wild salmon ☐ Grain-fed beef ☐ Non-organic soy

30) Rank the following options from what you find most important (1) to what you find least important (8)

___water use
___land use
___greenhouse gas emissions
___nutrient emissions
___chemicals
___omega 3 content
___antibiotics
___nutrition

31) When you are purchasing food, is there anything that you find that you find that makes choosing an option difficult? (i.e. labeling, conflicting information, food recommendations, guidelines, etc.)

Part 3:

For this section, please re-examine the 6 protein options available, this time using all the information available in the first part (Tables 1 and 2) as well as additional information provided in Table 3.

Greenhouse gas (GHG) emissions: Attributed to climate change (i.e. carbon dioxide, methane)

Nutrient emissions: Nutrients (i.e. nitrogen or phosphorus) released to the environment during production of food, contributes to dead zones at the coast or in lakes

Table 3: Certain environmental and health impacts of each protein source

	Wild salmon	**Farmed salmon**	**Grass-fed beef**	**Grain-fed beef**	**Organic soy**	**Non-organic soy**
Omega-3 (mg/g)	10.69	21.14	0.17	0	0.01	0.01[a]
Water use (gallons/100g)	0	No data	628.6	723.4	62.7[b]	62.7[b]
Land use (m^2/100g)	No data	0.00128	3.69-18.44 (east US), 73.8-848.7 (west US)	1.665	0.338	0.346
GHG emissions (kg CO_{2e}/kg food)	4.51	4.14	19.2	15.23	0.01257	0.02649
Nutrient emissions (kg PO_4-eq/100g)	No data	<1	14.2	22.3	No data	No data
mercury	low	low	low	low	low	low
added hormones	low	low	low	high	low	low
antibiotics	low	moderate	low	high	low	low
possibility of pathogens	moderate	moderate	high	high	low[c]	low[c]
phytoestrogens	low	low	low	low	high	high
possibility of synthetic pesticides	moderate	high[d]	low	low	low	high[e]

[a]No research to indicate that organic farming alters the omega content of soybeans
[b]No differentiation between organic and inorganic
[c]beans only, doesn't include bean sprouts
[d]levels not above EPA tolerance (USDA Pesticide Data Program 2013)
[e]levels not above EPA tolerance (FDA Pesticide Monitoring Program 2012)

32) How likely are you to purchase farmed salmon?

(Would not purchase) 0 1 2 3 4 5 (Very likely)

33) How likely are you to purchase wild salmon?

(Would not purchase) 0 1 2 3 4 5 (Very likely)

34) How likely are you to purchase grass-fed beef?

(Would not purchase) 0 1 2 3 4 5 (Very likely)

35) How likely are you to purchase grain-fed beef?

(Would not purchase) 0 1 2 3 4 5 (Very likely)

36) How likely are you to purchase organically grown soybeans?

(Would not purchase) 0 1 2 3 4 5 (Very likely)

37) How likely are you to purchase non-organically grown soybeans?

(Would not purchase) 0 1 2 3 4 5 (Very likely)

38) What impact did the price have on your ranking?

(No impact) 0 1 2 3 4 5 (High impact)

39) What impact did the nutrition information have on your ranking?

(No impact) 0 1 2 3 4 5 (High impact)

40) What impact did the contaminant information have on your ranking?

(No impact) 0 1 2 3 4 5 (High impact)

41) What impact did the water use information have on your ranking?

(No impact) 0 1 2 3 4 5 (High impact)

42) What impact did the land use information have on your ranking?

(No impact) 0 1 2 3 4 5 (High impact)

43) What impact did the greenhouse gas emissions have on your ranking?

(No impact) 0 1 2 3 4 5 (High impact)

44) What impact did the nutrient emissions information have on your decision?

(No impact) 0 1 2 3 4 5 (High impact)

45) Although not directly covered in this survey, what impact did animal welfare have on your decision?

(No impact) 0 1 2 3 4 5 (High impact)

46) Please list any other factors that affected your ranking, with as much explanation as necessary (can be repeated from the first section).

47) I would spend time looking up information about the issues I didn't already know about or take into consideration.

☐ Strongly agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly disagree

Part 4:

48) Where did you find out about this survey?

49) Where you do you do most of your grocery shopping?

50) What is your age?

51) What is your sex?
- ☐ Male
- ☐ Female

52) Who do you provide food for most often?
- ☐ Yourself
- ☐ Yourself and other unrelated person(s)
- ☐ Yourself and family (no children)
- ☐ Yourself and family (with children)
- ☐ I'm not the main food provide

53) Do you consider yourself to have any of the following diets? (Choose all that apply)
- ☐ Vegetarian
- ☐ Vegan
- ☐ No special diet
- ☐ Other:________________

54) Do you consider yourself:
- ☐ Underweight
- ☐ Average weight
- ☐ Overweight

55) How often do you eat at restaurants?
- ☐ A few times per year
- ☐ A few times per month
- ☐ Multiple times per week

56) What is your household income compared to the Arizona mean ($45,000)?
- ☐ Below
- ☐ Similar
- ☐ Above
- ☐ Rather not say

57) Are there any historical or cultural factors that impact your protein decisions (i.e. family history, religion, personal experiences, etc.)?

58) Please give any other comments you have about the survey or its content.

