Critical Approaches to Superfoods

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Extractionist Logics: The Missing Link Between Functional Foods and Superfoods

Christy Spackman

"Ready. Easy. Fizzy. Zesty. Pure. Wet. Brisk. Zippy. Tasty."

Filled with colorful bottles, the display case under this line of words at the Union Square Whole Foods in New York City in late 2008 offered to not only assuage thirst, it offered much more. The messages on, and ostensibly the products in, the wide array of bottles promised weight loss, increased brain function, and, most tellingly, the possibility of a dose of antioxidants to take the daily struggle for longevity down to the body's most molecular levels demonstrated through graphs of Oxygen Radical Absorbance Capacity (ORAC). These functional beverages, like their functional food counterparts, promised access to otherwise difficult to access health-promoting molecules via the technological wizardry of industrial food. They offered, in short, hope in a bottle.

Ten years later, a line of messages about the wholeness of the company—from the Whole Kids to the Whole Cities and Whole Planet initiatives—crown the same display case. The messaging shift indexes a change found in the still-present array of colorful bottles promising a better future through consumption. Labels no longer sport graphs of ORAC activity. Rather than discussing how a particular beverage may prevent specific forms of cellular damage caused by invisible molecules, the beverage labels now highlight how their *wholeness* can make a healthier you. Their core ingredients, most of the bottles indicate, are not isolated extractions, but rather superfoods; whole foods commonly used by "traditional cultures" that science has identified as containing high levels of good-for-the-body molecules (Loyer 2016a). The messaging implies that you could easily make these beverages yourself—should you have the inclination and access to the right distribution chains.

This chapter examines how, in the span of a few years, the predominant food-as-medicine discourse shifted from one primarily characterized by nutritional reductionism (Scrinis 2008) to one primarily characterized by wholeness. I investigate the regulatory and technological infrastructures that have facilitated contemporary mobilization of nutritional reductionism in food manufacturing and marketing, infrastructures that pushed industrial logics of molecularization and rebuilding to their most fantastical forms (foods such as pasta fortified with omega-3 fatty acids normally found in fish, for example), and then examine how these infrastructures have entered into the superfood landscape. I focus primarily on the entwining of regulatory and techno-scientific infrastructures in creating what I term "extractionist logics." Extractionist logics refer to the way that nutritional reductionism activates the molecular imagination in researchers, policymakers, food producers, marketers, and eaters in a way that enacts a doubled extraction: first the extraction of molecules from source ingredients/foods; and second, the transformation of eaters into micro-extractors of knowledge and value (energetic, health, social, cultural) from the food choices available to them.

To do this, I first situate functional foods within the larger history of food as medicine. I then examine how techniques in chemistry and biology, developed primarily during the second half of the twentieth century, enabled the rise of an epistemic culture of extraction that contributed to the growth of the functional food market in the United States. I specifically examine the rise and subsequent decline of the ORAC assay as a mode of understanding and communicating molecular materiality across a range of scales. I focus on the ORAC assay for two reasons: it was the first method officially adopted by the Association of Official Agricultural Chemists to measure total antioxidant capacity, and it was the form of measurement commonly mobilized on in-market communication and popular literature during the 2008–12 period. Using Cori Hayden's suggestion that "knowledge and bioartifacts contain, reproduce, or represent people's interests" (Hayden 2003, 19), I explore how identifying and measuring antioxidant activity contained, reproduced, or represented people's interests, a process that allowed extractionist logics to circulate not only beyond the laboratory, but also beyond the functional food landscape they codeveloped with.

Reading through their claims of potential impact on cellular and molecular mechanisms, functional foods exist somewhere between food and medicine. This liminality not only creates spaces of confusion for consumers, it also supports the popularity of the superfood category by facilitating a search for health through foods understood as potentially having therapeutic benefits. How, though, do these foods come to be understood as potentially therapeutic? Writing about pharmaceuticals, Sismondo and Greene note that “bare molecules do not become pharmaceuticals without ties to health concerns, scientific knowledge, appropriate regulation, effective marketing, and receptive prescribers and publics” (Sismondo and Greene 2015, 2). One could make a similar statement with regards to the bioactive molecules found in food: they do not become functionally important micronutrients, nor epigenetically dangerous signals (see Landecker 2011), without ties to health concerns, scientific knowledge, technical practice, regulation, marketing, and receptive publics. By examining how ties between various actors support the emergence and endurance of extractionist logics, we gain an understanding of how science and technology facilitate a certain form of legibility for food—of its core molecular ingredients—that intertwines with market economies in ways that transcend the fashion cycle (Davis 1992). These extractionist logics facilitate what Reisman (this volume), building on Guthman’s work (2011), refers to as a “material-semiotic fix,” a compilation of meaning that contributes to the continued expansion of certain food markets. As examining extractionist logics in-the-making demonstrates, what appear as food “trends” are rather reflections of social concerns about bodies and health that are deeply rooted in complex relationships between a range of economic, regulatory, and scientific actors.

