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# Hungry for Information: Public Attitudes Toward Food Nanotechnology and Labeling

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## Abstract

*What people think about food nanotechnology (nanofood) is under-explored in the United States, especially outside of quantitative surveys. As such, we set out to examine public attitudes toward food nanotechnology in conversational, focus group settings in order to identify policy options for nanofood governance, and in particular, options for labeling. Through analysis of focus groups in six U.S. locations, we found that the vast majority of the participants wanted nanotechnology labels for all types of food products, and most were willing to pay a premium for labeling. Participants cited abilities to choose and avoid potential risk as the main purposes of nanofood labels. However, they recognized that labels alone do not provide much meaning and that information concerning food nanotechnology products needs to be sought and supplied beyond the label to enable informed choices. Additionally, willingness-to-use and risk–benefit perceptions varied according to the position and intended functions of the nanomaterials in food products.*

**KEY WORDS:** food, nanotechnology, labeling, governance, regulation, policy

## Introduction

Nanotechnology, the manipulation of matter and creation of structures at the nanometer scale, is rapidly growing in numerous areas, including academia, the military, and both the public and private sector research and development (R&D). Although researchers and organization leaders throughout these groups are essential drivers for advancement, consumers as a collective represent an equally important piece in nanotechnology's development. While consumers generally do not actively set public and private sector technology R&D goals, they are ultimately the end users of a significant portion of such R&D. As a testament to this, currently over 1,300 nanotechnology-based consumer products circulate the global marketplace with much expectation for market growth (Project on Emerging Nanotechnologies [PEN], 2012). Such products span a wide array of categories from cosmetics and medical tools, to clothing and sporting equipment.

One product area with much investment and promise is food. Nanotechnology provides much potential for food innovations and the expansion of food science (Sanguansri & Augustin, 2006). Broadly, nanotechnology food R&D includes the areas of food storage, safety, texture, flavor, nutrition, quality, and freshness, in addition to being applicable to all components of the food production chain (Bouwmeester et al., 2009; Buzby, 2010; Chaudhry et al., 2008; Farhang, 2009; Kuzma & VerHage, 2006; Kuzma, Romanchek, & Kokotovich, 2008). Although

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considerable amounts and types of R&D remain prospective, the Project on Emerging Nanotechnologies product inventory lists 105 food and beverage products in its database, though this may be an underestimate (Chun, 2009). Regardless, the number of these products is expected to rapidly grow (Chaudhry et al., 2008; House of Lords, Science and Technology Committee, 2010), which is logical, given the large, though uncertain, amount of financial investments in nanotechnology food products R&D (Berube, 2006; Dudo, Choi, & Scheufele, 2011; Kuzma & VerHage, 2006). Accordingly, in addition to products and R&D, media attention is also on the rise. Looking 30 years retrospectively, media coverage of nanotechnology in food grew substantially, with the exception of a slight drop over years 2006 through 2009 (Dudo et al., 2011).

Given the clear continuing expansion of food processed using nanotechnology or made with nanomaterials and rising media attention, consumers will naturally become more exposed to such products and information concerning them. Consequently, since consumers are end users of food products, their perceptions of such products will grow increasingly important as the nanotechnology food product market grows. Logically, a market cannot develop and food nanotechnology investment will diminish if the public rejects or distrusts the outputs and institutions involved with food nanotechnology. As a result, not only will the public's acceptance, confidence, and trust impact the potential development of food nanotechnology (Buzby, 2010; Chaudhry et al., 2008; Dudo et al., 2011), but also nanotechnology's success as a key technology may well depend on the public's perceptions and resulting views and behavior (Köhler & Som, 2008; Macoubrie, 2006; Royal Society and Royal Academy of Engineering, 2004). Moreover, equally if not more important than economic and technological considerations, are ethical concerns. Engaging with public perception issues invokes important matters of consumers' rights (Throne-Holst & Strandbakken, 2009), such as consumers' right to know and right to choose regarding nanotechnology products and information. Acknowledging public perception as the nanotechnology food market expands is a key component to ensuring the moral dimensions of the public as a stakeholder in nanotechnology's development are addressed.

Food labels are one of the major aspects of food products with which the public interacts and that fundamentally affect consumer behavior and perception. Notably, public perception of nanotechnology food product labels remains unexplored, save for a few studies where labeling emerged secondarily to a different aspect of food nanotechnology or was not the primary study focus (Burri & Bellucci, 2008; Pidgeon & Rogers-Hayden, 2007; Throne-Holst & Strandbakken, 2009). Moreover, use of nonsurvey techniques for public perception of nanotechnology in general and across various applications pales in comparison with survey usage. Survey usage far outweighs nonsurvey usage in the literature, creating an abundance of descriptive and some inferential statistics but leaving a gap in deeper and more complex public thought and rationale. To unpack public perceptions in a way that is valuable for stakeholders involved in nanotechnology food products and labeling, the public included, applying open-ended and detail-rich nonsurvey techniques is essential.

In this paper, the topic of nanotechnology food product labeling is therefore explored through public perception obtained in a setting meant to elicit details and

rationale not attainable with closed-ended survey methods. First, we review previous work on public perception of nanotechnology, including issues of nanofood products and general food labeling, and discuss detailed motivations for this study. Then we describe our data collection and analysis methodologies. Next, we describe qualitative content analysis results for the public's perception of nanotechnology food product labeling and quantitative results from focus group worksheet responses (Appendix C) and the postsurvey (Appendix D). Finally, we discuss policy implications stemming from the results.

### *Public Perception of Nanotechnology in Food*

Numerous studies have analyzed public perception of nanotechnology both in general and considering specific factors and contexts for uses and products. Overall, a large percentage of the public has little or no familiarity with nanotechnology and is unsure whether the risks outweigh the benefits of nanotechnology and vice versa (Satterfield, Kandlikar, Beaudrie, Conti, & Harthorn, 2009). The following factors have been demonstrated to significantly affect nanotechnology perception: framing effects, media exposure, trust in regulation/risk management, intuitive toxicology, attitudes toward environmental risks and science/technology, perceived naturalness, psychometric variables, cultural biases, affect as a heuristic, religiosity, income, and education (Satterfield et al., 2009). Political leanings, race, age, and gender have been found across studies to be both significant and insignificant factors in determining nanotechnology perception (Kahan, Braman, Slovic, Gastil, & Cohen, 2009; Satterfield et al., 2009).

Given the broad array of perception factors studied and the steady growth of nanotechnology perception research, scholars have published meta-analyses and literature summaries to attempt to organize the array of individual studies and articles and provide direction for future studies. Satterfield et al. (2009) covered key nanotechnology public perception surveys up to 2008. Currall (2009) aimed specifically at arguing for theoretical development beyond simple descriptive studies, citing work on the cultural-cognition thesis (Kahan et al., 2009), religiosity and moral acceptance of nanotechnology (Scheufele, Corley, Shih, Dalrymple, & Ho, 2009), and contextual factors such as institutions (Pidgeon, Harthorn, Bryant, & Rogers-Hayden, 2009) as importantly advancing the breadth of theoretical considerations. Both Besley (2010) and Siegrist (2010) conducted reviews of previous nanotechnology public perception studies, each presenting similar issues, albeit discussing emerging themes differently. Besley (2010) provided a more descriptive summary of previous results in the areas of public knowledge, awareness, and other factors affecting nanotechnology perception. Siegrist (2010) incorporated comparisons to biotechnology and matters affecting nanotechnology's sustainable development.

One key area is perception of consumer products containing nanomaterials, specifically nanofood products. The nanofood industry is likely to grow rapidly in the near future (Chau, Wu, & Yen, 2007; Chaudhry et al., 2008); however, nanotechnology's advancement potentially hinges on the public's acceptance (Köhler & Som, 2008; Macoubrie, 2006; Royal Society and Royal Academy of Engineering, 2004). As demonstrated by the varied acceptance of genetically modified organisms across countries, shifting public perception in response to news media,

organizational/governmental outreach, or product-application availability and use may determine the success or failure of the technology. Notably, nanofood public perception research is generally sparse (Cook & Fairweather, 2007; Siegrist, Cousin, Kastenholz, & Wiek, 2007), presenting a significant challenge for the safe, effective, and fair development of the nanofood industry. Food as a nanoapplication is especially useful for eliciting public opinion. It is a tangible product that people interact with directly and daily, potentially facilitating clearer, better defined, and a greater variety of consumer judgment formations, compared with products without as much direct, frequent interaction (e.g., building materials).

Studies of public perception of food products containing nanomaterials or produced using novel technologies yield several insights thus far. In general, factors affecting consumer acceptance of agrifood nanotechnology are dynamic, complex, interactive, and interdependent (Yawson & Kuzma, 2010). More specifically, Siegrist et al. (2007) created a hypothetical model where consumer's social trust (in nanotechnology producers) impacted the affect regarding nanotechnology food information, which in turn fed into consumer benefit and risk perceptions, ultimately determining willingness to buy a given nanotechnology food product. Intuitively, social trust in producers had a positive willingness-to-buy impact, while perceived benefits had more of an effect than perceived risks. Contrastingly, perceived risks of a processing technology were the most important variable in deciding interest in use of a food product processed with a novel technology (Cardello, Schutz, & Lesher, 2007). Thus, consumers' conceptualization of nanotechnology in food may be more nuanced or differently developed than equivalent conceptualizations of novel technologies. On the other hand, consumers who demonstrated a willingness to consume foods processed by one novel technology had lower concern ratings for all technologies (Cardello, 2003).

Looking at a wider array of influences, perceived benefits, perceived risks, perceived naturalness, and trust were important factors for determining public acceptance of innovative food technologies (Siegrist, 2008), while similarly, the factors of food type, processing or production technology, costs, benefits, risk, endorsing agencies, and product information were significant components of consumers deciding about their use of food products processed with novel technologies (Cardello et al., 2007).

Lastly, shifting attention to particular perception differentiations within food nanotechnology, Siegrist et al. (2007) found the public is reluctant to accept nanotechnology foods and packaging, though nanotechnology packaging was perceived as more beneficial than nanotechnology foods. Furthermore, consumer willingness to buy was lower for hypothetical products with an added health benefit resulting from nanomaterial additives compared with natural additives, though higher compared with products with no additional benefit at all (Siegrist, Stampfli, & Kastenholz, 2009). Consumers appear to desire health benefits even if it requires ambivalently perceived nanotechnology additives.

In summary, the strong role of perceived risks and benefits in conjunction with technology/product perception variation demonstrates the more abstract behavior among consumers to roughly estimate and weigh (differentially) risks and benefits in decision making. However, consumer-perceived risks and benefits of innovative food technologies and products may be unreliable as people may inaccurately assess

such risks and benefits, placing more emphasis on consideration of consumer trust (Siegrist, 2008).

An essential issue linked to nanomaterials in food, consumer perceptions, and willingness to pay is the labeling of food products containing nanomaterials. Nanotechnology product labeling is currently a contentious issue in America among select groups. Various organizations including Friends of the Earth, Greenpeace, and the Center for Environmental Health, among others, formulated a citizen's petition in 2006, calling for the Food and Drug Administration (FDA) to institute regulations on products it oversees with nanomaterials, including additional labeling on given products (Monica, 2008). Other groups such as the Consumers Union and Environmental Working Group have maintained mandatory nanotechnology product labeling stances. In response to the petition and continued pressure from organizations to regulate and label nanotechnology specifically within products, the FDA reviewed arguments and solicited feedback from groups and experts through means of a Nanotechnology Task Force (Monica, 2008).

