



Communication

Organic and Conventional Produce in the U.S.: Examining Safety and Quality, Economic Values, and Consumer Attitudes

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Academic Editor: Douglas D. Archbold

Received: 1 December 2015; Accepted: 23 March 2016; Published: 5 May 2016

Abstract: Organic agriculture is an industry sector that has been experiencing steady global growth in recent years. The United States is ranked first in organic food consumption, followed by Germany and France. In 2014, the estimated market value of organic foods in the U.S. was \$42 billion; 43% of this total was attributed to produce (fruits and vegetables). Organic production systems in the U.S. must adhere to National Organic Program (NOP) standards that integrate cultural, biological, and mechanical practices. These standards promote the recycling of resources and ecological balance while conserving biodiversity. While the U.S. organic produce sector is steadily expanding, many questions related to price, safety, nutritional quality, and consumer preference remain. This paper will provide comparisons and insights in the following areas: (1) the economic contribution and impact of the organic produce market; (2) the U.S. National Organic Standards and requirements, as well as the certification process; (3) the nutritional quality and safety of organic produce; (4) consumer attitudes and preferences regarding organic produce; and (5) future research directions and developments for the organic produce industry.

Keywords: food safety; organic produce; nutritional quality; microbial safety

1. Introduction

Organic agriculture is an industry sector that has been experiencing steady global growth in recent years. The difference between organic and conventional products is how they are grown (produced) and processed; specific regulations as to what is considered organic or nonorganic (conventional) can vary by region. For example, the regulations for the European Union (EU) can be found in Council Regulation (EEC) 834/2007 and 889/2008 and 1235/2008 on organic production of agricultural products [1]; for the U.S., pertinent regulations can be found at [2]. The Research Institute of Organic Agriculture (FiBL) in collaboration with the International Federation of Organic Agricultural Movements (IFOAM) recently released a comprehensive review of global organic agricultural statistics and emerging trends. The document provides a comprehensive overview of standards and regulations in various regions of the world as well as current statistics on organic production areas, producers of organic crops, organic markets, and data on specific crops such as citrus, fruits (temperate, tropical and subtropical), and vegetables [3]. As with conventional production systems, organic production

systems include a wide range of practices deemed acceptable under various organic rules, laws, and regulations. This particular manuscript will focus on organic and conventional produce (fruits and vegetables) in the United States, with a particular focus on economic value, safety and quality, and consumer attitudes.

2. Economic Impact of Organic Produce in the United States

Globally, the United States is ranked first in organic food consumption, followed by Germany and France. Organic food sales in the United States totaled \$24.8 billion in 2012, accounting for 3.7% of total U.S. food sales and 11.4% of U.S. fruit and vegetable sales [4]. Organic production of various crops and animal-derived products has been one of the fastest-growing segments of U.S. agriculture in the last decade (United States Department of Agriculture Agricultural Marketing Service [2,5,6]. In 2014, the estimated market value of organic foods in the U.S. was \$42 billion; 43% of this total was attributed to produce (fruits and vegetables) [6]. In 2008, there were 168,776 acres (approx. 68,300 ha) dedicated to certified organic vegetable production in the U.S. [6,7]. California continues to lead the nation in certified organic vegetable production, with more than 104,076 acres (42,118 ha) under cultivation.

3. The U.S. National Organic Standards and Requirements and Certification Process

In the United States, organic vegetable and fruit production must be in compliance with the National Organic Program (NOP) standards [2], which are designed to create production systems that “respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity” (USDA/AMS, 2009, para. 6) [2]. To be classified (or certified) as organic growers or producers, producers must develop and submit an organic system plan. The plan must cover all aspects of vegetable and fruit production, ranging from soil fertility to postharvest processing and handling; this includes weed and insect control plans, disease management, and crop rotations. (Vegetables and fruit must be grown in rotation with other crops.) In developing an organic system plan, producers need to consult the NOP Generic National List (GNL) which brings together in one location a generic list of materials that can be utilized for organic production. Alternatively, the Organic Materials Review Institute (OMRI) also provides a list of brand name products that can be utilized in organic production (www.omri.org) [8].