Methodological Note

This research is based on a dual process of observing physical and epistemic objects. The physical objects I observed were functional beverages, primarily collected by myself and augmented by donations from colleagues from 2008 to 2014, with the bulk of collecting occurring between 2008 and 2012. Now housed at the Southern Food and Beverage Museum, the collection contains more than forty examples of beverages categorized as functional by on-package messaging or advertising. The epistemic objects I observed were much less concrete, in line with Hans-Jorg Rheinberger’s definition of epistemic objects as material objects that exceed or transcend efforts to know them, and in the process are continually kept alive as objects of scientific research (Rheinberger 1997, 2005, 406–7). Following Rheinberger, I observed food as it traveled through scientific laboratories and out into the world in the form of publications, regulatory statements, marketing labels, and policies, with a focus on the work produced by the laboratory of Ronald L. Prior at both the United State Department of Agriculture's (USDA) Agricultural Research Service and at the USDA Human Nutrition Research Center on Aging at Tufts University.

Bridging Food and Medicine

From a bird's eye view, the idea that food can act in medicinal ways—that eating certain foods can bring health, wellness, and longevity—underlies both functional foods and superfoods. Thinking of food as medicine is not new. For much of history, food has been one of the core sources of medicine: from the Galenic understanding of foods as balancing humors (Albala 2002; Shapin 2011) to the intimate entwinement of medicinal foods with the Chinese meal structure (Farquhar 2002). In many cases, sensorial perception (touch, taste, smell, sight, texture) played a core role in evaluating the medicinal properties of foods. This relationship between perceptual experience and eating undergirded medical practice in the Western world until the Cartesian Revolution in scientific thinking began to upend the relationship between individual bodies and expertise.

As chemical, mechanical, and biological modes of knowing the world became increasingly accepted over the eighteenth and nineteenth centuries, the authority of individual knowledge about the medicinal uses of food decreased. Physicians in the United States have worked since colonial times to gain control over access to patients and how patients are treated, often by seeking to marginalize treatments and therapies that fall outside of the technological and mechanistic worldview of modern Western medicine (Andrews 1996; Starr 1982). In the early twentieth century, the discovery, purification, and administration of vitamins resulted in theatrical-like demonstrations of the efficacy of nutritional knowledge (Apple 1996). Noticeable improvements in the population's health followed. Mainstream thought, embodied in regulatory policy, came to embrace an understanding of food as a deliverer of molecular entities—macronutrients and micronutrients—that could affect health.

How individuals and institutions in the United States think about health has shifted during the twentieth century. Increasingly, scholars point out, parts of life once considered outside the purview of medicine have been medicalized and, more recently, biomedicalized (Clark et al. 2010). Medicalization is the view that everyday problems and behaviors are things that can be treated by medical intervention; many scholars see this as a central, characterizing aspect of life in the twentieth century. Feeling sad? Take a pill! Biomedicalization, in turn, refers to how technological and scientific knowledge-production infrastructures focused on biological processes (genetics, cell signaling, etc.) have remade medicalization (Clark et al. 2010). Both processes operate by understanding and promoting understandings of bodies as always out of order (Dumit 2012; Nichter and Thompson 2006), something that regularly invites seeking after an idealized, perfect self via consumer activity (e.g., Sikka 2019).

Public and private institutions have not only mobilized market economies to address the body's ills during the twentieth century. They have also mobilized market economies to promote environmental conservation and economic development. Hayden suggests since the 1980s this "paradigm of sustainable development" has led to "nature, as biodiversity … being framed as a storehouse of valuable genetic resources" (Hayden 2003, 49). Shared between the pharmaceutical industry, biodiversity scientists, and NGOs, efforts to use the market to protect nature manifested as increased attention to molecules found in plants and microbes as potential sources of new medicinal cures (Hayden 2003, 57). Seeing nature as a storehouse of untapped molecules resulted in what many have called bioprospecting, a new manifestation of an ages-old process of extracting plants from one location on the globe and transporting them to other locales for exploitation. Reading nature this way intimately links the natural and technological: one can't understand nature as molecular without analytical instruments that identify molecules.

Like the pharmaceutical sciences, nutritional science sees nature as a storehouse of valuable molecular resources. It is hard from a present-day vantage to fathom a life before food was molecular, before it came with labels telling eaters how much energy each gram could generate, or what percentage of one's recommended daily allowance of vitamins and minerals such a food contained. A reduction to food as composed of molecules that carry different biological impacts undergirds current scientific and social understandings of food; Gyorgy Scrinis terms this approach "nutritionism" (2008). Despite calls by a subset of nutritionists to expand their view (Hoffman 2003), Scrinis argues that nutrition as a field remains focused on the relationship between molecular components found in foods and the corresponding cellular functions of the eating body. Emily Yates-Doerr points out, in her examination of nutritional education in the Guatemalan highlands, that nutritionism creates systematic knowledge about the world; this knowledge can be mobilized to create and enact policy, inform education, and ultimately shape population health (Mudry 2009; Yates-Doerr 2015). Functional foods came into being, especially in the United States, in this cultural milieu where bodies were increasingly understood as at-risk, where health policy and marketing efforts tasked individuals with using market systems to manage their own wellness, and where naturally occurring or chemically manufactured molecules carried the potential to rescue both individual body and world environment.