The FDA's July 2007 Task Force Report detailed their resulting stances and judgments. As it relates to labeling, the FDA held the position that mandatory product labeling should not be implemented as the current science had not indicated product classes with nanomaterials were riskier than product classes without nanomaterials (Monica, 2008). Instead, the FDA called for evaluation on a ". . . case-by-case basis whether labeling must or may contain information on the use of nanoscale materials." Moreover, the FDA sustained the idea that a warning label might not be useful if consumers do not understand nanotechnology's effect on a product. Since the 2007 report, the FDA has put forth voluntary guidelines for consultation concerning food products with "Significant Manufacturing Process Changes, Including Emerging Technologies," with nanotechnology as the key emerging technology discussed in the guidance (FDA, 2012). However, this guidance does not necessarily require the FDA's premarket review of nanomaterials in food, and the FDA has no special plans to require labeling for foods containing nanomaterials or manufactured using nanotechnology.

The FDA's stance stands in some contrast to that of the European Union's (EU) approach and legislation. The Novel Foods Regulation is the key EU regulatory document in which food with nanomaterials is implicated (Falkner, Breggin, Jaspers, Pendergrass, & Porter, 2009). Overall, the document covers food and food ingredients not consumed in the EU before May 1997, with the original goal to address GM foods; however, as it requires labeling of food and food ingredients produced with a novel process, nanotechnology in food easily applied. Accordingly, the European Parliament and European Commission put forth suggested revisions in 2009 for the Novel Foods Regulation to include food with engineered nanomaterials as "novel foods" and to mandate labeling of nanomaterials in ingredient listings. As a consequence of this and other policies, strong divergence of nanotechnology regulatory policy and risk management between the United States and EU is likely, leading to possible breakdowns or conflicts in international trade and regulatory agreement, among other problems.

Few studies have analyzed nanotechnology labeling issues, let alone addressed consumer perceptions and opinions of nanotechnology product labels. A premise not unique to nanotechnology products but well applicable is that labeling allows

consumers to purchase products while managing risks (D'Silva & Bowman, 2010; Stokes, 2009). Concepts of mandatory labeling systems are often invoked, but given the FDA's resistance to mandatory nanotechnology product labeling, voluntary schemes are also discussed and being embraced in a limited fashion (Falkner et al., 2009). Under a mandatory system, consumers would benefit from improved information flow, ideally correcting consumers' knowledge deficiencies in order to make a rational product decision (Stokes, 2009). Labeling, especially under the present nanotechnology context, additionally brings in socio-ethical concepts of consumer rights, specifically, "The right to be informed" and "The right to choose" (Kuzma & Besley, 2008; Throne-Holst & Strandbakken, 2009).

Major drawbacks for mandatory labeling involve presumed high cost to industry for compliance and possible confusion, information overload, increased risk perception in conjunction with decreased benefit perception, or providing misleading communication to consumers (D'Silva & Bowman, 2010; Siegrist & Keller, 2011; Stokes, 2009). Instituting a voluntary system may be viewed as a low-cost and efficient alternative to a mandatory system (Stokes, 2009; Marchant, Sylvester, & Abbott, 2010), but uncertain industry compliance, inconsistency of message/labels, and potential divergence of practices between sectors and industries present significant challenges for an effective system intended to inform consumers (Department for Environment, Food and Rural Affairs, 2008; D'Silva & Bowman, 2010; Stokes, 2009). Moreover, in the case of organic labeling, the voluntary nature of the system has put the burden on industry and consumers to pay the additional costs incurred to support the system (Kuzma & Besley, 2008).

As briefly referenced for mandatory labeling, but equally relevant to any labeling approach, accurate consumer understanding and label interpretation is essential. A label encourages consumers to engage in a cost–benefit analysis, though at the hazard of overestimating a product's risk of use (Stokes, 2009), reiterating consumers' likely perceived risk inaccuracy problems raised by Siegrist (2008). Along similar lines, Siegrist and Keller (2011) found Swiss consumer risk perceptions increased while benefit perceptions decreased at the mere presence of a nanotechnology product label on sunscreen. Troubles also may arise if consumers cannot ascertain the specific health and environmental risks; it lowers safety expectations for a product, or it is unclear or complicated such that a consumer truly cannot make an informed decision (D'Silva & Bowman, 2010; Pape, 2009). Consequently, labeling and consumer understanding issues are far from settled and much remains to be researched and debated.

Lastly, one of the most essential components of nanotechnology product labeling is public perception and opinion. Few studies address the topic and limited results exist, particularly because labeling matters are discussed secondarily or in conjunction with several other nanotechnology product issues. Based on a large citizens' jury in the UK, NanoJury UK, and among numerous recommendations, one relevant to labeling emerged: "All manufactured nanoparticles should be labelled (*sic*) in plain English, classified and tested for safety as if they were a new substance" (Pidgeon & Rogers-Hayden, 2007). Similar to NanoJury UK, a Swiss focus group event, nano-*publifocus*, addressed several nanotechnology aspects, with a key sentiment emerging that products with synthetic nanoparticles should be specifically labeled to inform users of what chemicals/compounds were present in order to

make an informed choice (Burri & Bellucci, 2008). Participants in Norwegian focus groups also implicitly voiced preference for nanotechnology product labels when discussing general nanotechnology matters and under the context of specific products (nonfood), implicating rights to be informed and choose (Throne-Holst & Strandbakken, 2009). Notably, despite consistency of results thus far, all such studies were based in European countries, and thus present representativeness challenges given varying perceptions among European and American populations. In summary, the dearth of nanotechnology product labeling research in the United States presents an important void to be filled, particularly in the expanding area of food products. This paper addresses this gap by exploring public perceptions of nanotechnology in food, and in particular labeling of such foods, through U.S. focus group discussions.

### *Methodology*

Studies eliciting public perception of nanotechnology in general and for specific applications and contexts have almost exclusively employed surveys. A few exceptions include Pidgeon et al. (2009) (use of a deliberative technique), Pidgeon and Rogers-Hayden (2007) (citizens jury at NanoJury UK), Burri and Belucci (2008) (Swiss nano-*publifocus* focus groups), Macoubrie (2006) (experimental groups), and Throne-Holst and Strandbakken (2009) (incorporated focus groups among other processes). Although food product label topics arose variably in the aforementioned nonsurvey studies, no study has heretofore employed a nonsurvey technique with a specific component designed to exclusively elicit public perception of nanotechnology food product labels. Thus, much of this essential information remains unexplored.

Focus groups are an effective nonsurvey technique for investigating public perception of nanotechnology food product labeling. While surveys are beneficial for inferential statistics and simplifying matters down to point estimates and intervals, they often overlook or completely ignore underlying processes or complexities participants use to select their choices. For the case of nanotechnology food product labeling, a survey can easily indicate frequencies of people who desire labeling. On the other hand, it cannot readily answer *why* individuals desire labeling or not, and even then, differentiate between various reasons of support or rejection. Focus groups facilitate detail-rich conversations and assist in unpacking the rationale behind preferences (Morgan, 1996). In addition to providing a medium for an open-ended response, the nature of hearing others' thoughts creates the potential for ideas to be activated in participants that they would not have had on their own, a so-called "group effect" (Carey, 1994; Carey & Smith, 1994; Morgan & Krueger, 1993). Therefore, the process behind making a decision, pieces of that process, and potential connections between concepts are more freely revealed.

Moreover, for less codified issues such as preferred labeling content or subjects for which little is known, a deliberative technique is far better suited than a closed-ended survey to produce and reflect the range and detailed thoughts of the public. In other words, it is difficult to design a closed-ended question for a topic whose best set of responses is unclear or impractically vast. Importantly, focus groups do not exclude the application of surveys and actually facilitate construction of helpful

closed-ended questions. That is, even with limited groundwork established by an open-ended, deliberative process like a focus group, closed-ended surveys may be designed around the range of views participants spoke to during the focus group (Morgan, 1996). Therefore, focus groups are an important tool for not only creating a framework for exploring public perception of nanotechnology food product labels and the rationale behind them but also for producing effective future surveys to home in on quantitative aspects.

Considering the previous research as a whole and the advantages afforded by focus group use, the following questions guided our analysis and discussion: What are the major themes raised by participants regarding nanotechnology food product labeling? What are consequent implications for future nanotechnology food labeling policy?

Seven focus groups, 90 minutes in length and ranging in size from seven to ten participants, were conducted between September 2010 and January 2011 in the Minnesota cities of Minneapolis, Richfield, and Bloomington, and the North Carolina cities of Raleigh, Garner, and Cary. Cities were selected based on the main city location, the largest suburb, and finally a randomly selected city between 30,000 and 60,000 residents, all within the counties of Hennepin, Minnesota, and Wake, North Carolina.

Participants were recruited using a stratified random sample, with the goal of having equal female and male numbers in each group, while matching a demographic county profile. Those who had a prior background in or extensive knowledge of nanotechnology were excluded from participation. The profiles were based on age, sex, race, education, family household income, and ideology (liberal, moderate, and conservative) criteria and generated by means of census data in conjunction with information supplied from select city community centers. Telephone and cell phone samples for each city were acquired and used to recruit 12 participants for each focus group, with the expectation of 75 percent attendance per group. Participants were given light dinner refreshments and $100 cash for their participation.

A total of 56 participants partook in one of the seven focus groups ($n_1 = 8$, $n_2 = 10$, $n_3 = 8$, $n_4 = 7$, $n_5 = 8$, $n_6 = 7$, and $n_7 = 8$). The overall demographic distribution contained more males (64 percent, n = 36) versus females (36 percent, n = 20); whites/Caucasians (84 percent, n = 47) versus blacks/African Americans (11 percent, n = 6) and Asians/Pacific Islanders (4 percent, n = 2); and those with a postgraduate or professional degree (27 percent, n = 15) versus college graduate (23 percent, n = 13), some college (16 percent, n = 9), high school graduate (14 percent, n = 8), technical college graduate (7 percent, n = 4), some high school (5 percent, n = 3), some technical college (2 percent, n = 1), and "Other" education (2 percent, n = 1). Race/ethnicity and education had n = 1 and n = 2 "No Answer" responses, respectively. The most common age bracket was 50–60 (36 percent, n = 20) compared with "Over 60" (23 percent, n = 13), 41–49 (23 percent, n = 13), 31–39 (7 percent, n = 4), and "Under 30" (7 percent, n = 4). Additionally, two provided "No Answer" for their ages.

Focus groups were executed by a moderator and note-taker, in addition to all groups being audio recorded. Transcripts for data analysis were constructed from the audio recordings, guided by note-taker notes. Data sources for each group

consisted of focus group transcripts, in-group worksheet responses (Appendix C), and responses to a postsurvey (Appendix D). Each group followed the same moderator-initiated topic and question flow, which occurred as follows: participants' first thoughts concerning nanotechnology, moderator's reading of a prepared general background statement concerning nanotechnology, resulting participant perceptions and reactions, moderator's reading of a prepared statement concerning nanotechnology in food applications, resulting participant perceptions and reactions, individualized completion of in-group worksheets, discussion concerning worksheet responses, discussion concerning nanotechnology food product labeling, and final participant thoughts.

