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Keys to Understanding and Addressing Consumer Perceptions and Concerns about Processed Foods

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Historically, processing has played a key role in each step of the food system, from production to consumption. In ancient times, simple food preservation practices were used, such as salt addition, smoke drying, and fermentation. Today, thanks to modern processing methods based on knowledge and technology acquired through the years, the food industry is able to offer consumers quality products, assure food safety, preserve important nutrients, and supplement products with the vitamins and minerals required to support health (15). The contributions of food processing and food science research are key factors in overcoming the challenges of feeding the growing world population, which it is estimated will reach 9 billion by 2050 (9).

Despite all the progress and developments in food processing, processed foods recently have been blamed for making consumers unhealthy, sick, and obese (32). A quick Internet search reveals numerous reports, blogs, and websites recommending consumers avoid eating processed foods altogether. Alarmingly, most of these recommendations are not based on scientific evidence that supports their claims. As a community of food scientists, it is necessary for us to evaluate such claims and to help clarify important concepts for consumers, to better communicate how and why foods are processed, and to help consumers understand the risks associated with their food consumption habits.

The goal of this article is not to debate all of the most frequent arguments found in the media, especially concerning processed cereal products, but instead to provide explanations to specific misinterpretations concerning processed food products based on current studies, describe some of the challenges the grain processing industry faces, and consider consumer learning theory.

Common Consumer Concerns

Processing and Product Labels. The U.S. Food and Drug Administration (FDA) defines a processed food as "any food other than a raw agricultural commodity and includes any raw agricultural commodity that has been subject to processing, such as canning, cooking, freezing, dehydration, or milling" (48). A study conducted by Monteiro et al. (32) evaluated the nutritional composition of different food products in Brazilian diets. The products were classified based on their processing level (minimally processed, processed culinary ingredients, and ultra-processed ready-to-eat products), and results showed that the ultra-processed foods evaluated contained more sugar, fat, and sodium and were generally more energy dense (32). This study demonstrates that we cannot turn a blind eye to the cases that have created legitimate suspicion among consumers. Product reformulation with alternative ingredients is one strategy the food industry relies on to develop ultra-processed ready-to-eat products with healthier nutritional profiles.

Although the importance of food processing seems evident to those in the food industry, a gap exists between this perspective and consumer understanding. The consumer perception of ultra-processed foods differs greatly from that of the food scientist. Katz and Williams (25) have demonstrated that the information provided on food product labels strongly influences consumer perceptions about the level of processing used for those products. Thus, the concept of a "clean label" is important and requires a detailed ingredient description (25). Consumers increasingly are demanding transparency from food manufacturers and expect clear communication about what is in a food product and how the product has been processed (25,41).

The 2005 *Dietary Guidelines for Americans* (47) recommends that Americans, among other things, "Consume 3 or more ounce-equivalents of whole-grain products per day, with the rest of the recommended grains coming from enriched or whole-grain products. In general, at least half the grains should come from whole grains." Consumer purchasing behavior for whole grain products was strongly influenced by the release of the 2005 *Dietary Guidelines for Americans* (47): the sales of whole grain breads and baked goods increased 23% in the 52 weeks after the dietary recommendations were released, and whole grain pasta sales rose

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27% in the same period (28). Even though the intention to consume whole grain products exists, however, the wide variety of label statements used can cause misconceptions about the amounts of whole grains consumers are actually incorporating into their diets (31). Marketplace research has found that many food products with whole grain label statements contain less than the amount required to make them a "good source" of fiber (labeled as <3 g/serving) (20). Thus, precise regulation of whole grain label claims and emphasis on consumer education is required for clarity (20).

Increasing Prevalence of Obesity. Consumption of processed food products is often associated with the increasing prevalence of obesity in the United States and elsewhere in the developed world (4). In the United States, the percentage of the population suffering from obesity dramatically increased from 10–14% in 1990 to almost 30% in 2010 (7). Different environmental, genetic, and psychosocial factors interact in obesity prevalence, but in the end, weight gain results from an imbalance between calories ingested and energy expended (22). During a 2009 symposium hosted by the American Society for Nutrition, An Integrative View of Obesity, several methods that could be used to attempt to reverse the upward trend in obesity were suggested, including public health campaigns, community and medical programs, and changes in the food supply, eating patterns, and lifestyles (3). The food industry aims to help achieve the objective of obesity reduction by making available more food products that fit within established dietary guidelines. To this end, 3,272 new products formulated with whole grains were introduced in 2010 (9% more than in 2009) to aid consumers in following whole grain intake recommendations (44).