Regulatory Fences

National regulatory bodies have played a key part in the making of functional foods. As a category, functional foods came into being as part of a Japanese state-sponsored project exploring how food, when twinned with medical science, could be used to "beat life-style related diseases" (Arai 2002, S139; Spackman 2014). Aimed at producing "foods for specified health use," the project sought to address problems such as increases in allergic reactions to foods as well as diseases brought on by ever-increasing lifespans (Swinbanks and O'Brien 1993). The project carried the added bonus of attracting international attention from researchers and food producers.

Loosely defined as "foods that provide a health benefit beyond basic nutrition" (Joy 2007), the functional food category could best be described as one that goes beyond conventional foods. Thus, although as the ADA notes in their 2009 position statement on functional foods that the simplest functional foods are fruits and vegetables (American Dietetic Association 2009), the moniker generally refers to foods "enhanced" or fortified with compounds understood to be biologically active. It is this understanding of parts of food as biologically active—able to reduce inflammation, or improve brain power, for example—that brings functional foods right up to the regulatory line dividing food from medicine and, as such, enters them into entirely new regulatory landscapes.

The unevenness of the regulatory landscape around food marketing in the United States facilitated the growth of functional foods. The functional food category as currently constituted emerged during the deregulatory Reagan era, with the allowance of "health claims without premarket approval" by the Food and Drug Administration (FDA) in 1987 (Heller 2005, 171). Not surprisingly, the number of claims on food labels exploded, with the cover story of *Business Weekly* demanding on October 9, 1989, "Can Corn Flakes Cure Cancer? Of Course Not. But Health Claims for Foods Are Becoming Ridiculous." By 1990, the US Congress responded to calls for reform from consumer advocates, industry players, and regulators by passing the Nutrition Labeling and Education Act (NLEA). NLEA permits health claims that "describe a relationship between a food substance and a disease" and carry the backing of "significant scientific agreement among qualified experts" regarding the validity of the claim (American Dietetic Association 2009). NLEA-approved claims require significant research time and money; currently only twelve types of claims are approved (Center for Food Safety and Applied Nutrition, Office of Nutritional Products, Labeling, and Dietary Supplements 2013). Consider, for example, the claim found on a Bolthouse Farms Heart Healthy Pear Merlot Apple Juice Blend: "Barlive barley betafiber is a natural source of beta-glucan soluble fiber that helps support heart health with 3 g per day, when consumed as part of a low fat, low cholesterol diet. This bottle of juice contains 1.4 g of beta-glucan soluble fiber (0.75 g per 8 oz serving)." This claim is NLEA-approved under 21 CFR 101.81, "Soluble Fiber from Certain Foods and Risk of Coronary Heart Disease." Implementation of NLEA slowed the frenzied business of making health claims on food to an ordered trickle between 1990 and 1994.

Many, especially those in the supplement business, found the NLEA overly constraining, a regulatory dead end that got in the way of consumer choice. In 1994, Congress officially responded to those concerns by passing the Dietary Supplement Health and Education Act (DSHEA) (Apple 1996, 174–7). Supported by both Republicans and Democrats, DSHEA re-opened the door for functional foods by allowing structure/function claims. These claims, unlike those permitted by the NLEA, "describe how a food component or ingredient affects the structure and/or function of the body (e.g., calcium builds strong bones) without linking it to a specific disease" (American Dietetic Association 2009). As long as a food fell into the category of dietary supplement, the claim did *not* need the backing of significant scientific agreement. Supplement users around the country rejoiced.

Further modifications occurred in 1997 under the Food and Drug Administration Modernization Act of 1997, allowing "manufacturers to use health claims if such claims are based on current, published, authoritative statements" from the National Institute of Health, Centers for Disease Control and Prevention, or National Academy of Sciences (American Dietetic Association 2009). Five years later, in 2003, the FDA further loosened regulations by allowing qualified health claims: claims that do not yet meet the standard of significant scientific agreement, but do have some scientific support. Examples of qualified claims include claims linking green tea consumption to decreased risk of cancer and omega-3 fatty acids with a reduced risk of coronary heart disease.

Currently, functional foods, depending on the health claims made and ingredients used in their manufacture, are "regulated as 'foods,' 'dietary supplements,' 'drugs,' 'medical foods,' or 'food for special dietary use'"(Heller 2005, 169). Manufacturers found significant wiggle room in how they label and market their products via this wide swath of regulatory niches, especially post-2003. This regulatory infrastructure facilitated the explosive growth of the functional food market during the aughts.

At the heart of the debates about managing food and supplement labeling during the 1990s and early aughts was a question of how much knowledge about how a *molecule* or mixture of molecules functioned in the human body was needed before market release. This is a question of legibility, of how an entire epistemic system asks and answers questions about how nature works. For those researching and promoting functional foods, technology was critical to making molecules legible, to offer at least some claims that linked structure with function.

