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Advances of organic products over conventional productions with respect to nutritional quality and food security

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ABSTRACT

Organic products are derived from the organic production system, following organic agricultural cultivation standards, and processing schedules must be identified by an independent certificate authority. The main characteristic of the organic agricultural production system is that all artificial synthetic materials such as pesticides, fertilizers, growth regulators, feed additives, and gene engineering products are not allowed to use. However, there is much debate on organic production quality and health safety issues in academic circles. Some people believe that there is a "Three Cannot" problem with organic production, that is, organic products "cannot be distinguished, cannot be tasted and cannot be measured" compared to common ones. To objectively reflect the differences in nutritional quality and food safety between organic and conventional products, we combined extensive literatures with our research data and have reported some advances in the sensory quality, nutritional value, and safety of the two types of products. The results showed that organic products tasted better; the percentage of leanness was higher, and the products tasted much tender. The dry matter content of most organic crops was about 7–20% higher than that of conventional foods, and enriched vitamin C, anthocyanins, isoflavones, carotenoids, and other phenolic compounds and more elements such as P, Fe, and Mg and trace elements such as Zn, Cu, and Cr were verified in organic crops. Organic animal products contain more beneficial polyunsaturated fatty acids; the nitrate content in organic fruits and vegetables was 20–50% of that in normal fruits. No pesticide residues and less heavy metals were found in the organic products. Our investigation showed that there were obvious differences in quality and safety between the products that originated from organic agriculture systems and conventional alternatives. This conclusion can provide an important theoretical basis for the healthy development of the organic industry.

Organic products are derived from the organic production system, which are produced and processed according to the international standards of organic agriculture, with the products being certified by an independent certificate authority [1]. The essential requirements of organic production are: (1) none applications of organisms and products that generated from genetic engineering; (2) none usage of chemical synthetic pesticides, fertilizers, growth regulators and feed additives, etc.; (3) applying a series of sustainable agricultural technologies and maintaining stable agricultural production system based on natural rules and ecological principles [2].

Organic foods have obvious advantages in promoting human health, ecological protection and biodiversity maintenance, and thus have been widely accepted by consumers especially consumers in developed countries [3]. The data from FiBL-IFOAM of 2016 showed that, global market capitalization of organic foods had reached 800 billion dollars. There are 172 countries that produced certified organic foods and the total producing area has reached 4.37 million hectares, with 2300 thousand farmers engaging in organic farming [4]. Because of natural sources, rich nutrition, high quality and safe environmental protection, consumers from all over the world tend to buy organic foods. In the United States, for instance, though organic products are 30–60% more expensive than conventional ones, organic food have still accounted for 4% of the nation's food sales [5]. In China, the price of organic products is 2.5–3 times of the conventional ones [6].

Developing organic farming in China is facing serious problems, mainly including organic certifications lacking management, and the organic market is disturbed by fake and poor quality products, which hits the consumers' confidence. More seriously, consumers are short of awareness of organic foods, and lack direct communications with organic producers, resulting in mistrusting organic producers and operators. All the obstacles have restricted the development of organic agriculture eventually [7]. Even for the quality and food safety of organic

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products, the academic circles have no agreed conclusions [8–9]. In April 2009, Quality Low Input Food Report of European Union summarized the research data of five years and found significant differences in grains and livestock under organic and conventional production systems. The main differences included (1) organic food contained more beneficial nutrition such as vitamins, polyunsaturated fatty acids, antioxidants, etc.; (2) organic food had lower levels of heavy metals, fungal toxins and pesticide residues [8]. On the contrary, Spangler from Stanford University analysed the differences in vitamins and nutrients of organic and conventional grains, vegetables, fruits, meats, poultry, eggs, milk, through reviewing 223 studies. Unfortunately, he found that "The published literature lacks strong evidence that organic foods are significantly more nutritious than conventional foods" [9]. Further research is needed for revealing the truth in terms of nutrition, ecological conservation and food safety.

China has successfully fed 20% people of the world with <7% of the world's cultivated lands, however consumed 35% of the world's chemical nitrogen fertilizer and 70% of the world's agricultural water resources [10]. The continuous food supplying capacity of China is severely restricted by the result of widely applying chemical fertilizers rather than nourishing the land, leading to farmland's hardening and acidification [11–13]. In recent years, a series of food safety incidents have come to light, and people tend to pay increasing attentions to the relationships between food nutrition and health [14]. To scientifically solve the problems of food quantity and food safety, we must separate the food for human from those for animals. For human food supply, we should adopt organic agricultural measures, improve agricultural products, and reduce the production and consumption of chemical fertilizers, pesticides and agricultural films [15]. While to correctly guide the development of organic industry, we must illustrate with facts by using a scientific attitude and avoiding subjective judgment. We therefore focus on studying the sensory quality, nutritional value, and safety aspects of agricultural products. We have combined extensive literature with our research data to prepare this report, hoping to provide a scientific basis for the development of organic agriculture, especially in China.