The OMRI is a nonprofit organization that has no connection with the NOP, and the OMRI Products List (OPL) represents that organization’s recommendations regarding the acceptability of brand-name products for organic production, processing, and handling. The products included in the OPL have been reviewed against the standards developed by OMRI for assessing compliance with the NOP Rule (NOP/7 CFR Part 205) [2]. Only those products that have passed this review are included in the OPL and can display the OMRI Listed™ seal on labels and in advertising and promotions. Because participation in the OMRI program is voluntary, and there is cost involved, the OPL (OMRI Products List) is not a comprehensive listing of products suitable for organic production, processing, and handling. Therefore, a product’s absence from the OPL does not imply its failure to comply with the NOP Rule.

Certifying land for organic production requires that no prohibited substances be applied for a minimum of three years prior to harvest. The NOP certifying agencies carry out detailed annual inspections to verify that production and handling processes on organic farms comply with NOP standards. Currently there are approximately 80 certification agencies in the U.S., all accredited by the USDA, and applicants have the freedom to select any accredited U.S. certification agency. As a result, in the U.S., when consumers buy Certified Organic farm products, they can be certain that they are supporting farmers who take their stewardship roles so seriously that they have voluntarily accepted strict federally regulated standards [9]. In addition, the USDA National Organic Program also provides strategic plans, which are open and transparent for 2015–2018 [10].

4. Nutritional Quality and Safety of Organic *vs.* Conventional Produce

Overall, according to the recent literature, consumers continue to perceive that organic produce is more nutritious and safer. However, while the organic production of fruits and vegetables has experienced rapid growth, very few well-controlled studies have been published to prove or disprove these beliefs. This section of the manuscript will focus on traditional nutrients and selected phytonutrients; for the most part, the literature will cover recent major reviews from 2009 to present. Only limited data are available for specific produce in limited geographical areas and for specific nutrients.

A recent review of studies (published in 2011) suggests that ingestion of organic produce leads to a higher intake of phenolic compounds and vitamin C, as well as lowering the amount of nitrates and pesticides consumed [11–14]. According to a review by Hunter *et al.* [13], organically grown produce has about a 12% higher concentration of secondary metabolites. If these secondary metabolites positively influence health, organic foods may possess advantages over conventional foods. According to the latest major review (a meta-analysis) by Barański *et al.* [15], on average, organic crops have higher concentrations of antioxidants, lower concentrations of cadmium, and a lower incidence of pesticide residues than nonorganic crops, across regions and production seasons.

However, other recent systemic reviews of nutrition and health effects of organic foods conducted in the US have revealed few health benefits from consuming organic foods [16,17]. Another recent study by the American Academy of Pediatrics examining the potential health and environmental advantages and disadvantages of organic foods revealed the following: (a) due to a lack of control as well as other issues with measurement, nutritional differences between organic and conventional produce appear to be minimal; (b) organic produce contains fewer pesticide residues, but it remained unclear how clinically relevant this is [18].

In terms of safety, there seems to be a consensus in literature that organically-grown fruits and vegetables tend to have lower incidences of pesticide residue contamination and lower levels of nitrates [11,12,14]. In the United States, according to the latest (2013) report from the USDA, more than 99% of all products sampled by the program had pesticide residues below the EPA tolerance. However, this report did not distinguish between organic or conventional production; it simply designated the sample as domestic, imported, or unknown. It is notable that fresh and processed fruit and vegetables accounted for 84% of the 10,104 collected samples for pesticide analyses. More than 40% of the samples had *no* detectable pesticide residue. Produce with detectable pesticide residues (5%) included bananas, broccoli, carrots, cauliflower, celery, green beans, mushrooms, nectarines, peaches, plums, raspberries, and summer and winter squashes [5].

When it comes to bacterial contamination, the most recent comprehensive review concluded that there is no statistically significant difference between organic and conventional produce [17]. In addition, in terms of fungal toxins and heavy metal contamination, the latest reviews revealed mixed results. These mixed results were also consistent with some earlier major published reviews that are not cited in this manuscript.