Analyzing Antioxidants

Regulatory infrastructures were not the only thing driving researchers, product developers, and marketers to focus in on functional foods. Like Japan, lawmakers and researchers in the United States shared an interest in addressing disease caused by lifestyle and aging. This is most evident in the work of centers and institutes gathered under the umbrella of the US National Institute of Health, especially the National Institute on Aging (NIA). Established in 1974 by an act of Congress, by 1993 the NIA began focusing on translational research that offered to make the findings of basic and clinic-based research applicable to improving life. In other words, they sought to "mainstream the 'bench to bedside'" approach to research and to "[explore] the underlying molecular mechanisms responsible for the functional decline that occurs with aging" while testing interventions into the aging process (National Institute of Health 2017). If familiar molecules such as vitamins E and C, readily available from foods, could help reduce the rate of oxidation in laboratory and animal tests, what other molecules might be out there, and what role might they play?

Understanding the biochemical activity of molecules in the body is the core goal of nutrition research. In 1993, NIA researchers Guouhua Cao, Helaine M. Alessio, and Richard G. Culture published a paper in the journal *Free Radical Biology and Medicine*. Entitled "Oxygen-radical Absorbance Capacity Assay for

Antioxidants," the paper recounts what the authors term a "relatively simple but sensitive and reliable method of quantitating the oxygen-radical absorbing capacity of antioxidants in [blood] serum" (Cao et al. 1993, 303). The paper came at a time when scholarly attention to the role of free radicals—reactive oxygen species—in human diseases had notably increased. Researchers understood that the presence of certain biological molecules, for example, Low Density Lipoprotein (LDL; a form of cholesterol) was linked to increased risk of disease. What they didn't understand was how those molecules acted to cause disease in the body, for example, how elevated levels of LDL might contribute to the formation of atherosclerotic plaques (Jürgens et al. 1987). For researchers in the mid-1990s interested in heart disease, for example, oxidation—a chemical change that occurs when one molecule loses electrons—repeatedly appeared in *in vitro* (aka test tube) laboratory tests as a potential cause of transforming LDL from a relatively benign compound into one that could harm health (Steinberg 1995).[1] This "oxidative modification hypothesis," that modification of the molecular structure of LDL (or other fatty proteins found in blood) via oxidation was core to the development of atherosclerosis, suggested that a specific set of molecular interactions resulted in the transition from health to sickness. It followed, then, that if one could intervene in that specific set of molecular interactions (oxidation), one could possibly delay or prevent disease onset.

Researchers understood a range of compounds as potential sources of oxidative stress. Environmental pollutants, ultraviolet light, or rancid fats all presented the capability of introducing reactive oxygen species into the body. These are molecules that can not only modify proteins, they can also damage DNA. A logical step for those trained in the central tenets of molecular biology, where structure and function are always intertwined, was to investigate whether one could intervene in unwanted damage from reactive oxygen species that bodies encountered in their everyday environment via antioxidants.

Antioxidants are exactly what they sound like: molecules that act against oxidation. In a 1936 patent application, Henry Mattill and Harold Olcott, employees of Lever Brothers (the precursor to Unilever), referred to antioxidants as "inhibitols," molecules with antioxidant "character capable of being used without harmful adulteration of the food substance to be preserved against injurious oxidation changes" (Mattill and Olcott 1937). A familiar example of antioxidants is beta-carotene (water-soluble vitamin A), as well as vitamins C and E. Purified forms of these plant-derived substances have been in use since the 1930s in industrial food production, as additives that prevent rancidity and extend shelf life. As such, it was not much of a leap to go from additives that helped prolong a food's shelf life to molecular ingestibles that could act as inhibitols in the body proper.

Demonstrating the ability of something to inhibit oxidation, however, was less straightforward than researchers would have preferred. Cao, Alessio, and Culture's paper promised otherwise. Although the reported method didn't allow measurement of an individual antioxidant's activity, it did allow evaluation of the *total* antioxidant capacity of serum, and did so in a quantitatively reproducible manner.[2] This meant that researchers could test whether supplementation or diet modification increased the overall amount of antioxidants found in the bloodstream. The assay's ability to quantify the reaction over time, a later review would report, proved especially useful for measuring antioxidant activity found in samples that did not immediately react (Huang et al. 2005, 1846). Cao's method decreased the barrier to demonstrating antioxidant activity. Although not the first, nor only method developed for in vitro measurement of antioxidant levels, the ORAC assay was rapidly improved and widely adopted, notably by Cao's colleagues at the NIA in the National Institute of Health.

Contemporary scientific processes of knowing, as a range of scholars of science and technology note, depend on creating knowledge that can circulate away from the bodies and places where it is produced (Harding 1986; Knorr Cetina 1999; Porter 1996). Reproducible generation of quantitative measures greases the mechanisms of knowledge production. Cao, Alessio, and Culture's method, in creating a mode for quantifying the total presence of antioxidants in serum, offered new possibilities for those researching the role of dietary compounds in increasing antioxidant levels in blood serum, as well as the potential role of these compounds in preventing attacks from reactive oxidative species.