Use of Additives in Foods. The use of chemical additives in processed foods is also a prevalent consumer concern, because consumers perceive "artificial" ingredients as potential hazards. Surveys have revealed that respondents are unaware of the functions and advantages of chemical food additives (41,49), such as food preservation. Although food technologists may have all the scientific information needed to support the safety of a specific food additive, consumer preferences must also be satisfied to assure repeated purchase of a product. To help address these concerns, when possible, the food industry should use natural preservatives derived from spices, herbs, teas, oils seeds, cereals, cocoa shells, grains, fruits, and vegetables as alternatives to replace artificial preservatives that consumers may view as undesirable (21,30).

White (Refined) Wheat Flour and Its Allergenicity. Cereal grains have been the base of human diets since ancient civilizations developed agriculture. Cereal grains provide carbohydrates, proteins, fiber, vitamins, and minerals and also are associated with prevention of chronic diseases when consumed as whole grains (2). A portion of the vitamins, minerals, and fiber are removed from the grain during the milling process used to produce flour, during which the pericarp and germ are fractionated and segregated. In the United States refined wheat flour has been enriched with iron, riboflavin, niacin, and thiamin since 1941, and fortification with folic acid was mandated by the FDA in 1998. Enrichment of refined wheat flour has helped to eradicate pellagra and beriberi in the United States, and fortification with folic acid has decreased neural tube birth defects (1,50).

Recently, in spite of the nutritional benefits obtained from enriched grains, cereals have been labeled as "fattening" (2), because in the past most baked goods were made with high levels of refined white flour, sugar, and fat. Today, however, the food industry is reformulating such products to reduce their salt and saturated fat contents. In New Zealand, the percentage of bread products meeting the national target of sodium content reduction increased from 49% in 2007 to 90% in 2010 (11). In addition, whole grains and fiber are being included as alternative ingredients to enhance the nutritional profiles of a variety of food products. Kraft Foods, Nabisco, General Mills, and Post product lines all have included whole grains in their formulations, and Nestlé's Lean Cuisine Spa product line remains focused on whole grains (44). Biotechnology also is offering new alternatives to increase the health-promoting properties of cereals, including biofortification; increased iron availability and β-glucan and resistant starch contents; and reduced grain allergenicity (2). In general, there is evidence that supports the idea that consuming half of the recommended portion of grains as refined grains does not increase disease risk, as long as the grains consumed are not combined with high levels of sugar, fat, or sodium (1). In addition, reducing or eliminating the level of grain consumption in the diet may have adverse effects on health. It has been demonstrated that children who consume breakfast cereals have higher levels of calcium, folic acid, iron, vitamin C, and fiber than those who do not (2,10).

Wheat allergies and gluten intolerance are additional factors that explain why consumers with these conditions avoids wheat and gluten-containing products in their diets. In the United States 1% of the population has been diagnosed with celiac disease (an autoimmune disease caused by gluten intolerance), and 4–6% of the population may present other types of gluten sensitivity (8,42). For individuals who are especially sensitive to gluten proteins, it is important to avoid consuming foods that contain wheat or other gluten-containing grains. Fortunately, alternative gluten-free products made with grains such as amaranth, oat, quinoa, chia, and others are increasingly available on the market.

Gluten is composed of alcohol-soluble (gliadins) and alcohol-insoluble (glutenins) subunits (36); most of the toxic activity related to gluten proteins is due to gliadin (43). It has been suggested that wheat breeding is a causal factor in the increasing number of people who are sensitive to wheat products, presumably due to the higher gluten content of commercialavailable wheat varieties (23). However, Kasarda (23), who conducted a study to evaluate changes in the gluten content of wheat grown in the United States during the 20th century, found no clear evidence that increasing gluten content is linked to the growing number of cases of celiac disease. Similar ongoing studies are investigating genetically modified (GM) wheat varieties, even though such crops are not commercially available, because the allergenicity of GM products is a major concern (27).

Understanding Consumer Perceptions of Food Technology

Despite research indicating that science literacy in the United States has held steady over the past two decades (33) and according to some sources has even risen (46), public understanding of science and science literacy is still low among Americans (37). More than 70% remain uninformed about science and scientific issues, and surveys suggest Americans are "not as accepting of scientific facts as other nations" (40).

The science literacy construct includes several concepts: ideas and frameworks that explain science, methods by which science is conducted and on which scientific claims are based, and the strengths and limitations of the application of science in daily life (33). It is important to note that individuals are not considered scientifically literate or illiterate; rather scientific literacy is evaluated as a matter of degrees. The Organisation for Economic Co-operation and Development, an organization gathering assessment data for student learning, defines scientific literacy "as the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through humanity" (35). In addition, "a good understanding of basic science terms, concepts, and facts; an ability to comprehend how [science or technology] generates and assesses evidence; and capacity to distinguish science from pseudoscience are widely used indicators of science literacy" (33).