Experts agree that quality (including nutritional quality) and safety of fresh produce is a complex issue which is affected by a variety of factors, such as environmental conditions, production practices, postharvest processing and handling, and bioavailability after consumption. A body of research reveals that the compositional differences between organic and conventional produce depends on production practices and surrounding environments for both systems. In addition, postharvest processing, storage, handling, preparation, cooking, and processing prior to consumption all affect nutrition, bioavailability, and functionality (Table 1). Once produce is consumed, only certain amounts of nutrients are absorbed into the human body, bloodstream, or targeted tissue and reach clinically relevant levels. It seems that comparing the absolute difference in the nutrients of fruits and vegetable grown under different production methods may not be sufficient. Many experts have suggested conducting further research, looking at a broader range of nutrients and potential impact on human health outcomes [11,12,14,17,18]. Based on current knowledge, the question becomes: are we asking appropriate research questions?

Table 1. Summary of factors affecting quality and nutritional quality of produce from production to consumption and absorption in the body.

Production Stage	Harvest, Postharvest Handling, Packaging and Storage	Preparation and Cooking and Processing	In Human Body (After Consumption)
-Immediate environment (e.g., geographic zones) -Production conditions -Fertilization -Pest control -Season -Water -Light/day length -Soil types/growing mediums -Plant genotypes -Analytical methods for assessment of selected nutrient components and the sample preparation methods	-Harvest methods -Harvest maturity -Plant parts -Postharvest handling and processing techniques -Time and temperature of storage -Analytical methods for assessment of selected nutrients components and the sample preparation methods	-Preparation methods -Cooking and processing methods -Consumer handling and storage -Analytical methods for assessment of selected nutrients components and the sample preparation methods	-Age, gender and genetic of individual -Enzymatic levels -Manner of eating (e.g., chewing) -Stage of health -Analytical methods for assessment of selected nutrients components and the sample preparation methods

Source: [11–19].

5. Consumer Attitudes and Preference Regarding Organic Produce

According to recent consumer surveys, 84% of American consumers buy organic food. Certified organic produce is common in most grocery chains and fetches substantial price premiums in the U.S. Customers' top motivations for purchasing organic produce include health reasons and avoiding genetically modified organisms (GMOs) [4]. Nevertheless, consumers purchase organic foods for many different reasons, including environmental factors [13,17] and the perception that organic food tastes better [17]. According to a review by Yiridoe *et al.* [20], a clearer picture of consumer attitudes and willingness to pay will help the organic industry in the future. Even if consumers are willing to pay, knowledge and awareness of organic foods may not be consistent, so future consumer research will be helpful to better understand trends.

6. Future Research

Does conventional and organic produce differ when it comes to safety and quality? Are there compositional differences between the two? Current data offer few clear answers. Much depends on production practices and the surrounding environment, as well as postharvest processing, storage, handling, preparation, cooking, and processing prior to consumption. Furthermore, bioavailability after consumption and functionality also depend on the biological condition of the end user. In order to formulate meaningful research in this area, many factors must be considered. For example, with available GPS and geospatial technology, mapping of soil information throughout production regions can be incorporated and adjusted in the comparison studies. Development of specific biomarkers for tracking the consumption of specific secondary metabolites and assessing the benefits of consumption as they relate to different groups of consumers could come into play. In addition, understanding consumers and the knowledge and motivations that affect current and future behaviors will help the industry. Last but not least, critical reviews of analytical procedures will help provide a better understanding of the situation. These are but a few examples of future themes for research in these areas.

7. Conclusions

There is no doubt that the organic produce market provide significant economic impact in the U.S., but when it comes to quality and safety, current data offer few clear answers. Much depends on production practices and the surrounding environment, as well as postharvest processing, storage, handling, preparation, cooking, and processing prior to consumption. While consumers are willing to pay, knowledge and awareness of organic foods may not be consistent.

Acknowledgments: This work is partially funded by the NIFA HATCH Fund (FLA-FYC-005476).

Author Contributions: Amarat Simonne conducted the safety and quality issues, Monica Ozores-Hampton and Danielle Treadwell pursued organic standards and production and Lisa House conducted the consumer preference issues.

Conflicts of Interest: The authors declare no conflict of interest.

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