Communicating Molecular Materiality

Between 1993 and 1995, publications about the antioxidant capacity of foods remained relatively constant. However, in 1995, Cao alongside a group of other researchers at the Jean Meyer USDA Human Nutrition Research Center on Aging developed a way of automating the ORAC assay. This drastically decreased the cost of sampling and increased the number of samples that could be tested in a given time (Cao et al. 1995). In line with common nutritional understanding of diet as key to health, and fruits and vegetables as good-for-you foods, researchers at the Center on Aging (and elsewhere) began testing the total antioxidant capacity of a range of foods.

By measuring total antioxidant capacity of foods, the ORAC assay allowed researchers to begin what could be described as an ongoing series of “trials of strength” (Latour 1993, 79), tests that pitted different foods against each other with the goal of revealing which ones might be most applicable in the search to improve and extend human life. Researchers at the Research Center on Aging, led by Cornell-trained researcher Ronald Prior, quickly took advantage of the test’s ability to rapidly compare antioxidant capacity of different foods. They started with familiar foods: one of the first and most widely cited of these tests examined the antioxidant capacity of twelve fruits readily available in Boston supermarkets in the winter. Of the twelve fruits tested—(listed here in order of their antioxidant capacity) strawberry, kiwi, plum, orange, red grape, kiwi fruit, pink grapefruit, white grape, banana, apple, tomato, pear, and honeydew—strawberry came out on top, its juice extract two times more effective at preventing oxidation in the assay than orange juice, and greater than thirteen times more effective than honeydew (Wang et al. 1996). Their research demonstrated that the one known antioxidant present in many of these foods—vitamin C—was not the only compound exhibiting antioxidant capacity. This indicated that fruits and vegetables contained additional compounds beyond the familiar vitamins and minerals identified during the first half of the twentieth century that may help prevent oxidation. Later that year, the researchers moved on to vegetables. In a trial of strength between twenty-two vegetables easily found at Boston supermarkets, garlic, kale, spinach, Brussels sprouts, alfalfa sprouts, broccoli florets, and beets performed best (Cao et al. 1996). Viewed through the lens of antioxidant capacity, some fruit and vegetable extracts were distinctly better than others.

Although these trials of strength initially examined fruits and vegetables “local” to the continental United States, researchers soon expanded their efforts to include foodstuffs from more distant locales. The 1996 assay of twenty-two vegetables also examined green and black tea, showing them significantly more effective than any of the vegetables in preventing oxidation *in vitro* against one of the reactive agents (Cao et al. 1996). In placing fruits, vegetables, and a common plant-based beverage in an *in vitro* arena and pitting them against known oxidative stressors, the researchers sought to make visible the micro-contests they hypothesized as occurring in the eating, breathing, aging body.

Building on their findings that fruits and vegetables contained compounds that acted as antioxidants, Prior and colleagues began investigating what chemical structures beyond vitamin C might contribute to antioxidant function

(Cao 1997). In this they followed the logics of nutritional reductionism *and* the core logic of molecular biology: that a molecule's structure shaped its biological function. Moving from total antioxidant capacity, which revealed the entirety of a foodstuff's antioxidant potential, to the particular relationship between a molecule's structure and its function engaged researchers in a process of "molecular imagination" (Landecker 2011, 185). For Hannah Landecker, writing about genetically modified organisms, molecular imagination is a process of "imaginative acts of thinking, visualizing and controlling food" as an external molecular source that can "interact with our internal molecules," and in doing so dissolves the boundaries between one's particular body and the larger landscape that produces the foods we eat (Landecker 2011, 185). Building on knowledge about the molecular structure of known antioxidants such as beta-carotene, researchers focused their attention on specific sub-groups of phytochemicals found in plants: flavonoids and anthocyanins. Isolated, these compounds could be tested and ranked for their antioxidant activity (Wang et al. 1997), and in the process activate new forms of molecular imagination on how plants acted.

Drawing on their understanding of the molecular structure of known antioxidants, researchers began to look more closely at flavonoids and anthocyanins, compounds that contribute to the bright colors in plants (reviewed in Pietta 2000). Identifying these molecules not only as responsible for the vivid color of blueberries or mangos, but also as core players in the antioxidant potential of foods offered a short-cut for communicating with the public about how to identify antioxidant-rich foods. All one needed to do was "eat the rainbow." By 1999, the phrase "Eat the Rainbow" began regularly appearing in mass media outlets, and in 2000 had trickled down enough that a young science fair contestant in Canada took home laurels for her "Eat the Rainbow" project (Jackson 2000). The focus on flavonoids and anthocyanins as the molecular sources of antioxidant activity in whole foods joined an easily accessible visual indicator, color, to the molecularly elucidated ties between molecular structure and *in vitro* (as well as anticipated *in vivo*) function.

The rapid ability to test antioxidant capacity, and resulting ORAC values, facilitated the emergence of new, increasingly molecularized, hierarchies of nutritional value. The ORAC assay not only permitted comparison between strawberries and apples, it also permitted researchers to quantify differences in antioxidant levels *within* plant species (Ehlenfeldt and Prior 2001) and between domesticated and wild cultivars (Deighton et al. 2000). Via the ORAC assay, researchers were also able to enter into conversations about terroir, demonstrating that geographic origin and harvest time could contribute to total antioxidant capacity (Ou et al. 2002).[3] ORAC made the micromolecular components of foods, and their potential interactions with a range of environments, accessible. In addition, the ORAC test (along with other tests of oxidative capacity) closely linked specific molecules and molecular families with their potential to fight off oxidation outside of the test tube, and did so in a way that tied health not only to how people eat, but also to how they considered the entire agricultural process.