Why is the public level of science literacy important? A person's level of science literacy impacts their ability to understand the often complex science-based issues involved in food production, not to mention the associated public policy issues (e.g., regulation, labeling). The challenge of science literacy can be magnified for consumers when it comes to food science and technology perceptions because people tend to have a personal relationship with the foods they choose to eat (6) and can view technology related to foods with suspicion.

Several reasons have been put forth to explain the challenges affecting consumer perceptions of food processing, including intense media coverage of negative food technology-related incidents. For example, in the United States, the author of a commentary published in *Nature* suggested genetically modified Bt corn was responsible for damage to the monarch butterfly population. Several strong criticisms were leveled at the assertion, including the fact that the commentary had been submitted previously as a research paper to the same publication and was rejected. The incident drew intense media coverage, pitting biotech researchers against "innocent" butterflies and prompting a *USA Today* headline announcing, "Engineered Corn Kills Butterflies" (40). In Europe, consumers tend to be even more risk-adverse due in large part to concerns stemming from governmental mismanagement of bovine spongiform encephalopathy in Britain and the Belgian dioxin crisis, as well as media coverage of Dolly, the first successfully cloned sheep, in 1996 (39,40).

While it is clear food processing technologies have the ability to improve food characteristics, including taste, freshness or stability (shelf life), nutritive value, etc. (16), Bruhn (5) points out that whether consumers accept food technologies is based on their perceptions of the benefits and risks of the end products. "Risks are enhanced in the public's mind when imposed by others, when not accompanied by clear benefits, or when viewed as unfair." Bruhn (5) also indicates that rather than seeking out specific technologies associated with food production, consumers are primarily interested in products that contain specific benefits. They seek benefits primarily related to taste, but also favor products with health benefits and increasingly favor those manufactured in a sustainable or environmentally conscious manner. Another significant concern for consumers is technologies that pose risks perceived as beyond their control. Irradiated food provides an apt illustration: consumers are able to determine for themselves how an irradiated food tastes, but they do not have the requisite scientific knowledge or ability to determine the potential long-term effects the product may have on their health. Such knowledge "require[s] additional input beyond the individuals' capabilities," thus contributing to the consumer's perception of risk related to food irradiation (5).

Several technologies have engendered significant concern among consumers. In a study analyzing seven technologies with varying levels of identified consumer concern, researchers examined consumer perceptions of risk related to GM foods and crops, nutrigenomics, animal cloning, nanotechnology, food irradiation, high-pressure processing, and pulsed electric fields (16). In the analysis, Frewer et al. (16) determined that several key factors exist related to public acceptance of technologies: perceived personal benefits (health, economic, social, and environmental); perceived societal benefits (health, economic, social, and environmental); fairness or the differential accruement of risks and benefits; ethical concerns; perceived personal risks; perceived societal risks; perceived efficacy of regulatory frameworks; attitude activation or cognitive association; perceived scientific knowledge or uncertainty; perceived naturalness; ability to control choice, including labeling and traceability; level of public involvement in development of the technology; trust in science and regulation; and sociocultural differences, such as socioeconomic data and cultural and demographic information. This is clearly not a simple set of issues in the eyes of consumers.

Affecting Consumer Perceptions of Food Technologies

In a recent essay Scheufele (40) raises questions concerning critical societal complexities related to communication about science (specifically scientific controversies) and provides insights into factors affecting consumer perceptions. Modern science, Scheufele (40) contends, faces several challenges in relation to public opinion and acceptance. Although the existence of challenges is not unique to modern science, their characteristics may be. Three specific challenges facing the science–communication intersection are listed: the preparedness of individuals for new scientific information (i.e., level of science literacy); the nature of modern or "postnormal" science (i.e., scientific technologies and breakthroughs that challenge the notion of facts and indisputable values, for which the stakes are high, and that require rapid decision making, such as nanotechnology); and a shift in the traditional public–science infrastructure (i.e., changes in the manner in which people obtain information about science—a move away from use of traditional print and broadcast media to the Internet as a dominant source for information). This last challenge is of particular concern because a shrinking number of traditional media outlets for scientific information means shrinking coverage of scientific information and significantly fewer science journalists who are specifically trained to understand and interpret scientific information for lay audiences. This decrease means fewer professional communicators with intentional education and knowledge reserves about science.