1. Differences of sensory quality between organic products and conventional products

Sensory qualities such as shape, color, taste, smell and homogeneity are the most intuitionistic descriptions and judge indexes for food quality. Studies have found that, in comparison with the past, the tomato's sweetness has dropped from 3.24 to 2.77 and sugar content decreased from 5.29% to 4.85%, while the firmness has increased from 6.86 to 12.1 [16]. The main reason is that people pursue high yield and increase chemical fertilizers' dosage and shorten the mature period of fruits and vegetables through artificial ripening, violating the plants' natural growth laws. Compared with conventional fruits and vegetables, in despite of inconsistence in appearance and even insect bites, organic fruits and vegetables grow following natural principles, absorb macroelements and microelements from organic fertilizers, and produce natural food with "good taste". The "good taste" is derived from nature, and what the customers eat is the most natural parts [17–19]. Some reported that the contents of soluble sugar, organic acid, aromatic compound in organic apples are higher than that in the conventional ones, and as a consequence, organic apples smell and taste better [20–21]. Some also found organic potatoes have lower browning degree and taste much more brittle after frying compared with conventional ones [22]. Instead, some still argued that there were no differences in sensory quality between organic and conventional grains [23]. For instance, Tobin et al. employed volunteers to judge the sensory quality of 9 fresh organic and conventional vegetables and fruits, and found no obvious differences existed between organic and conventional products [24]. Even through, organic poultry farming is allowing the poultry grow in the natural environment, breathe fresh air and feed on natural-source food such as insects, earthworms, seeds and tender leaves. The organic poultry have delicate and compact flesh, and the eggs taste better [25].

2. Differences in nutrition between organic and conventional products

2.1. Dry matter content

Dry matter is accumulated through the plant photosynthesis, which is the rest of the organism after being fully dried under constant temperature of 60–90 °C. Dry matter is an important indicator for measuring organic matter's accumulation and nutrition composition, including starch, cellulose, protein, fat, inorganic minerals, etc. It was noted that organic fruits and vegetables contained higher content of dry matter than the conventional ones [26–28], which may due to the fact that conventional plants which grow consuming excessive chemical fertilizers need absorbing more water [28]. Nevertheless, there are also studies found that dry matter in organic products was less than that in the conventional ones. For instance, Huber et al. compared dry matter content of 19 organic and conventional fruits and vegetables, in which only 10 showed that organic products had 20% higher dry matter content [29]. By contrast, Gastol et al. noted that in comparison with the conventional products, dry matter content was higher in organic pears, black currants, beetroots and celeries, but lower in organic carrots and apples [30]. Brazinskiene et al. revealed that conventional potatoes contained much more dry matter than the organic ones (Table 1) [31]. The above mentioned debates may be due to the fact that different results may be associated with different crop types.

2.2. Proteins and amino acids

Protein is the material basis for life which is the most important material for forming cells. Protein consist of 20 kinds of amino acids in different composition, among which there are 8 essential amino acids that must be supplied by food. In organic farming system, due to the insufficient supply of nitrogen fertilizer, the protein content in organic products is somewhat lower than that in conventional ones. However, some studies found that organic products had high protein content, which maybe because the metabolism of plants was driven towards the process of increasing some essential amino acids when the nitrogen source was limited [32]. Protein content is not the only indicator reflecting the crop quality. High quality protein should be digested easily and contain human body essential amino acids. Vrcek et al. compared the protein content and its digestibility between organic and conventional wheat flour and found, the organic wheat flour had 14% and 17% lower average protein content than the conventional separately, but had 2.9% and 5.1% higher protein digestibility than the conventional one [33]. Carillo et al. discovered that the organic potatoes powder ($7.0\ g \cdot 100\ g^{-1}$) not only contained 1.49 times higher protein content than the conventional ones ($4.7\ g \cdot 100\ g^{-1}$), but also had 25.7% richer total amino acids over the conventional. The former contained more alanine, arginine, asparagine, aspartic acid, glutamic acid and other amino acids [34].

Table 1
Dry matter content of organic and conventional vegetables and fruits.

Material	Dry matter content (%)		References
	Organic	Conventional	
Pear	12	11.2	Gąstoł et al. (2011) [30]
Blackcurrant	15.2	12.6	
Beetroot	12.2	8.3	
Celery	10.4	8.9	
Carrot	9.7	10.4	
Apple	12.4	13.4	
Potato	22.1	23.4	Brazinskiene et al. (2014) [31]