Worksheets listed the broad nanotechnology food application areas, "Food additive," "Packaging," and "Processing," with space for participants to list their perceived benefits and concerns, in addition to selecting their willingness to use per application and advertised benefit, on a 1-to-5 scale. Postsurveys were emailed to participants after focus group completion and asked questions regarding issues related to nanotechnology in general and in food, including willingness to use, labeling, and regulatory matters. See Appendix A for the full focus group discussion guide, Appendix B for prepared background statements, Appendix C for in-group worksheet, and Appendix D for the post-survey.

Transcripts were analyzed using NVivo (QSR International Pty Ltd, Doncaster, Victoria, Australia) content analysis software by means of assigning codes to participants' statements. Both authors were involved in designing and executing the coding scheme. The lead author did the initial coding, and the corresponding author checked the results.

First, a large number of coding themes were generated based on typical terms arising in the emerging technologies and public perception literature (such as "Trust," "Risk," and "Benefits"). Second, numerous new coding themes were created inductively upon reading through focus group transcripts. A multilevel descriptive coding method was applied with most statements being assigned to one or more codes. Codes mostly fell into one of the three following categories: topic, intent, or a combination of both. Topic codes reference a specific subject raised by the participant, whereas intent codes were additionally assigned when some sort of preference or recommendation was supplied. As most statements involved preference or views regarding one or more topics, the majority of codes represented a topic-intent combination. In order to capture the range of issues, scope, and complexity in numerous comments, several codes were frequently assigned to account for concrete or specific issues raised and larger themes participants may knowingly or unknowingly have implied (e.g., concerns regarding nanotechnology's use in children's products speaks to the concrete issue of children's products in addition to the broader themes of risk and intergenerational differences).

As each group followed the same question flow, corresponding transcripts were easily divided into six phases: (1) unprimed nanotechnology perceptions, (2) general nanotechnology perceptions, (3) nanotechnology in food products perceptions, (4) nanofood product willingness-to-use worksheet and consequent discussion, (5) nanotechnology food product labeling discussions, and (6) final thoughts. Phase demarcations were determined based on the moderator's explicit transition questions or statements, which clearly specified what topic was to be discussed by

the group. Each phase elicited enough topic variety with respect to every other phase that separate coding lists were generated for each phase and applied across all groups. As a result, each phase contains a notable number of codes unique to that phase; however, many themes arose repeatedly across phases. Although all phases in each focus group were coded, analysis for this paper focuses on nanotechnology food product willingness to use and labeling (phases 4 and 5) from the group as a whole, as well as postsurvey results related to nanofood labeling. Future analyses are planned that will examine qualitative and quantitative responses to nanotechnology in food more generally.

Upon full transcript coding completion, the number of codes for each theme was tallied. Counts were assigned according to what constituted a complete expression of a theme or multiparticipant exchange regarding a theme. Codes with at least ten counts were isolated as key labeling themes. The resulting list of themes was refined to reduce redundancy and clarify meaning and dichotomized according to their relevancy to nanotechnology food product labeling. Regarding the latter point, themes associated with nanotechnology labeling, but for which labeling was not the specific subject of the comment or exchange, were classified as "related" themes, whereas the rest were considered "direct" nanotechnology product labeling themes. Direct themes more easily fell into a hierarchical structure, resulting in the creation of four main themes and several subthemes.

Quantitative worksheet responses from the focus groups (phase 4) and postsurvey responses were tabulated, analyzed using descriptive statistics, and graphically presented using STATA (StataCorp LP, College Station, Texas, USA).

### *Study Limitations*

Several limitations of our focus group study are worth noting. The small sample size (n = 56 for focus groups and worksheet responses; n = 34 for postsurvey) reduces inferential power for the quantitative worksheet and postsurvey results. Additionally, a small sample size coupled with underrepresentation for multiple demographics (e.g., non-Caucasians, females, those under age 40, and so on) restricts generalizability of results, whether quantitative or qualitative. For focus groups, however, this is to be expected as the goal is in-depth and quality discussions that explore issues heretofore under-investigated.

The nature of focus group execution presents further challenges. For example, introverted individuals may not participate as readily, and this potential imbalance skews the discussion toward the extraverted participants' ideas. A technique to mitigate this bias, which was employed by our moderators, is to directly ask quieter participants questions once a topic is generated. Although directed calling is effective at ensuring all views on a specific topic are eventually heard, more talkative participants nonetheless exert essential control as their initial contributions determine the topics to be covered. Extraverts will thus be overrepresented in the conversation flow.

Another challenge with employing focus groups relates to moderator-controlled variations. While one discussion guide (i.e., set of specific guiding questions) was used for all focus groups (see Appendix A), the moderator frequently had to ask various follow-up questions to maintain substantive dialog. Consequently, several

impromptu questions stimulating important exchanges were not raised uniformly in all groups. Fortunately, such variability was not widely problematic, as all focus groups consisted of the same six phases with the same preliminary prompts. Below we present the results from our study that relate to food and nanotechnology products and their labeling.

### *Key Nanofood Product Labeling Themes*

Table 1 presents a hierarchically arranged set of themes, with an example statement or exchange, raised during the labeling phase discussions. These themes related directly to nanofood labeling. Themes brought up in the labeling discussion but not specific to labeling for nanofoods are depicted in Table 2.

For the nanofood-labeling specific themes (Table 1), a two-tiered hierarchy was developed in order to intuitively group related themes. The major themes that emerged fall under the categories of "Label Preferences," "Label Use Moderators," and "Information Sources," each of which contains respective subthemes. Additionally, "Skepticism" was included as a stand-alone theme, as several statements regarding nanotechnology labeling invoked such a sentiment. Each theme and subtheme is discussed below.

"Desire for a label," "Usage and purpose," and "Characteristics" comprise the main parent theme, "Label Preferences." This covers statements regarding the content and views about the nanotechnology product label itself, and therefore speaks to factors intrinsic to the label. "Desire for a label" is a straightforward code, signifying valence toward a label's presence. Most participants who spoke on the matter voiced a desire for a nanotechnology product label (Table 3). Only one participant (out of 56) vocalized opposition to a label in this phase, while a few were unsure. Comments speaking to how someone uses a label, thinks a label is used, or for what purpose the label exists were counted under "Usage and purpose." Several kinds of functions were suggested, including treatment of the label as an informational device. Lastly, "Characteristics" address participants' sharing of concrete suggestions for a label's content or its location on a given product. The most commonly recommended characteristic was to display the label on a package's front side.

The second major theme, "Label Use Moderators," is composed of "Effectiveness and consumer behavior," "Regulation perception," and "Consumer choice perception." These subthemes help describe factors spoken by participants that are extrinsic to the label itself but still affect the label's use. "Effectiveness and consumer behavior" covers the numerous statements of concern pertaining to the usefulness and impact of a nanotechnology product label in terms of purchasing decisions. A significant view in this subtheme was how public lack of knowledge concerning nanotechnology or information on labels contributes to a label's ineffectiveness. The perceived ineffectiveness impacted how participants considered the purchasing of a labeled nanotechnology product, as suggested by this individual, "*. . . but putting that (label) 'made with nanotechnology' isn't going to mean anything to anyone, unless they know (what nanotechnology is).*" Six exchanges were sorted into the "Regulation perception" subtheme, which integrated opinions concerning regulation into a nanotechnology labeling context. Two key disparate views emerged. One participant voiced

**Table 1.** Nanotechnology Product Labeling Themes and Subthemes Raised During Phase Five

| Theme (Total Counts) | Sub-Themes (Counts) | Example Statements |
|---|---|---|
| Label Preferences (67) | Desire for a label (26) | Moderator(5): . . . Do you feel like this is something that should be labeled as being nanotechnology involved?<br>5.4: Yes.<br>5.5: If there are potential harmful side effects.<br>5.4: Especially if there is ongoing research I think it should be labeled. |
| | Usage and purpose (11) | 7.3: People should be informed too. Let's just say that there wasn't a label on there that this was nano or whatever and suddenly your children or you started feeling bad, you have no idea why, you are still drinking the same Pepsi you drank for the past 5 years but something has changed, it has a new nano can or whatever, you go to the doctor and nothing has changed so just inform people I think. |
| | Characteristics (30) | 4.3: Yeah, we don't want it in the small print on the bottom. I mean in the beginning I wanted it on the front, I want them to tell me it is in there, ten years from now maybe they take it off or they put it in the small print, I don't care anymore. |
| Label Use Moderators (30) | Effectiveness and consumer behavior (15) | 1.6: Well it depends how it is worded too. You know you can say anything on a package and people might not pay any attention to that. But how the wording is in it, will have a great deal on the effect it has on whether a person will view it negatively or positively. Happy little nano, ok fine! But bad nano? There is so much jargon that scientists use, or that advertiser's use that uh . . . what is the truth? |
| | Regulation perception (6) | 5.7: I don't think it is going to be our concern anyways. I think it is going to be up to the FDA. So if they say it is ok then it is ok. You know, they say they want it on the package then that is how it is going to be, if they say it is fine and you don't need to put it on the package then that is what it will be. I don't think it will be up to consumers to have a decision on whether they put it on packages or not. |
| | Consumer choice perception (9) | 4.6: Just like people are making the choice between natural, organic or not organic because now we kind of understand what that means. Even though labels are sort of not totally consistent but at least we understand the organic and now we can make the choice that we understand what it is. You just put nanotechnology in something without understanding it but if we begin to understand the difference we can make a choice. So if there was a difference and it came in both, people would want to understand the difference. |
| Information Sources (14) | Institution-based (7) | 2.9: I think the public should be informed and make sure they're understood. You know what I mean, that should be enforced and understood so there is not any mixed feelings so there is not any people that don't understand it, you know what I mean, everybody's got the same booklet and the same pamphlet and it describes exactly to a T, so I mean there is no . . . |
| | Personally-based (7) | 2.3: I mean with the government, I mean the food labels and things like that, you can get with the government I know they have free pamphlets you can get to the people. And the responsibility is on the individual to learn. You're either concerned, I know a lot of people will be incredibly concerned about it and some people think it is what it is, but it's still your responsibility, it is my responsibility to learn what I am eating. What is the information? If there is something that catches my attention I'm like . . . ok I want to do a little research. I'm going to go to that company's website, I expect to be explained to me in normal terms not legal terms, you know? Lawyer terms that no one can understand anything, but I think the real responsibility is on the individual. |
| Skepticism (6) | | Moderator(3): Would you like to say a label on all of that?<br>3.2: I don't think they will. They don't do it right now, what is natural, that has been a point of contention for a long time, you can't say it's natural because it's got what percentage of it is natural and what percent of it is chemical or whatever nano, so I think you know, I see it coming down to a big corporation marketing and it is going to be overwhelming with all the benefits and none of the drawbacks, you know if we buy a can of Coke and they did the advertisement the way they do the prescription drugs on TV you wouldn't even buy a can of Coke anymore because of all those disclaimers they put on there you know, a lot of those are like saving things but they want to advertise so they throw all those disclaimers. If they did that on the products we wouldn't buy all the products because of all the disclaimers they put on it. Are they going to have all the disclaimers on it, I don't think so. |

*Note:* "Counts" refers to the number of statements or exchanges coded for the given theme.