Scheufele (40) suggests scientists can no longer afford to continue employing the deficit model of communication; the idea, as described in Sturgis and Allum (45), that "a more scientifically literate public would be more supportive of scientific research programs and more enthusiastic about technological innovations." Additionally, the scientific community cannot assume that the main purpose of mass media is to inform people about science (or any other topic). "We know from decades of communication research that media influences are multifaceted and go well beyond simply conveying information" (40) and that the impacts of media messages about science and scientists are not limited to information, but are incorporated as part of a larger mental construct regarding complex science-related issues such as concerns about food production technologies.

Ultimately, trust, transparency, and communication will be the keys to unlocking consumer perceptions with respect to food technologies. Rollin et al. (39) note "consumers' reactions to new food technologies are not a one-dimensional relationship. Understanding consumers' risk-benefit perceptions, sociodemographic attributes, knowledge and information, as well as trust in the source of information, will be crucial to the realization and success of technological advances." Frewer et al. (17) determined that consumers link trust with individuals and organizations they perceive as being concerned about the public's welfare and that are knowledgeable and neutral in their judgment or presentation of information.

Two additional concepts are important to consider. Food scientists must seek a greater understanding of the social amplification of risk—the idea that when an individual has a lack of direct personal experience related to a particular risk, information about that risk is obtained through two channels: the news media and informal personal networks (24). In short, when consumers do not have personal experience with respect to food science and technology, they will rely on information gathered from the Internet and/or those in their personal networks who do. Food scientists must understand that when considering decisions related to complex scientific (and sometimes controversial) subjects, individuals look to opinion leaders to help guide their decisions (38).

Communication and transparency play a critical role in consumer acceptance of food-related technologies (5,6). It is important to consider the reciprocal function of communication, including the concept of listening to consumers' needs and concerns and responding using a variety of methods and sources according to audience needs, which may vary by age, gender, and other demographic characteristics. "To increase trust and the likelihood that communications are understood...[communications] should be built around what the public wants to know, as determined by consumer research" (5).

The Challenge of an Expanding Global Population for the Food Industry and Society

The projected worldwide population growth to 9 billion by 2050 represents an undeniable global challenge that will require the combined efforts of scientists, private industry, governments, and society. The food industry must continue to make significant contributions to overcoming such a challenge by providing enough tasty, safe, nutritious, and processed food to feed 9 billon people within 36 years. Some of the major challenges are associated with food safety, security, and process sustainability.

Food safety is a perpetual and important issue to address in the food industry. Generally it is fresh fruits, vegetables, and raw meats that have been associated with foodborne outbreaks, caused mainly by *Salmonella* spp. and *Escherichia coli* O157:H7 (18,19), but cereals are also susceptible to contamination in the field and during processing with biological, chemical, and physical hazards that can adversely affect consumers if proper interventions are not considered. Wheat flour commonly has been considered safe due to its low moisture content and the heat treatment it undergoes during baking. However, in 2009, a multistate outbreak of *E. coli* O157:H7 was associated with the consumption of raw cookie dough, which revealed the need to reformulate cookie dough mixes and to educate consumers about the risk of consuming uncooked dough (34). Most of the contamination of grains takes place on the surface of the grain itself; therefore, the milling process reduces the microbial load by removing some of the outer layers (i.e., pericarp) (26). However, a peer-reviewed study showed that internalization of up to 2% of *E. coli* O157:H7 can occur in wheat seedlings, demonstrating the ability of *E. coli* O157:H7 to reach the internal wheat phyllo-plane (29). The food industry has implemented the use of heat-treated flour as a quick action to minimize new outbreaks (34). In addition, ongoing studies targeting milling interventions and understanding critical environmental factors influencing the safety of cereal products will provide more information that can be used to better manage cereal food safety.

By 2050, food production should gradually increase by 70% overall, and double in developing countries (12). Given the fact that cereal grains are the major source of food for human consumption worldwide, events in the cereal sector have direct implications for the global food supply. Of the 2.4 billion tons of cereals currently produced annually, 1.1 billion tons is used for human consumption, 800 million tons is used for animal feed, and 500 million tons is wasted (14). In developing countries food is often lost before it reaches markets, while in the developed world food is wasted by consumers (13). Effective solutions to improve crop yield, infrastructure, distribution, consumer purchasing, and adequate food preparation offer opportunities to help guarantee food access to every individual.

The fundamental factors required to assure the sustainability of cereal processing include increased process efficiency; reduced processing waste; redefined applications for generated by-products; efficient utilization of energy, water, and other resources; and minimization of environmental impacts. Wheat, rice, barley, and oats are important cereals not only for their nutritional value but also for the full utilization that can be obtained from them with adequate processing.

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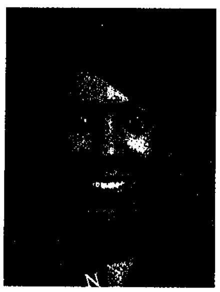

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