Table 1: Price of each protein type

	Farmed salmon	Wild salmon	Grass-fed beef	Grain-fed beef	Organic soy	Inorganic soy
price[a]	$8.99/lb	$11.99/lb	$14.99/lb	$12.99/lb	$5.62/lb	$3.78/lb

[a]Based on Safeway prices

Table 2: Nutrition information for 100g of protein type

Nutrient	**unit**	**Farmed salmon**	**Wild salmon**	**Grass-fed beef**	**Grain-fed**	**Soybeans**
Calories	kcal	208	142	117	138	147
Protein	g	20.42	21.31	23.07	22.93	12.95
Total fat	g	13.42	5.61	2.69	5.15	6.8
Saturated fat	g	3.05	1.182	1.032	1.905	0.786
Cholesterol	mg	55	53	55	53	0
Sodium, Na	mg	59	112	55	57	15
Potassium, K	mg	363	343	342	354	620
Carbohydrate	g	0	0	0	0	11.05
Fiber	g	0	0	0	0	4.2
Calcium, Ca	mg	9	10	9	25	197
Iron, Fe	mg	0.34	0.42	1.85	1.64	3.55
Vitamin C	mg	3.9	0	0	0	29
Vitamin A, IU	IU	50	193	0	0	180

APPENDIX B

OMITTED SURVEY RESPONSES

The following responses were omitted from data analysis due to incorrect or unclear answers. Note that these do not include open ended questions or questions that were simply not answered by the participant. The following responses were all answered, yet in a way that could not be analyzed with the rest of the responses. Any responses missing from the final data analysis that are not listed here were not filled out by the participant.

S6: Q30-Began ranking the options, but only ranked 4 of the 8 choices

S8: Q30-Ranked 3-10 instead of 1-8

S18: Q30-Incomplete ranking

S21: Q30-Incomplete ranking

A5: Q30-Three options were ranked 1, one option was ranked 2, one option ranked 8, and other 3 options not ranked at all

A8: Q30-Options were ranked 1-7 and one option was left blank, while 8 was not assigned to any option

A10: Q30-Seven options were ranked 1-7, and the 8th was left blank

A12: Q30-Options were ranked 1-7 and one option was left blank, while 8 was not assigned to any option

M1: Q30-Six of the options were assigned the number 1, and the other two were assigned the number 4

M9: Q30-The only mark on the response was an “x” next to one choice. No ranking was attempted.

M14: Q30-Ranked options from 1-9, but skipped the number7

M17: Q11-Some options were checked and some were circled, with no explanation of what each mark was intended to mean

APPENDIX C

REFERENCES FOR TABLE 3 IN THE SURVEY

	Wild salmon	Farmed salmon	Grass-fed beef	Grain-fed beef	Organic soy	Non-organic soy
Omega-3 (mg/g)	10.69 (1)	21.14 (2)	0.17 (3)	0 (4)	0.01 (5)	0.01[a] (5)
Water use (gallons/100g)	0	No data	628.6 (6)	723.4 (6)	62.7[b] (6)	62.7[b] (6)
Land use (m^2/100g)	No data	0.00128 (7)	3.69-18.44 (east US), (8) 73.8-848.7 (west US) (8)	1.665 (9)	0.338 (10)	0.346 (10)
GHG emissions (kg CO_{2e}/kg food)	4.51 (11)	4.14 (12)	19.2 (13)	15.23 (12)	0.01257 (14)	0.02649 (14)
Nutrient emissions (kg PO_4-eq/100g)	No data	<1 (15)	14.2 (13)	22.3 (13)	No data	No data
mercury	Low (16, 17)	low (16, 17)	low (18)	low (18)	low	low
added hormones	low	low (19)	low (20)	High (20, 21)	low	low
antibiotics	low	moderate (22)	low (12)	high (22)	low	low
possibility of pathogens	moderate (23)	Moderate (23)	high (23, 24)	high (23, 24)	low[c] (23)	low[c] (23)
phytoestrogens	low (25)	low (25)	low (25)	low (25)	high (26)	high (26)
possibility of synthetic pesticides	moderate (27)	high[d] (27)	low	low	low (28)	high[e] (29)

1) (U.S. Department of Agriculture 2013): #15085
2) (U.S. Department of Agriculture 2013): #15236
3) (U.S. Department of Agriculture 2013): #13000
4) (U.S. Department of Agriculture 2013): #13019
5) (Russo 2009)
6) (Mekonnen and Hoekstra 2010)
7) (Brooks 2007)
8) (Jacobs 1991)
9) (Eshel, et al. 2014)
10) (Pimental, Hepperly, et al. 2005)
11) (Tyedmers 2000)
12) (Hamerschlag and Venkat 2011)
13) (Pelletier, Pirog and Rasmussen 2010)
14) (Lal 2004)
15) (Pelletier, Tyedmers, et al. 2009)
16) (Kelly, et al. 2007)
17) (Food and Drug Administration 2015)
18) (Batista, et al. 2012)
19) (National Marine Fisheries Service n.d.)
20) (McClusky, et al. 2005)
21) (Johnson 2015)
22) (L. Burridge, et al. 2010)

23) (Dewaal and Glassman 2014)
24) (Fegan, et al. 2004)
25) (Kuhnle, et al. 2008)
26) (Bhagwate, Haytowitz and Holden 2008)
27) (Hites, et al. 2004)
28) (National Organic Program 2000)
29) (E. U.S. Department of Agriculture 2012)

APPENDIX D

ELECTRONIC DECISION TOOLS USED IN META-ANALYSIS

All websites are correct as of November 2015
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