**Table 2.** Themes Participants Associated With Nanotechnology Product Labeling Discussions

| Theme (Counts) | Example Statements |
|---|---|
| Reference to existing products (57) | 2.3: Well you know you look at this [holds up Diet Coke], this has a warning on it, cigarettes have a warning in it, and yet people still drink it. It tells you what it is but if you don't know what this warning means, ya know? You don't know. |
| | 1.5: Although, I will give kudos to formulas, obviously a good thing, I have a ten month old kid myself, so we breast fed for the first couple months and then it has been formula ever since and I don't think they grow formula on trees and I don't think that comes out of cows but, somehow they genetically engineered it, and it's pretty darn good for my kid, so, he keeps gaining weight so, I suppose there is some positives behind it. |
| Risks (40) | 2.3: Well we don't really know about GMO. How is that going to affect us long term? Ok, I'm almost 50, I've got some concerns, but if I had a three-year-old child I am going to be more concerned. What is the long term because GMO products haven't been around that long in my lifetime but it is a potential everyday occurrence for a three-year-old growing up. It's like you said, you talked about the lead soldering, you know, I wasn't exposed to that but my dad was [Cross-coded under "Reference to existing products," "Past Information," and "Trust"] |
| | 3.7: At least I would say is that harmful to you it is not a . . . you need to know how nanotechnology affects your body, is it going to block your arteries, maybe one molecule will kill you, you don't know. |
| Willingness to use (36) | 3.1: Well you know we've got additives in everything we eat almost, unless it came out of the garden or you made it, and um you make choices like that all the time, but most of the time it comes down to the marketing that you have been marketed to and you say oh yeah that really looks good, I am going to try that, and then if you like it you keep on trying it and all of a sudden, no, let me read that package again, no I like it I will keep doing it, that's what it comes down to a lot. |
| | 5.6: I think it is a huge learning curve for the average person who would be comfortable saying I want to go buy this because it has nanotechnology in it. Most people would see nanotechnology, there are lots of 20 syllable ingredients we can't pronounce and we don't know what they are anyways. People are going to buy it, if it is not a wholesome food anyway, buyer beware. |
| Skepticism (26) | 4.3: If my lettuce rots tell them to call my lawyers see if I can get my money back. I'm just skeptical until I've been shown it's a benefit or not a benefit to me. I don't understand nanotechnology myself so I am skeptical of it, especially if it's going to cost me more money for something I can't prove to myself cause I may end up dead from it. It's like life insurance; it ain't much good for the guy who bought it for himself. [Cross-coded under "Benefits," "Reference to Existing Products" "Risks"] |
| | 6.7: It would really have to convince me it was worth paying more. Just because it says nanotechnology doesn't mean it's better. It would have to be something with my own research that convinces me. [Cross-coded under "Trust"] |
| Other product labels (23) | 3.6: I think the oversight is pretty extensive on the food industry and you know they have the label when it is in the same plant as peanuts and other nuts even if it doesn't contain any of those things and so I think it is going to be on a label, anything new like that is going to be on all labels, it is going to be required. [Cross-coded under "Trust"] |
| | 1.2: Labels are used now on just about everything and any kind of additive you've ever heard of and most that you haven't, trees and nuts with it on it, manufacturing |
| Trust (19) | 2.3: Well I think if you have a drug specific to you, so you are probably getting a doctor to prescribe it and I would expect my doctor to know, why do I want this drug over this drug, and I expect my doctor to explain to me, here is choice, which one do you want to use and I would ask his expertise opinion because in that respect I don't have that necessarily, I can do research myself but if I need something right away I'm going to ask the expert. [Cross-coded under "Reference to existing product" and "Willingness to use"] |
| | 7.5: You said already with labels on cigarettes cause these problems. I mean at least inform the public and let them make the decision themselves. Like he said if it looks good I am going to buy it, I don't care for it, I trust people the FDA, the people producing it to make sure it is edible and nutritional or whatever. [Cross-coded under "Reference to existing product"] |
| Testing (16) | 7.5: Yeah but if you say I am going to do 5 years research, I'm going to do 10 years, I'm going to do 15, then you're 15 years off from making any money and your company doesn't produce. You have to draw the line, I did 5 years of this and simulated this for 15 years, let's go to production. |
| | 5.7: There is always going to be a group of scientists somewhere that is going to dissect what you put in foods. Anything that comes out, especially any new technologies is going to have scientists, going to have some group that says, we tested this and it is going to fail your kidneys. There is always a group that is going to dissect when a new product comes along. [Cross-coded under "Risks"] |

| | |
|---|---|
| Concern for public's interest (15) | 1.7: Well I think it might be a mindset too. Are they really out to hurt me? Or are they really out to give me more nutrition?<br>1.1: I agree, I would think more along the lines that they are trying to do something good.<br>1.7: Yeah, agreed<br>1.1: They're not trying to . . .<br>1.8: Do us all in<br>1.1: Well, or, take over our minds with some kind of control<br>[Cross-coded under "Risks" and "Trust"]<br>4.3: I don't think any technology is brought in, in our best interest except for money, money brings in technology, they can sell it to you and make money on it, they will research it trust me. [Cross-coded under "Skepticism" and "Trust"] |
| Past information (15) | 4.1: Remember eggs were no good for you; bacon was no good for you.<br>4.5: Even vodka is good for you.<br>Group: (Laughs)<br>4.3: Eat fish, but don't eat it if it came out of that river or this lake or . . .<br>[Cross-coded under "Reference to existing products"]<br>3.4: Take this stuff, it used to have NutraSweet in it, everybody drank it and then they get the long term effects on it and then all of a sudden I can't even pronounce this word, it contains this product so it's there you know.<br>3.1: Psycho mated soft drinks in Canada.<br>3.6: Globally where is this going to go.<br>3.1: But then you got studies that say that study was no good. What studies do you believe?<br>[Cross-coded under "Reference to existing products," "Risks," "Skepticism," "Testing," and "Trust"] |
| Benefits (14) | 3.6: No, I don't know if something like this came up, a product come out I don't know that naturally everyone would gravitate towards it, I mean naturally there would some that are not all that concerned anyways, and they go oh this tastes better trial, but in general people, there is a hesitancy when you come out with something like that. I think a lot of people have the common sense. [Cross-coded under "Skepticism" and "Willingness to use"]<br>4.3: So like if my lettuce lasts for three weeks in Canada with no refrigerator I will pay a nickel more for the bag.<br>4.7: That is new and improved.<br>[Cross-coded under "Reference to existing products"] |
| Nutrition and health (10) | 5.8: I have been trying to do a better job. I go to the gym for the last year and a half or so and I am trying to focus more on the healthy fats, proteins, and good carbs, just try to focus on those a little better stuff. When I was a freshman in college I just ate whatever was in front of me.<br>Moderator(5): So you still don't read the labels though right.<br>5.8: Um, I have started to look at labels for the specific items but I don't read the whole ingredients.<br>4.7: Trans-fat, when that came out that was big, it was big on everything, now it is on the back.<br>4.1: Now it is big that it says zero trans-fat.<br>4.7: It was such a big deal, but I think when this comes out people are going to be curious about it and you know try some things and see if there is a difference but I think it depends on how it's given to the public and how it's delivered.<br>[Cross-coded under "Reference to existing products," "Other product labels," and "Risks"] |

*Note:* "Counts" refers to the number of statements or exchanges coded for the given theme. Almost all statements were coded under multiple themes, i.e., "cross-coded." However, such cross-codes are highlighted for other themes only present in this table.

**Table 3.** Participant Labeling Preferences

| Response Category | Counts | Example Statement/Exchange |
|---|---|---|
| Yes | 17 | 2.5: With food I don't care about everything, I'm the kind of shopper, I go to the store, I don't look at the calories, I don't look at the fat intake, I don't look at the sodium, I buy what I want to buy, but if it has this nanotechnology I would want to know, I would want everything labeled. |
| No | 1 | 7.6: Virtually I mean think of how many years that we, it is extremely common and beneficial practice that we use pesticides for food production. We did not label that these foods have pesticides on them. Now today we label them if they don't have pesticides on them but we didn't do that then, and we can say what we want about pesticides but if we did not use pesticides in this country, we should go around and decide which 1 out of 3 of us would starve to death and that is just a fact, so we didn't label that. There was some talk about labeling food if it was genetically engineered, but I don't remember seeing a label that says genetically engineered. Not in all the corn you were talking about, not in the cows you were talking about, dairy cows are giving that additive that increases milk production, so we are not doing that. I don't think labeling is a real, I wouldn't want the public to construe labeling as nanotechnology as protection because it's not. If there is something unsafe we need to identify it, prove it and stop using it. We don't need to label it and everybody use it anyway. |
| Mixed | 3 | 4.6: Depends on the risk. Well if we find out more information and they say it causes cancer in rats, like smoking does, some of us are going to choose not to smoke because of that. It depends on the risk. Then I would want it large enough where I would notice it. The risk is well, it might just like everything else we eat, and I might not pay any attention to it. |
| Apathetic | 6 | 4.3: I don't care about the labeling on the food. I want to know it's safe, before the people making the food start using it. The government, I don't care who tells me, I want somebody who knows what nanotechnology is, is putting it in the food or whatever, I want them to publically say this is safe, will not harm you, we guarantee it. |
| Unsure | 1 | 5.4: When it comes to the time when we know what it means, it might be made prominent. It might be required to be made prominent and attractive for the producer. The producer might say this is going to be a big thing because of what the society now makes of it. But we are not there yet. |

*Note:* One statement and one exchange each presented two categories of labeling preference and were coded as such.

confidence that the FDA would eventually require a label, "*I think the oversight is pretty extensive on the food industry and you know they have the label when it is in the same plant as peanuts and other nuts, even if it doesn't contain any of those things, and so I think it is going to be on a label, anything new like that is going to be on all labels, it is going to be required*." while another voiced much skepticism concerning the FDA's actions (see example quote in Table 1 for "Skepticism"). The "Consumer choice perception" subtheme involved statements from vocal proponents of label implementation. Consumer choice and the right to be informed were reasons for desiring the label and were typically invoked in these exchanges. The label therefore acted as an enabler of consumer choice from their perspective. For example, in the words of two participants, "*I think it's about giving people the information so they can make a choice, so the individual can make a choice*" and "*You make your choice. You want it you buy it, you read it, you don't want it, and you don't buy it*."

"Information Sources" as a parent theme focuses on the issue of how the public should acquire their knowledge concerning nanotechnology in order to understand a label on a nanotechnology product. Relevant remarks were dichotomized as either "Institutionally based" or "Personally based." "Institutionally based" comments incorporated the judgment that governments or businesses should be or

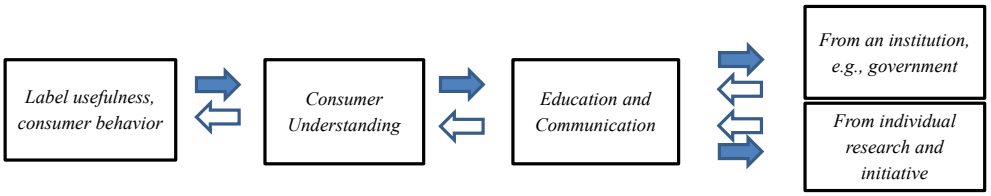
have been the source of public information and education. Such statements were generally tied to other issues like trust, as in this comment, "*I just hope that the industry would try to do an appropriate job and say hey this is in here or it is made with this kind of processing plant, if you are forthcoming then you don't have to tell as many lies later.*" Comments coded as "Personally based" stand in contrast to institutional accountability. These participants implied that the consumer should take charge of their own learning and bear the responsibility for searching for information regarding nanotechnology in products or on a label. As in the case with "Institutionally based" comments, other issues were wrapped into the statements. For example, skepticism underlies this person's words, "*It would really have to convince me it was worth paying more. Just because it says nanotechnology doesn't mean it's better. It would have to be something with my own research that convinces me.*"

Lastly, a few comments asserted suspicion or skepticism in a nanotechnology product labeling context and were accordingly assigned as "Skepticism" statements. Importantly, some participants doubted that labeling would be implemented or that consumers would have a voice in the decision-making process surrounding such implementation. Skepticism also was a prominent theme outside of direct references to labeling in phase 5 (Table 2). We see skepticism as overlapping with, yet distinct from, trust, in that it implies a lack of faith not only in institutions but also actions or what will happen.