Molecular Politics

Despite the significant attention from researchers interested in how food and the body interact, information about antioxidant potential remained scattered in scientific papers rather than publicly aggregated. That changed in 2007 when the USDA released a database listing antioxidant activity as measured by the ORAC procedure for 277 foods. The database compiled a wide range of non-processed and processed foods such as fruits, vegetables, and nuts with more processed foods such as oils, rolled grains, and juices. In 2010, an additional forty-nine foods were added to the database. The authors of the introduction to the 2010 release highlighted that the second version included the addition of maple syrup, açaí, and goji berries (Haytowitz and Bhagwat 2010, i); all three products had gained recent power on the market and carried links to either indigenous foodways or far-flung places of production. The database itself was compiled from data generated by a range of sources. These ranged from foods analyzed by the USDA as part of the National Food and Nutrient Analysis Program, foods collected and analyzed as part of the food composition database for American Indians and Alaskan Natives, data collected from available literature, and data from some food industry sources (Haytowitz and Bhagwat 2010, 2). In other words, the database assembled together and contained a range of different interests.

Although the database highlighted differences in the quality of the data, its true charisma lay in the column containing the results of the varied trials of strength assembled by the database. Those charismatic numbers conveniently assembled by the USDA were easy to extract, reproduce, and repackage into infographics that quickly communicated how potent a food's antioxidant capacity was. For example, the Wild Blueberry Association of North America circulated a press release on May 5, 2008, titled "Blueberry Juice Tops the ORAC Antioxidant Chart." The chart demonstrated the superior antioxidant value of blueberry juice to other juices, using the USDA's own database to bolster the agricultural association's efforts to sell blueberries not just as a fruit, but rather as a value-added juice, a "concentrated sources of protective natural compounds" (Wild Blueberry Association of North America 2008). Once translated into easily digestible graphs, information about antioxidant levels became much more amenable to the print, web-based, and on-package mediums of late twentieth- and early twenty-first-century health communication so critical to efforts to expand consumption in an otherwise inelastic market. The ORAC numbers, assembled together by the USDA website, created a new legibility for a scientific concept—oxidation and its prevention—that otherwise remained relatively resistant to everyday discourse.

The numbers added for the second release of the database carried a different sort of charisma—one that drew on a desire for foods from indigenous or distant sources as evidenced through the inclusion of foodstuffs such as açaí, gogi berry, and mangosteen (McDonell 2016)—a charisma that facilitated extractionist logics. As scholars like Hi'ilei Hobart show in their examination of poi in Hawai'i, historic modes of extracting indigenous foods have often relied on use of technology to transform foods from abject to acceptable (2017; see also García 2013). Similarly, measurement of ORAC activities offered the possibility of technologically transforming local food knowledge, geographically situated away from the ills of the "Global North," into products that could be extracted from their whole food milieu and then tested. The resulting trials of strength produced numbers that justified further investment in, and subsequent extraction of, those foods from their agricultural places of production and into the global food market.

In compiling and making public the ORAC database, the USDA as an institution, and its associated researchers, found themselves tangled in an accumulation of interests facilitated by the presence of a collated, government-sponsored database. Like the Wild Blueberry Association, many food producers, importers, marketers, and bloggers found the numbers generated by ORAC assays useful modes for comparing and communicating about foods. The loosened regulatory landscape highlighted above facilitated a proliferation of messaging about products. Packaging and nutrition articles promoted the idea that certain foods contained higher levels of biologically active molecules than others, often represented through graphs comparing ORAC numbers. Others simply invited eaters to activate their imagination of what was happening in the body. Naked's Pomegranate Blueberry juice, for example, noted that "Fresh, pure; If antioxidants are the foot soldiers in the war against cell-damaging free radicals, then Naked Juice Pomegranate Blueberry is a Five-Star General …. prepare for battle, drink your super juice and left, right, left your way to good health" (Table 4.1).[4] Although not explicitly medicinal, communication about these foods winked and nodded toward larger societal fears about aging and exposure to the miasmatic dangers of the late twentieth and early twenty-first

Table 4.1 Functional drinks examined, 2009. I have attempted to maintain first letter formatting in all names and claims