Participants brought up other themes during phase 5 that did not necessarily coincide with or refer specifically to comments on food nanotechnology labeling. In order of frequency, these included: reference to existing products (n = 57), risks (n = 40), willingness to use (n = 36), skepticism (n = 26), other product labels (23), trust (n = 19), testing (n = 16), concern for public's interest (n = 15), past information (15), benefits (n = 14), and nutrition and health (n = 10). These themes give an indication of what participants associate with nanofood labeling. The results generally reflect previous literature on public perception of nanotechnology (as discussed above), with significant attention to risks, trust, and benefits as people form opinions concerning nanotechnology products. In these comments, there seemed to be more attention to risks and testing than benefits, which supports more recent studies on nanotechnology labeling indicating that labels increase risk perception (Siegrist & Keller, 2011). However, a new discovery in our conversational settings is that participants rely heavily on experiences with all sorts of other products and their labels in order to form opinions concerning nanotechnology and food labeling. They logically turn to historical experiences in the face of new situations.

### *Thematic Flow for the Public's Effective Use of a Label*

A core of set of connections between statements in the labeling discussions dealt with the larger issue of how the public can effectively use a nanotechnology product label for a purchasing decision. Figure 1 presents a flow of major nanotechnology labeling themes, as formed by strings of participant exchanges. Through such sequential comment analysis, the components that emerged in determining "Label Usefulness" were "Consumer Understanding," which is dependent upon "Education and Communication," which can be employed using an "Institutionally based" approach or a "Personally based" approach as discussed above.




**Illustrative statements:**

Moderator(4): So let's just imagine for a minute they are labeling all those things. The products are labeled. Would that change your feelings about purchasing them?
4.1: It all depends on if we understand what this is going to do to us. I don't care if it is the government who is going to teach it to us, whatever. We have to know.

2.9: Well if there was a bottle of nanotechnology aspirin and a bottle of regular aspirin and I know that the nanotechnology aspirin was going to work faster and better I would buy the nanotechnology aspirin.
2.5: See I wouldn't. Because I just couldn't, maybe if it's been out there for awhile.
2.3: But maybe you would if you understood it.
2.5: Yes, if I understood it, I would
2.4: Education
2.5: I would educate, but the nanotechnology in food, I would go home and read about it

**Figure 1.** Thematic flow for the public's effective use of a label
The ability for a consumer to sufficiently use a label in order to make a purchase decision emerged repeatedly across groups through several themes that naturally form a dependent chain. Light arrows show the order of influence, with education from institutions or individual initiative ultimately impacting consumer label use. Dark arrows represent how the given factors arose in conversational flow, starting from the issue of, "Would/how you, as a consumer, desire/use a nanotechnology food product label?" Light arrows thus read as "influences," and dark arrows read as "depends upon."

The concern about "Consumer Understanding" of labeling stemmed from a wide array of participant comments invoking uncertainty about what nanotechnology is. In short, such comments took the form of "*How can I interpret a nanotechnology label if I don't know what nanotechnology is?*" We see this as a "self-aware knowledge-gap" in the context of labeling. The next step expressed by the participants would be to engage in education or communication of some kind. Comment-wise, these took the form of an answer to the question posed above, "*We first must understand what nanotechnology is*" in order to interpret a label. Demanding to understand nanotechnology necessitates the final component: "*Who does the educating/communicating?*" Participants who spoke to the matter presented two choices of either an institution such as government or industry or simply the individual taking it upon him/herself to self-education through the web or other media. No obvious preference or consensus was reached within any group concerning which of the two sources (external entities supplying the information or self) should be relied upon more heavily.

### *Label Purposes*

In the phase 5 discussions, consideration of whether or not nanotechnology food products should be labeled elicited a range of responses, with "yes" being the most common (Table 3). Only one participant answered "no," but did so in the context of desiring to avoid a false sense of protection that labeling might provide if a given nano-ingredient was unsafe. A few voiced mixed/tentative reactions or apathy. The

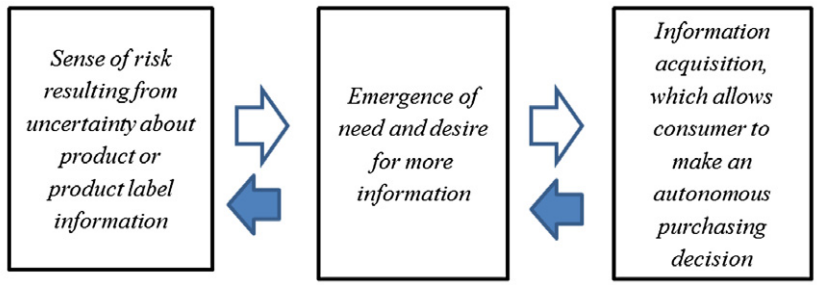



**Figure 2.** Thematic flow for public's sense of a label's purpose
Light arrows read as "influences," and dark arrows read as "depends upon."

major threads running through these exchanges were how the level of risk determined the necessity of the label or that certain individuals simply do not read labels, making labels meaningless to them. Regardless of labeling preference, the connection of risk to most all responses was evident, which implies how participants conceptualize nanotechnology's interaction with food and the purpose of a label.

Extracting the motivations behind the labeling support reveals that those who cited a reason for desiring a label did so primarily in the context of desiring information in order to be allowed to make a choice (Figure 2). Consumer choice and desire for information often were justifications on their own merit, "*I think it's about giving people the information so they can make a choice, so the individual can make a choice*." In contrast, one elaborate statement reflects an expansion upon consumer choice as one's autonomy to avoid or accept risk: "*So is it 2% nanotechnology, now I can at least make an informed decision about how much risk I am taking. If they can find a way to say it's nanotechnology, and it was for the processing of it, and it was cheaper for you, and we could ship it longer, and nothing to do with making it more nutritional, then I am less likely to say well I'm a buyer, so I'm going to take a risk because it will increase your profit margin, not so much.*" Risk was a strong theme throughout all focus groups in the labeling discussion phase and an important factor motivating consumer choice (Tables 1 and 2). Thus, when participants invoked consumer choice in a labeling context, they had risk in mind or saw consumer choice's value on its own principle.

Another dimension of label purpose that participants mentioned was fear. Two people invoked the idea that a label scares consumers: "*I think labeling scares people . . . I think they're trying to improve, but that is why labels are scary because the way they're worded . . . All the long, long words*" and from the same focus group and conversation, "*I would think so too, it scares me, and well it's all, a circular saw.*" The idea of a fear response as it relates to nanotechnology aligns well with Siegrist and Keller (2011), in which Swiss consumer risk perceptions increased while benefit perceptions decreased at the mere presence of a nanotechnology product label on sunscreen.

Putting the pieces of labeling preference and purpose together, the result is a picture of labeling in which risk and autonomy underlie most every relevant statement. Additionally, with the exception of comments citing to "Scare" as a label's purpose, all others linked to a sense of product risk, a need for information, and

a need to make an autonomous choice (Figure 2). An important connection to make for labeling policy is how label purpose reveals suggestions for labeling characteristics.

### *Label Characteristics*

In our groups, participants covered several areas of label characteristics but were mainly focused on communication and presentation issues. Interestingly, statements fell into one of two groups: how labeling *should* be versus how labeling *will* be. Although moderator prompts were geared to elicit the former, the latter emerged often, possibly indicating among participants a sense of concession to whatever regulators or companies decide. As examples, one participant maintained that the FDA will require nanotechnology to be on the label, while another cynically asserted that companies will hide behind marketing and fail to reveal anything potentially negative on a label. Both views demonstrate what *will* happen in their minds in response to a prompt about what *should* happen. This can further be viewed as an example of "Skepticism," a major theme present throughout the focus groups.

Regarding what a label communicates and what it should communicate, concerns and differing views existed. A few participants contended labels tend to use jargon or "long" words and evoked "scary" connotations. More generally, one person raised a simple yet profound point that not everything can be put on the label, while another had little idea how one could label something as "nanotechnology," given the broadness of the term. Related to handling nanotechnology's breadth as a term, two individuals shared starkly contrasting suggestions for what the label should say. One suggested the label remain "neutral," with the words "This product is enhanced with nano-materials." On the other hand, another proposed listing the percentage of the food composed of nanomaterials, in addition to the purpose/benefit of the added nanomaterials. Lastly, two participants independently suggested the addition of a website or a phone number to call if consumers wanted more information concerning nanotechnology used for or in the food product. Although a wide variety of ideas were presented, the dominant inclination is to provide as much information as possible, even in light of information overload or jargon. This connects to the many comments concerning a label's risk communication purpose (see above). This view is further supported when considering the remainder of nanotechnology labeling comments.

When considering label location and presence comments, some straightforward sentiments emerged. A slight majority of participants voicing preferences in this area advocated for front-of-package placement and/or with a large display or words. In contrast, the remaining ones suggested placing a nanotechnology identifier in the ingredients instead, especially if the nanomaterial is a food additive. Looking more specifically, those supporting front-of-package labels did so with different contexts. One called for a large front-of-package label if the "risk" of product usage was high enough, otherwise the participant would likely ignore a label if no notable risk was involved. In contrast, others simply wanted the front label to be applied at a product's outset, with one conceding to the label's removal or reduction to "small print" after ten years. The implicit assumption is that after enough time a label will not be necessary, given what will presumably be known about nanotechnology in

food products. Two other views raised but not widely discussed were using more noticeable print size for children's products (particularly if allergies are implicated), and application of a nanotechnology symbol or icon. Front-of-package and large size were the predominant ideas again indicating the label's risk communication purpose.

Finally, a group of statements spoke to label skepticism, which was addressed in conjunction with a label touting benefits. Sentiments expressed presumed if nanomaterial benefits were displayed on the front, then nanomaterial risks would be hidden on the back. Moreover, a strong concern existed among a few vocal participants that the risks would be lost among marketing messages talking purely about nanomaterial benefits. Skepticism thus perpetuated negativity regarding industry's role in communication concerning nanotechnology food products.

### *Survey Opinions of Different Nanofood Applications and Labeling*

In the fourth phase of each focus group, prior to in-depth discussions concerning nanofood labeling but after some learning about nanotechnology in food, participants were given worksheets and asked to indicate their willingness to use three different nanotechnology food applications per four functions of the application on a one-to-five scale (see Appendix C). All 56 participants completed the worksheet. The three application types were food additives, packaging, and processing, each of which was clarified on the sheet with a small graphic and descriptive preposition (i.e., "In" food, "On" food, and "For" food, respectively). The four functions assigned to each application are "Enhance Experience (e.g., flavor/color)," "Enhance Nutrition," "Prevent/Reduce Spoilage," and "Cheaper Production." Thus, each participant supplied up to 12 willingness-to-use responses. Worksheet results are shown in Figure 3. These results are limited in their statistical meaning (n = 56); however, we present them as supporting evidence for the qualitative comments and previous literature on public perceptions of different nanofood products (e.g., Siegrist et al., 2007; see also the "Public Perception of Nanotechnology in Food" section above).

Participants were more willing to use nanotechnology food applications involving packaging (combined mean across four functions = 3.5) than either food additives (combined mean = 3.0) or processing (combined mean = 3.0). The stronger willingness to use a packaging application relative to other nanotechnology applications aligns with previous results demonstrating the public's higher benefit perception of nanotechnology in food packaging compared with in food itself (Siegrist et al., 2007). More specifically, participants were most willing to use nanotechnology food packaging for the beneficial functions of enhancing nutrition (mean = 3.7), reducing spoilage (mean = 3.9), and leading to cheaper production (mean = 3.5). Focus group comments align with these results, with statements such as, "*. . . I think the packaging is the most appealing at least to me. I would think the public in general, the use of this in packaging is probably most appealing and [would] have the least number of concerns*" and "*I would be 100% for if I knew this was something that was going to increase the life of the food and I would know that it didn't have anything to do with altering the food at all*." Despite the higher relative packaging support, participants raised concerns, as they did with all applications, citing health concerns among

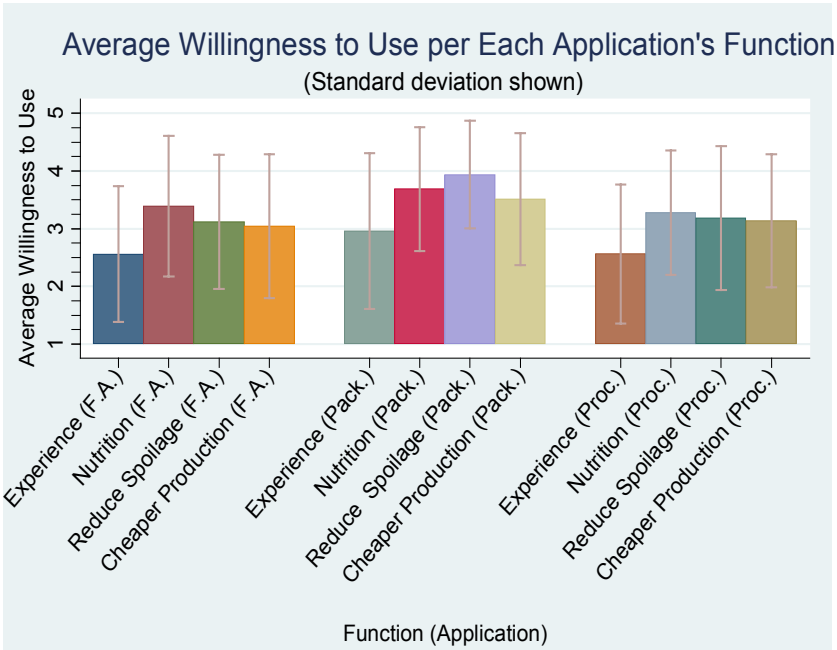



**Figure 3.** Average willingness to use of a nanotechnology food application for different benefits/functions of the given application. These results are from the in-focus group worksheet responses and all participants filled out the worksheets (n = 56). "F.A." = Food Additive, "Pack." = Packaging, and "Proc." = Processing.

others, e.g., "*You don't know if those packages are going to put something into the food itself, you don't know that. . . .*"

In contrast, participants were least willing to use nanotechnology to enhance experience, particularly across food additive (mean = 2.6) and processing applications (mean = 2.6). Numerous comments illustrated such limited willingness-to-use, with one participant noting "*. . . everything we have is nothing but an additive, we are just going to turn out to be one big chemical one of these days, and if the whole purpose is aesthetics, we don't need brighter orange carrots, we really ought to eat a carrot that looks like a carrot . . .* ," while another asserted "*I don't want anything added to it unless I add it, so I would be concerned knowing something that has been put in it, so-called 'enhance my experience,' I want to enhance my experience*."

In the days following completion of each focus group, a quantitative postsurvey was emailed to participants of each respective group (see Appendix D). The survey fulfilled the purposes of attempting to quantify participant views regarding select topics explored in the groups (e.g., desire for a label), generally comparing and contrasting results with focus group data and capturing certain ideas not necessarily discussed in each group (e.g., willingness to pay or willingness to avoid nanotechnology food products). Electronic postsurveys were completed by 61 percent (n = 34) of the total focus group sample. Although the limited sample size restricts the use of reliable inferential statistics, the postsurvey results provided additional support for qualitative and in-group worksheet results. As this paper's aim is to capture the qualitative aspects of the public's perceptions, postsurvey results are summarized only in brief, as follows.

Postsurvey results generally align with in-group discussions, while supplying new insights to be explored in future surveys. Regarding comfort with the idea of nanotechnology and engineered nanomaterials, packaging applications were again rated more favorably than both food product and processing applications, agreeing with in-group worksheet surveys, discussions, and findings by Siegrist et al (2007). Furthermore, when asked to compare risks vs. benefits across all three applications, on average, packaging was rated as having more benefits than risks. On the other hand, food products and processing applications were on average seen as having slightly more risks than benefits.

When considering labeling, as was strongly indicated throughout all groups, postsurvey respondents highly desired supplementary labeling for all food applications using or containing nanomaterials. More specifically, food product labeling was the most desired while packaging labeling was the least desired, albeit still clearly supported. When considering issues of label regulation across focus group conversations, postsurvey responses reinforce the mixed though generally positive views of support and trust in the FDA. A majority of postsurvey participants indicated some or complete trust in the FDA regulating a label specific for nanotechnology. However, several selected some or complete distrust in the FDA to regulate a label, matching the presence of some mistrust and skepticism from in-group comments.

Lastly, monetary issues surrounding willingness to avoid nanotechnology food products and willingness to pay for a supplementary label rarely surfaced among focus groups. Postsurvey results thus provide the initial insights. Notably, a majority of the postsurvey sample indicated that they would be willing to pay an additional cost not only for a nanomaterial-free product (in contrast to the same product with nanomaterials) but also for a product to be given a nanotechnology label if it contained nanomaterials. About 40 percent of the survey sample, in contrast, was not willing to pay extra for a nanomaterial-free product or nanotechnology label, and those willing to take on the additional costs varied noticeably in the cost amount selected (from 5 to 25 percent). Given the small sample of participants in the postsurvey, we suggest further large-scale studies to better determine the percent on average that consumers are willing-to-pay for nanotechnology food product labeling or willing-to-pay to avoid nanotechnology food products. However, the importance of learning about nanotechnology in conversational settings prior to such large-scale surveys (as in our focus groups) should be considered, as participant knowledge is likely limited.

## Discussion

This study is the first, to our knowledge, to concentrate on public attitudes toward nanofood labeling in the United States. As such, we took an exploratory and grounded theory approach to reveal insights that could be important for developing policies and programs. Focus group discussions, in-group response worksheets, and postsurvey results from this study begin to form a picture of what people view as important for nanofood governance and labeling more specifically. Future studies will be needed to further explore these results, as there were several limitations to this study including the small sample sizes for the postsurvey ($n = 34$)

and focus groups (n = 56) in the context of applying inferential statistics, sample underrepresentation for some demographic variables, potential overrepresentation of extroverted opinions in focus group conversations, and intergroup moderator consistency (see also the "Study Limitations" section above). These limitations are often associated with focus group research.

The impetus for this work is the view that consumers deserve a voice in decisions concerning food products that affect them and that they may ultimately decide the fate of nanofoods; therefore, decision makers attuned to their desires and needs are apt to formulate more fair and effective policies. Below we summarize the key insights gleaned from the work that could be used to inform public policy on nanofood labeling.

Labeling discussions activated numerous topics directly and indirectly related to nanofood product labeling. Skepticism and the influence of historical experiences were two themes that emerged in this study that have not been extensively covered in previous literature on public perception of nanotechnology. Participants were skeptical concerning actions, intentions, and promised outcomes, often without reference to particular organizations or their trust of them. In part, skepticism stemmed from historical experiences with other product domains like pesticides, nutritional and allergenicity labels, and prior food safety claims. Participants relied heavily on previous experiences related to nanofood labeling in order to form opinions on this new domain.

From the flow of the comments, a model of reasoning with regard to labeling was developed: label preferences are dependent on label use moderators, and ultimately need backing by outside educational sources and programs. Label preferences, label use moderators, and information sources were meta-themes through which participant reasoning and attitudes concerning nanofood labeling could be better understood. They also provided a framework of analysis conducive to examining policies for food nanotechnology labeling. Most participants desire a label for the purpose of an informational device, triggering them to seek more information and allowing them to make their own choice about risk tolerance. Overall, the participants expressed a strong desire for more information on food nanotechnology before forming solid judgments of the products. Strong preference emerged for a prominent, front-of-package label. A label is viewed as effective when the information on the label is understandable and leads to abilities for consumers to make an informed decision concerning consumption or purchasing. Education and information sources outside of the label were deemed very important. Participants placed responsibility on external groups such as government agencies to engage in outreach and education concerning nanofoods, as well as on themselves to take initiative to learn about nanotechnology. If product labeling falls under a mandatory government-regulated system, participants recommended that some form of education or outreach must occur in order for consumers to effectively use and make decisions using a label. From our focus groups, consumers want education concerning nanotechnology concomitantly with a nanotechnology label on food products, and they are self-aware of their limits in interpreting labels without relevant information. Ideally, trusted institutions would provide an accessible and organized clearinghouse of relevant information concerning labeled nanofood products, particularly information related to safety.

There were several concerns voiced regarding voluntary- or company-applied labeling schemes, citing skepticism related to their use as marketing tactics and their lack of transparency. In contrast, there was considerable trust in the FDA to manage a labeling and information program for nanofoods, as expressed in the focus group discussions and postevent surveys. Yet some participants were skeptical whether the FDA will require nanotechnology product labeling, and rightfully so. The FDA does not currently intend to label food nanotechnology products as containing nanomaterials. The agency's policy with nanotechnology foods mirrors its previous approach with biotechnology-derived foods, citing a lack of authority to label under the Federal Food, Drug, and Cosmetic Act without clear reasons associated with safety or substantial changes that would affect health (FDA, 2007). Regardless, the FDA's recent guidance on food substances manufactured using emerging technologies, including nanotechnology, does single out nanofood substances for premarket voluntary consultation. The agency states, "*At this time, we are not aware of any food ingredient or food contact substance intentionally engineered on the nanometer scale for which there are generally available safety data sufficient to serve as the foundation for a determination that the use of a food ingredient or FCS is GRAS*" (FDA, 2012). Thus, it seems as if the FDA is giving special attention to nanotechnology in food products and is questioning their safety as a group. However, it should be noted that there is no specific requirement for nanofoods to undergo mandatory FDA premarket approval processes.

Safety studies on food nanotechnology are emerging to suggest that nanomaterials in food can absorb through a healthy gastrointestinal tract, produce systemic adverse effects (Card, Jonaitis, Tafazoli, & Magnuson, 2011), and decrease nutrient absorption (Mahler et al., 2012). However, adverse effects of nanomaterials in food will remain uncertain for some time, as human risk-relevant studies are lacking (Card et al., 2011), funding is limited for such studies, and risk will depend on specific nanofood products. Not all nanofood products will be hazardous to human health, though it could be argued that until more testing is done, nanofoods warrant additional labeling on the basis of safety, given the special penetration and reactivity properties of nanomaterials in biological systems.