Drink	Flavor	Claims	Messages
Glacéau Vitamin Water	XXX (triple antioxidants) açaí-blueberry-pomegranate	10 calories, antioxidants, vitamins, superfruits, fight free radicals, naturally sweetened	Nutrient rich, calorie poor
SoBe Lifewater	Yumberry Pomegranate Vitamin-Enhanced Water Beverage Purify	Vitamins, herbal content: ginger and dandelion, 0 calories	Purify, life
Purity Organic Water	Orange Mango Water	Electrolytes, 60 calories, organic	Purity, restore, organic
Ayela's Herbal Water	Cloves Cardamom Cinnamon	Zero calories, zero artificial, zero preservatives, organic	Purified water, organic
Penta	Ultra-Purified, Antioxidant Water	Pure antioxidant, neutralizes free radicals, no additives, fully absorbed	Feel more energized and alert today, and healthier for years to come, purity
Sonu Water	Blueberry Pear	Electrolytes, vitamins	Organic
Metromint	Orangemint Water	real mint unsweetened	All natural, pure, relieves your thirst, soothes your body, and revives your soul
Honest Ade	Orange Mango with Mangosteen, Just a Tad Sweet	Less sugar, full day's vitamin C, antioxidant-rich	Purified water, organic
Honest Tea	Pomegranate Red Tea with Goji Berry	Antioxidant power	Purified water, great taste, good health, social impact, heavenly, organic

Drink	Flavor	Claims	Messages
Carpe Diem Kombucha			Cleanses and refreshes your body, your soul, metabolism enhancer, harmonizing effects on metabolism and digestive system, supports the body's immune system; historical precedent of Zen masters, organic
Function: Nightlife	Passionfruit Guava	All Natural, no preservatives, plant extracts and amino acids to support healthy dopamine levels; epimedium, niacin and cnidium get your blood flowing and amp up your stamina; includes a graphical representation of "relative functional units" of each functional ingredient	Helps promote sexual health, support desire, reward, satisfaction and proper circulation; created by physicians
Naked Antioxidant	Pomegranate Blueberry	Antioxidant, 100 percent juice, no added sugar, no preservatives, no inhibitions	Fresh, pure; if antioxidants are the foot soldiers in the war against cell-damaging free radicals, then Naked Juice Pomegranate Blueberry is a Five-Star General …. Prepare for battle, drink your super juice, and left, right, left your way to good health
Bolthouse Farms Heart Healthy	Pear Merlot	Promotes a healthy heart with barliv, 100 percent natural, omega-3-fatty acids, no preservatives, no artificial colors, no artificial flavors, no genetically modified ingredients, antioxidant rich	Heart healthy (FDA approved health claim), organic
Sambazon Açaí Antioxidant Superfood	Supergreens Revolution	2x the antioxidants of blueberries, healthy omegas 3-6-9, delivers phytonutrients, fiber, protein	Pure energy, incredible nutrition, superhealthy, organic

centuries (e.g., Liboiron 2013). In doing so, marketers sought to capture taste buds as well as the larger imagination of how bodies, at the molecular level, engage with environment.

In June 2012, the USDA responded to the exuberant excess of claims-making by withdrawing the database. The USDA's withdrawal revealed an ongoing molecular politics where *how* one understands a food's efficacy shapes *how* one orders and regulates knowledge. USDA researchers at the Human Nutrition Research Center on Aging had been tasked from the very get-go to develop translational research, to make the leap from *in vitro* findings to *in vivo* experimentation[5] with the aim of making life better. As such, a logic of extraction sat at the very core of their efforts. In withdrawing the database, the USDA sought to remove the appearance of any institutional belief in the capability of *in vitro* antioxidative assays to demonstrate the efficacy of natural or processed foods in intervening in *in vivo* processes. Labels, magazine articles, blog posts, and the like followed suit, moving away from presenting ORAC numbers and toward other modes of communication. The fad, one might assume, had peaked.

From ORAC to Superfoods

Even as functional foods faded into an everyday part of the US grocery store landscape, the subsequent success of superfoods as a communication category, when read within the framing of extractionist logics, suggests that the discovery and characterization of antioxidants were not simply a fad. Searching for a better life at the end of the twentieth century calls into being a certain form of individual: one equipped with the skillset to live and eat in ways that promote health. It calls for extraction of knowledge about the goodness of various foods, and molecules, in caring for the body (cf. Ives, this volume). Rather than ORAC assays doing the work of extracting the antioxidant value of various foods, it is now individual brains that are invited to do the work of looking at something and extrapolating whether the food will contain biologically active molecules.

Although the move to superfoods superficially appears to repudiate molecular extraction via technology as a mode of attaining health (recall the Whole Foods focus on "wholeness" mentioned above), the molecular continues to play a core role in communication. Even as use of ORAC numbers dropped, marketers, nutrition writers, and bloggers continued to mobilize a molecular understanding of whole fruits and vegetables as carriers of health-promoting molecules. They did so by drawing on the relationships between antioxidant activity and color.