The other argument for nanofood labeling is perhaps the more salient one and is based on our focus groups. Labeling is what consumers want for reasons of choice and to avoid risk (however minimal) until the uncertainty associated with the nanofood products that they purchase is reduced. Not only do the vast majority of participants want labeling, but also most are willing to pay a premium for it, as well as to pay to avoid purchasing nanotechnology food products altogether. The participants had clear views that labeling fulfills their rights to be informed (informed consent).

Diving deeper into participant perspectives and merging major labeling themes reveals that a nanotechnology label is likely a risk heuristic. This has implications for thinking about preferred labeling content and characteristics. Although a front-of-package label was spoken to most clearly, content suggestions were widely variable with no obvious consensus for a favored phrase or symbol. While label presence was strikingly desired among participants, there were limited perspectives concerning the label itself. Future studies should investigate preferred and effective labeling

characteristics by applying several sample labels on actual products and using them in survey or deliberative techniques with consumers.

Labeling studies should also explore whether different types of labels would be warranted for different types of nanoproducts. Although labeling was desired for all types of nanofood products in this study, differences in willingness-to-use and risk–benefit perceptions among them were found. Nanofood packaging was the application that participants were most willing to use, compared with food additives and processing applications. Food packaging applications of nanotechnology also exhibited the most positive risk–benefit perceptions. Preference for packaging above other applications confirms a similar finding by Siegrist et al. (2007), which employed quantitative survey methodologies in Switzerland. When comparing willingness to use for functions of nanofood applications, reducing spoilage and enhancing nutrition were rated more highly than enhancing experience and cheaper production. The former two speak to more health and societal benefits. Cheaper production seemed to have been less favored purpose of nanotechnology in food, in part due to participant views that cost reductions would not likely be passed along to the consumer. It is possible that different types of labels are warranted for different nanofood products given the purpose of labels as risk-information seeking triggers.

The results from this study lay groundwork on a wide range of topics to consider for nanofood labeling policy, such as public preferences related to labeling content, labeling characteristics, willingness to pay, willingness to avoid, and information concerning risk and safety. These topics should be explored using larger and more representative samples of the public in the United States. Additionally, focus groups or other deliberative techniques to evaluate sample labels and test education and outreach materials would provide salient contributions to nanofood governance and labeling policy that is effective and meets the needs of consumers. Of course, the need for such studies presumes a desire on the part of decision makers to listen to consumers, in addition to technical experts, when it comes to food and nanotechnology. Regardless, from this analysis, we illustrate how insights from conversational settings can help decision makers sort through the complexities of public perceptions and desires in order to craft effective policy surrounding food nanotechnology.

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## Appendix A: Focus Group Discussion Guide

**Stage I: Initial thoughts on Nanotechnology**

*Step 1: Start with initial open-ended question to which respondents will quietly write down their answers:*

**Phase 1. What comes to mind when you hear the word "nanotechnology"?**

*Step 2: Moderator collects written answers and initiates discussion about participants' responses*

*Step 3: Moderator reads a prepared background document covering two topics; participants will receive the background document as a handout after the moderator finishes reading:*

- General nanotechnology information document [see Appendix B]

*Step 4: Follow-up question for discussion:*

**Phase 2. What are your thoughts about nanotechnology now? Did any thoughts change?**

**Stage II: Nanotechnology Food and Agriculture Products**

*Pre Step: Moderator reads a prepared background document covering two topics; participants will receive the background document as a handout after the moderator finishes reading:*

- Nanotechnology in food products and packaging document [see Appendix B]

*Step 1: Start with questions for discussion:*

**Phase 3. What additional benefits and opportunities do you think there are for nanotechnology-based food and agriculture products?**

**What about additional concerns for nanotechnology-based food and agriculture products?**

**Phase 4.**

*Step 2: Distribution of product category work sheet:*

*Step 3: Participants fill out work sheet and then discuss their responses, which attempts to get at following question:*

**What products were you most and least willing to use? Why?**

**Stage III: Labeling**

**Phase 5.**

*Step 1: Continue with discussion questions:*

**Should these products with nanomaterials be labeled as having nanomaterials? Why?**

**Which product categories are most important to label? Why?**

**How would the presence of a label change your willingness to buy a nanotechnology-based food or agriculture product?**

*Step 2: Additional questions if time permitting:*

**What if these products were more expensive as a result of labeling? What is your willingness to buy these products? (closed responses on a survey would list additional cost amounts and an original price as a baseline reference)**

**Where would you like to see the label on the product?**

**What content would you like on the label?**

**Stage IV: Final thoughts**

**Phase 6: Do you have any final thoughts on nanotechnology, nanotechnology in food, or labeling?**

## Appendix B: In-group Informational Documents

### *Nanotechnology Overview*

Nanotechnology is a broad term that encompasses a variety of science and technology at a very small *scale*: nanotechnology refers to the manipulation of matter at the *nanoscale*. A "nanometer" (nm) equals one-billionth of a meter, the width of ten hydrogen atoms side-by-side. By comparison, a DNA molecule (genetic material of living organisms) is about 2.5 nm wide and a red blood cell is about 5,000 nm in diameter. Nanotechnology refers to a suite of techniques used to manipulate matter with precision at the scale of atoms and molecules. At the nanoscale, only the most powerful microscopes are able to actually see objects. (See Fig. A1 for a length scale with examples of different objects at different sizes.)

A critically important aspect of manipulating matter at the nanoscale (below 1000 nm) is that a material's properties can change, even a very familiar material. That is, at the nanoscale, materials can exhibit new properties, such as electrical conductivity, elasticity, enhanced strength, different colors, and different reactivity, when compared to the same material at the "normal" scale. This means, among other things, that using materials at the nanoscale can signify the creation of new materials that can be beneficial in many ways. It also means we cannot assume that materials that are safe and harmless at larger scales are necessarily safe and harmless at the nanoscale.

One example of a novel and widely applicable nanomaterial is the carbon nanotube (CNT). A CNT is a sheet of graphite (carbon atoms) simply wrapped into a tube shape .Notably, CNTs are the strongest and stiffest materials ever created while being fairly light, in addition to exhibiting other useful electrical, optical, and thermal properties. As a result of these beneficial characteristics, CNTs are already in sports equipment, computers, building materials, and vehicles. Despite the positive prospect of CNT products, concerns exist over the safety of CNTs. Studies indicate that CNTs can cause inflammation and other problems in the lungs, as well as skin damage when applied directly. Many experts believe that more research needs to be done to determine the potential risk to human and environmental health and safety stemming from CNTs in different applications.

Outside of CNTs, general nanotechnology advances are leading to current and proposed applications in numerous areas such as medicine and cosmetics. In the medical field, products and discoveries resulting from nanotechnology include new diagnostic tests, product materials for dental fillings and bone replacement, medical tools, and drugs for high cholesterol, appetite control, hormone therapy, and cancer, among others. Cancer drugs are being developed with nanotechnology that target tumor cells specifically. Many sunscreens already contain nanoparticles, which make them more transparent when applied to the skin. The potential risks of nanomaterials to human health and the environment were recently reviewed by many national and international expert groups and the consensus is generally that more research needs to be done to establish the actual risks of nanomaterials in all applications. Current studies on the risks of nanomaterials do not reflect real-world applications and are typically done on mice under artificial laboratory conditions.

### *Nanotechnology in Food and Agriculture*

Like other sectors, nanotechnology promises to revolutionize the whole food system – from food production to processing, storage, and development of innovative materials, products and applications. For example, nanomaterials in food products could allow color and flavor additives to be added without additional fats or other chemical agents. Nanosized and nano-encapsulated ingredients and additives could improve and create new tastes, flavors and textures. They also can enhance certain foods' nutritional value and can help increase nutrient uptake and absorption in the body. Although the potential applications of nanotechnology are wide ranging, the current applications in the food and agriculture sectors are relatively few. An overview of more than 1,000 nanotechnology-based consumer products that are currently available worldwide suggests that only around 9 percent of these are food and beverage products. Some examples include cocoa nanoparticles to improve taste of chocolate shakes, nanoparticles directly put in food to deliver health fish oils in bread without a fishy taste, and nanoparticles to deliver healthy plant cholesterol in cooking oil.

Other key application areas, beside foods themselves, are food packaging and processes to manufacture food, which currently play the largest role in nanotechnology food and agriculture applications. Of the total dollar value of all nanotechnology food applications in 2006, food ingredients comprised 24 percent, food processing 24 percent, and food packaging over 50 percent. Nanomaterial research for food packaging is currently aimed at those materials that come in contact with the food. Potential benefits to the package itself include better strength, flexibility, gas barrier properties (to keep food fresher), and temperature/moisture stability. Other potential benefits include packaging materials with antimicrobial properties for increased food safety, improved package biodegradability, and inclusion of sensors that detect and maintain the safety and quality of the food. In fact, food packaging materials with silver nanoparticles to kill bacteria and make food stay fresh longer are already available on the market.

While nanotechnologies offer many opportunities for innovation, the use of nanomaterials in food has raised a number of safety, environmental, ethical, policy, and regulatory issues. The main issues relate to the potential effects and impacts on human health and the environment that might arise from exposure to nanomaterials. In many products and applications, such as plastic materials for food packaging, nanomaterials may be incorporated in a fixed, bound or embedded form, and hence may not pose significant risk to consumer health or the environment (unless some hazardous particles migrate out during use or disposal). Other applications may pose a greater risk of exposure for consumers to free engineered nanomaterials; for example, certain foods and beverages may contain free floating nanoparticles or a nanopesticide formulation that may be released deliberately into the environment.

Some studies suggest that if humans are exposed to certain nanoparticles, those particles could end up in parts of the body that larger versions of those particles cannot reach. Examples include nanoparticles passing cellular,

blood-brain, and placental barriers, or accumulating in organs such as the kidney, spleen, or liver. Most experts agree that more studies are therefore needed to determine how nanotechnology applications such as nanoparticles act in food products, the human body, and the environment.

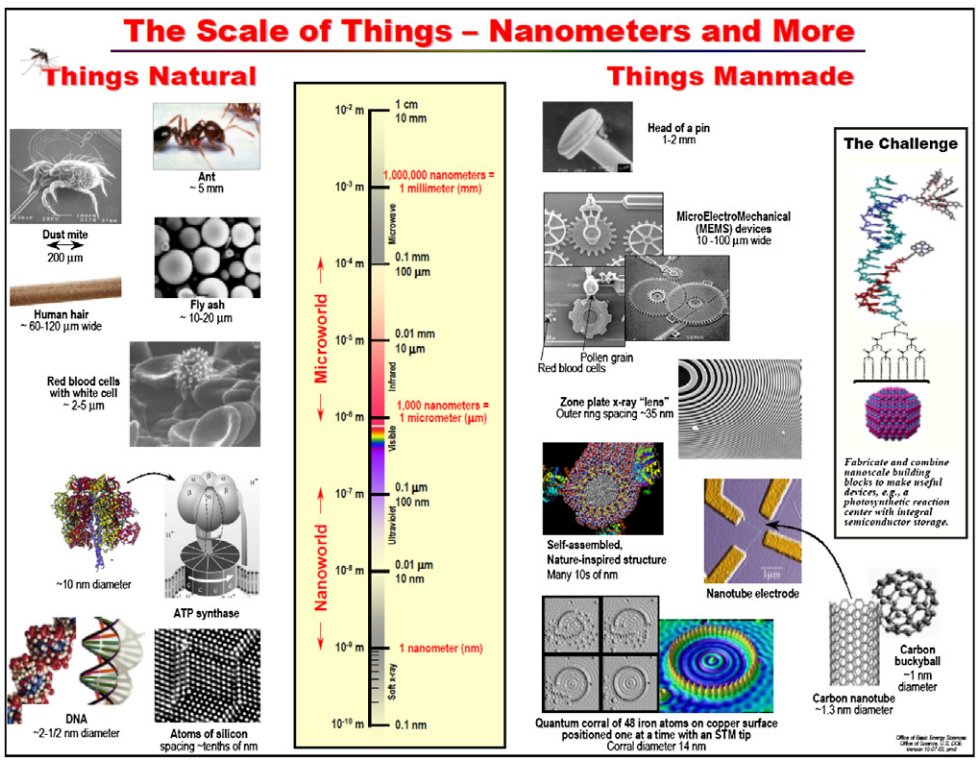
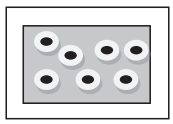
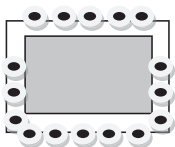
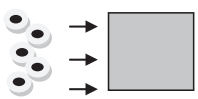



**Figure A1.** Information image presented during reading of general nanotechnology background material (Office of Basic Energy Sciences, 2003)

## Appendix C: In-group Worksheet

| Product Category | Nanomaterial's Purpose | *Benefits* | *Concerns* | *Willingness To Use (please circle your choice)* |
|---|---|---|---|---|
| Food additive **In**  | Enhance Experience (e.g., flavor/color) | | | 1 2 3 4 5 |
| | Enhance Nutrition | | | 1 2 3 4 5 |
| | Prevent/Reduce Spoilage | | | 1 2 3 4 5 |
| | Cheaper Production | | | 1 2 3 4 5 |
| Packaging **On**  | Enhance Experience (e.g., flavor/color) | | | 1 2 3 4 5 |
| | Enhance Nutrition | | | 1 2 3 4 5 |
| | Prevent/Reduce Spoilage | | | 1 2 3 4 5 |
| | Cheaper Production | | | 1 2 3 4 5 |
| Processing **For**  | Enhance Experience (e.g., flavor/color) | | | 1 2 3 4 5 |
| | Enhance Nutrition | | | 1 2 3 4 5 |
| | Prevent/Reduce Spoilage | | | 1 2 3 4 5 |
| | Cheaper Production | | | 1 2 3 4 5 |

Note. "Willingness to Use" scale: 1—Strongly unwilling to use 2—Unwilling to use 3—Neither willing nor unwilling 4—Willing to use 5—Strongly willing to use.

## Appendix D: Post-group Online Survey

An email with a link to the following survey was sent to each focus group participant, following completion of their respective focus groups.

1. Since the focus group ended, how much time have you spent searching for or reading about nanotechnology in general?
   1—No time at all
   2—Between 0 and 30 minutes
   3—Between 30 minutes and 1 hour
   4—Between 1 hour and 3 hours
   5—More than 3 hours

2. Since the focus group ended, how much time have you spent searching for or reading about nanotechnology in food and agriculture?
   1—No time at all
   2—Between 0 and 30 minutes
   3—Between 30 minutes and 1 hour
   4—Between 1 hour and 3 hours
   5—More than 3 hours

3. How comfortable are you with the idea of nanotechnology overall?
   1—Not comfortable at all
   2—Fairly Uncomfortable

3—Neither Comfortable/Uncomfortable
4—Fairly Comfortable
5—Very Comfortable

4. How comfortable are you with the idea of engineered nanomaterials food **products**?
   1—Not comfortable at all
   2—Fairly Uncomfortable
   3—Neither Comfortable/Uncomfortable
   4—Fairly Comfortable
   5—Very Comfortable

5. How comfortable are you with the idea of engineered nanomaterials in food **packaging**?
   1—Not comfortable at all
   2—Fairly Uncomfortable
   3—Neither Comfortable/Uncomfortable
   4—Fairly Comfortable
   5—Very Comfortable

6. How comfortable are you with the idea of nanotechnology being applied to food **processing**?
   1—Not comfortable at all
   2—Fairly Uncomfortable
   3—Neither Comfortable/Uncomfortable
   4—Fairly Comfortable
   5—Very Comfortable

7. How do you think benefits compare to risks for nanotechnology in general (scaled response: one end for benefits strongly outweighing risks, the other end vice versa)
   1—Risk strongly outweigh benefits
   2—Risks somewhat outweigh benefits
   3—Benefits and risks are about the same
   4—Benefits somewhat outweigh risks
   5—Benefits strongly outweigh risks

8. How do you think benefits compare to risks for food products containing engineered nanomaterials?
   1—Risk strongly outweigh benefits
   2—Risks somewhat outweigh benefits
   3—Benefits and risks are about the same
   4—Benefits somewhat outweigh risks
   5—Benefits strongly outweigh risks

9. How do you think benefits compare to risks for food packaging containing engineered nanomaterials?
   1—Risk strongly outweigh benefits
   2—Risks somewhat outweigh benefits
   3—Benefits and risks are about the same

4—Benefits somewhat outweigh risks
5—Benefits strongly outweigh risks

10. How do you think benefits compare to risks for food processing that uses nanotechnology?
    1—Risk strongly outweigh benefits
    2—Risks somewhat outweigh benefits
    3—Benefits and risks are about the same
    4—Benefits somewhat outweigh risks
    5—Benefits strongly outweigh risks

    For questions 11 through 13, please indicate your level of agreement with the following statements:

11. Food products containing engineered nanomaterials should be labeled with an additional nanotechnology label.
    1—Strongly disagree
    2—Disagree
    3—Neither agree nor disagree
    4—Agree
    5—Strongly Agree

12. Food stored in packaging materials containing engineered nanomaterials should be labeled with an additional nanotechnology label.
    1—Strongly disagree
    2—Disagree
    3—Neither agree nor disagree
    4—Agree
    5—Strongly Agree

13. Food processed using nanotechnology should be labeled with an additional nanotechnology label.
    1—Strongly disagree
    2—Disagree
    3—Neither agree nor disagree
    4—Agree
    5—Strongly Agree

14. Food product labels are currently regulated by the Food and Drug Administration (FDA). What level of trust do you have in the FDA to effectively ensure the safety of food **products** associated with nanotechnology?
    1—Complete distrust
    2—Some distrust
    3—Neither trust nor distrust
    4—Some Trust
    5—Complete trust

15. If nanotechnology food products and food packaged in materials containing nanotechnology are labeled with an additional nanotechnology label, how strongly do you trust the FDA to effectively regulate and enforce the **additional nanotechnology label**?

1—Complete distrust
2—Some distrust
3—neither trust nor distrust
4—Some Trust
5—Complete trust

16. Let's assume that adding an additional nanotechnology label increases the product's cost. Who should pay that extra cost?
    1—Consumers
    2—Producers (Makers of the nanofood product in industry)
    3—Government
    4—Consumers & Producers
    5—Consumers & Government
    6—Producers & Government
    7—All three groups
    8—None of them
    9—Other _____ (fill in blank)

17. If the cost of the additional nanotechnology label was placed in part or totally on consumers through raising the price of labeled products, what is the **maximum increase you would be willing to pay** for a product to have it labeled with a nanotechnology label, if the initial cost without the nanotechnology label is $5.00?
    Starting price without nanotechnology label: **$5.00**
    1—I would not be willing to pay extra for a nanotechnology label
    Total Product Price = $5.00
    2—Extra 1% = $0.05
    Total Product Price = $5.05
    3—Extra 5% = $0.25
    Total Product Price = $5.25
    4—Extra 10% = $0.50
    Total Product Price = $5.50
    5—Extra 15% = $0.75
    Total Product Price = $5.75
    6—Extra 20% = $1.00
    Total Product Price = $6.00
    7—Extra 25% = $1.25
    Total Product Price = $6.25
    8—I would be willing to pay **more** than 25% for the nanotechnology label
    Total Product Price = greater than $6.25

18. Imagine that nanotechnology product labeling is mandatory in the U.S. and that for all products containing nanomaterials, you have the option of buying the product *without* nanomaterials. If the product containing nanomaterials is $5.00, what is the **maximum increase price you would be willing to pay** for the product *without* nanomaterials?
    1—I would not be willing to pay extra for the product *without* nanomaterials
    Total Product Price = $5.00

2—Extra 1% = $0.05
Total Product Price = $5.05
3—Extra 5% = $0.25
Total Product Price = $5.25
4—Extra 10% = $0.50
Total Product Price = $5.50
5—Extra 15% = $0.75
Total Product Price = $5.75
6—Extra 20% = $1.00
Total Product Price = $6.00
7—Extra 25% = $1.25
Total Product Price = $6.25
8—I would be willing to pay **more** than 25% for the product *without* nanomaterials
Total Product Price = greater than $6.25

19. The following questions are about you so that we can learn how different types of people feel about the topics that are included in this study. **Please respond to the following questions:**
    a. What is your age? ____
    b. What is the highest educational level you completed?
    ____Less than high school
    ____Some high school
    ____High school (includes GED)
    ____Some college (includes Associate Degree)
    ____College graduate (BS, BA, etc)
    ____Some graduate education.
    ____Graduate degree (MA, MS, PhD, JD, MD, etc.).
    c. Are you:
    ____Female
    ____Male
    d. Race/ethnicity:
    Are you Hispanic or Latino?
    ____Yes
    ____No
    Please select one or more races that you identify with from the following:
    ____American Indian or Alaskan Native
    ____Asian
    ____Black or African American
    ____Native Hawaiian or Other Pacific Islander
    ____White
    e. Other than for family and community events (i.e. weddings, funerals, etc.) about how often have you attended religious services in the past twelve months?

| More than once a week | About once a week | 2–3 times a month | About once a month | Less than once a month | Only on special holy days | About once a year | Have not attended |
|---|---|---|---|---|---|---|---|

f. Whether you attend religious services or not, would you say you are a very religious person, somewhat religious, not too religious, or not at all religious?

| Very religious | Somewhat religious | Not too religious | Not religious at all |
|---|---|---|---|

g. How much does religion guide the decisions you make on a daily basis?

| Not at all | Not too much | A little | Some | Mostly | A great deal | Completely |
|---|---|---|---|---|---|---|

h. How much does your religiosity affect how you view issues relating to science and technology?

| Not at all | Not too much | A little | Some | Mostly | A great deal | Completely |
|---|---|---|---|---|---|---|

i. What was your total family income in 2008, before taxes and other deductions were taken out?

| Less than $25,000 | $25,000–$50,000 | $50,000–$75,000 | $75,000–$100,000 | $100,000–$150,000 | More than $150,000 |
|---|---|---|---|---|---|

j. The terms “liberal” and “conservative” mean different things to people. Generally speaking, how would you place your views on this scale?

| Very liberal | Somewhat liberal | Moderate | Somewhat conservative | Very conservative |
|---|---|---|---|---|