The idea that color could act as a short-cut to understanding the molecular content of plants without the work of going through a laboratory easily entered into the mass communication infrastructures of the early twenty-first century. Dynamic, colorful infographics urging children and adults to "Eat the Rainbow" have proliferated from public and private sources. Many still link the colors of the rainbow as found in fruits and vegetables to specific families of molecules and specific sorts of health-promoting properties. Swissotel, for example, has drawn together a chart using data from thirty-two public research institutions and privately owned health reporting resources that highlights how "**Red** foods contain phytochemicals including lycopene and anthocyanins … **Orange|Yellow** foods are packed with carotenoids … and tend to contain an abundance of vitamins and fibre … Chlorophyll, the pigment that makes plants **green**, is loaded with antioxidants … **Blue|Purple** loaded with anthocyanins and resveratrol … **White** coloured by anthoxanthins, they might also contain the beneficial phytonutrients allicin and quercetin" ("Colorful Foods: The Benefits of Eating the Rainbow" 2017). Although no longer linked to their specific ORAC values, the understanding of these pigmented molecules as potent antioxidants remains an easily legible bridge between the extracted fortification of functional foods and the wholeness of superfoods. Similarly, the healthy nature of colorful foods easily entered into the super-saturated, digitally perfected space of online platforms and apps. As a glance at the over 6 million #superfood- or #superfoods-tagged posts on Instagram shows, naturally occurring colors continue to mark a food's micronutrient and health-promoting status. Color as a marker of health corresponds especially well with the short-cut visuality of social media, allowing content generators and content consumers to quickly communicate about the health of an item and, in the process, signal their own stance on health maintenance (cf. Sikka 2019). Although the explicit technological engagement that characterized (and characterizes) functional food advertising is less apparent, technological extraction remains, haunting the images through the linkage between color and health that has now become common knowledge.

While infographics may highlight whole foods, it is notable that many (although not all—quinoa and rooibos offer notable counterpoints) of the foods promoted as superfoods are also significantly processed. As LeBlanc, Guthman, and Brondizio highlight in this volume, powdered smoothie mixes, juices, and energy bars make up a significant set of the industrial superfood market. These items, like their functional food counterparts, similarly offer to extract the powerful nutritive properties from food on behalf of consumers. The core difference between the two categories, rather, shows up in how explicitly extractionist logics are mobilized: marketing of functional foods specifically draws on scientific research to make its claims, while marketing of superfoods relies rather on the ability of a vague technological understanding, developed during the 1990s and early aughts, to facilitate translation between color, general molecular category, and health.

Ideas, Extracted

Extractionist logics function by linking together scientific research and technological innovation with the creation of an activated imagination of how molecules behave. The work of creating this mass molecular imagination does not just lie in the realm of nutritionists or marketers. Rather, the creation of a wide-ranging understanding of certain groups of molecules as having positive, disease-fighting impact on bodies comes into being via the action of a wide range of actors and interests. Research into the biological ability of molecules to prevent oxidation facilitated extractionist logics by enabling rapid, cost-effective screening of the antioxidant activity of a range of foodstuffs. Published antioxidant activity levels, embodied in the ORAC score, became communication devices that marketers and others used to compare familiar and unfamiliar products. These entered into already existing infrastructures, from the trade groups discussed elsewhere in this volume (Reisman) to the desires for foods that reconnected one to nature.

Distributed between researchers, policymakers, food producers, food marketers, and eaters, extractionist logics propose that the most valuable parts of foods—their micromolecular structures, found in microbial metabolites or the colorful phytochemicals fabricated through the plant-based labor of growing and reproducing—are there to be extracted, isolated, and reproduced through scientific and technological innovation. Once re-embodied in functional foods, these molecules and their accompanying logics situate eaters as micro-extractors, capable of using the knowledge they have gained through immersion in a saturated media environment to responsibly navigate and extract extra health-promoting value via consumption choices. Herein lies the continuum between functional and superfoods: both build on an epistemic foundation of examining antioxidant activity that has been used to create, excite, and profit from a molecular imagination informed by techno-science. Superfoods, like functional foods, are valued because they carry the potential of intervening in long-term human health. And, like functional foods, they remain epistemic objects that resist complete characterization.

Notes

1 Steinberg, who founded the University of California, San Diego's School of Medicine, is credited with the development of the oxidation hypothesis/oxidative modification hypothesis. Building on work that began in 1979 examining how macrophages were metabolized in cell culture, Steinberg's research career focused on understanding the biochemical mechanisms that led to the creation of atherosclerotic lesions. For a retrospective of his life's work see Steinberg (2009).

2 They did this by taking advantage of the fluorescent properties of an indicator protein. When oxidated, the level of fluorescence changes. The ability to detect this change and plot it out on a graph allowed researchers to quantify the reaction rate, and in the process quantify the effectiveness of antioxidants added to the serum.

3 It should be noted that the study by Ou et al., which examined an astonishing 927 samples, came out of Brunswick Laboratories. The group helped commercialize the ORAC assay.

4 All drinks but the Vitamin Water and Sobe Lifewater were purchased from Whole Foods in New York City; drinks were selected based on category of functional drink (enhanced water, tea, smoothie, other) and location within the refrigerated drink wall—all drinks were spatially separated from the "bottled water" section. Vitamin Water was obtained from a ten-day promotional event held at 626 Broadway during early April 2009; Sobe Lifewater was purchased at Key Foods. I chose Whole Foods as the primary purchase site due to the significant selection of functional beverages available in their refrigerated drinks section. I excluded sports and energy drinks from this survey based on the definition of functional drinks as offering some health benefit beyond that of basic nutrition.

5 Researchers found that consuming fruits and veggies raised the antioxidative capability of blood serum when that serum was tested using the ORAC assay. Such findings don't necessarily mean long-term health, of course, a tricky proposition given the nuance of food consumption versus the blunt force of pharmaceuticals.