International Journal of PharmTech Research
CODEN (USA): IJPRIF, ISSN: 0974-4304, ISSN(Online): 2455-9563
Vol.9, No.6, pp 316-324, 2016

Organic food and impact on human health

Akram Arianfar*, Maryam Sardarodiyan

Young Researchers and Elite club, Quchan Branch, Islamic Azad university, Quchan, Iran

Abstract : Organic farming, also known as biological or ecological farming, should follow a well-defined regulation and the mode of production must be controlled by a certification body. Its main constraints are a minimal use of off-farm inputs, the prohibition of synthetic chemicals (fertilizers, pesticides, drugs), the use of organic fertilizers and natural pesticides, long crop rotations, the maintenance of the organic matter and microbial life in the soil, the prohibition of gen- etically modified plants. For animal husbandry, organic regu- lations concern welfare, use of organic feeds and the limitation of therapeutic treatments (especially antibiotics and hormones). Organic farming involves obligations in relation to means of production but not in respect of the nutritional, health, or sensorial qualities of the products. Foods marketed under the label "organic" must contain at least 95% ingredients from organic agriculture, possibly with food additives from a very restrictive list. The paper gives an overview of recent studies investigating the health value of organic foods and presents a framework for estimating the scientific impact of these studies. Furthermore, the problems connected with the different research approaches are being discussed. Recent human epidemiological studies associated consumption of organic foods with lower risks of allergies, whereas findings of human intervention studies were still ambiguous. The hypothesis might be that organic food increases the capacity of living organisms towards resilience. To confirm this, effect studies on specific markers for health are necessary.
Key words: Organic food, Health, Humans, Intervention.

1. Introduction

The organic food industry in the United States is a fast-growing segment, with sales expected to reach $35 billion in 2014. Sales growth is occurring across multiple product segments, including produce, dairy, meat, grains, snack foods, and even condiments[1]. This growth in sales has been accompanied by a growth in the availability of organic products. Traditionally, organic products could only be found at specialty grocers like Whole Foods Market and Sprouts or at local farmer's markets, but consumers now have access to these items at a variety of mainstream grocery retailers[2]. In 2013, the discount retailer Aldi introduced its SimplyNature brand (which features both organic and natural products) and announced it would offer organic produce in its stores[3]. In the same year, the U.S. retailer Target began rolling out its Simply Balanced brand, which boasts many organic products as well as products without genetically-modified ingredients[4]. Most recently, Walmart joined the organic trend by partnering with Wild Oats to significantly increase its organic offerings in the ''pantry" section[5]. Research has estimated that the global organic industry is growing at a rate of 10–30% p.a. and is worth 33 billion dollars[6]. In Australia there is little data on industry size as most agricultural research does not differentiate between conventional and organic produce. However, estimates put Australian industry sales at around 400 million dollars annually[6]. The growth of the Australian organic industry, in terms of production, is largely influenced by overseas markets, especially Europe as they take around 70% of Australia's organic

exports[7]. Annual growth estimates show that organic production is expanding at a rate of 16% per annum[8]. In this paper an overview of recent studies on the topic is given, with a framework for estimating the scientific value of these studies. In addition, the problems connected with the different approaches are being discussed. A hypothesis is presented about the possible health effects that organic products might have, and suggestions are made for future research.

2. Organic knowledge

Knowledge is important as it is regarded as having an influence on the consumer decision making process[9]. Organic knowledge is affected by consumer mistrust of organic labelling practices[10]. Lea and Worsley's (2005) study found that approximately 50% of consumers consider organic labelling to be unreliable[11]. This suggests a degree of mistrust in the way that organisations apply the word 'organic' and implies that organic labels lack authority[12].

3. Factors Influencing the Quality of the Organic Food

Quality and safety of the organic food rely on many factors; they are presented in Fig 1. Abiotic factors comprising the quality of the environment are basic for the food production in general and in organic food in particular. Air, groundwater, surface water, and soil have to meet high qualitative demands; first of all, the level of contamination with chemical unwanted substances has to be low and safe for plant production. Next, biotic factors as cultivars of plants and races of animals are important, as well as the occurrence of the diseases and pests. The methods of soil fertilizations together with the methods of animal raising are fundamental for the quality of the produced crops and animal materials. Here, the farmers' knowledge, skills, and scrupulousness are also of high importance. The food processing methods are basic for the food products quality – in organic food processing, only c.50 natural substances are allowed, while in the conventional processing, several hundreds of the artificial synthetic substances are admissible. It makes the situation of the organic producers very difficult – the shelf life of the organic products is much shorter and the production is more expensive. On the other hand, the health merits of organic products are bigger[13].

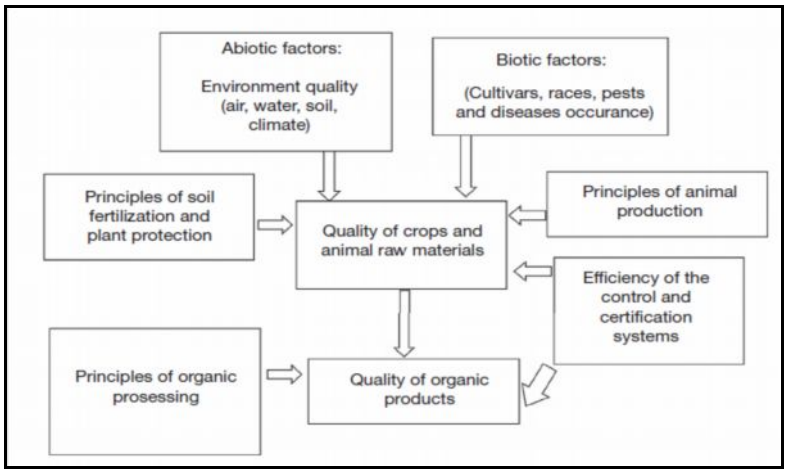

Fig.1: Factors influencing the quality of the organic raw materials and products, own elaboration[13].

4. Certification of Organic Production Systems

Initially there was a direct communication link between farmers and consumers of organic foods. Early consumers interested in organic food had to buy it directly from growers or farmers markets–know your farmer, know your food was the motto. By talking to farmers and seeing farming activities and conditions, individual acceptance of what constituted organic production was the norm. As demand for organic food continued to increase, high volume sales through supermarkets rapidly replaced the direct farmer connection. A system to convey the practices used in producing the organic food was needed. An organic certification system was the essential solution aimed at regulating and facilitating the sale of organic products to consumers. It was intended to assure quality and prevent fraud, and to promote commerce (Fig 2). In the context of these regulations, organic food is food produced in a way that complies with organic standards set by national governments and

international organizations[14]. Installation qualification is conducted to prove that equipment/system has been installed as per user and manufacturer recommendation and verifying that all required utilities have provided safe operation of equipment/system[15,16].

Fig 2: An example of alogo used for certified organic food[14].

5. Assuring the Organic Standards

The International Federation of Organic Agriculture Movements (IFOAM) (2009), is a global organization that accredits certifiers, creating an acceptable international organic standard. It includes the International Organic Accreditation Services (IOAS), which is responsible for the accreditation of the certification bodies and ensures the equivalence of accreditation programs in an international standard. Food safety testing is based on scientific knowledge of the critical points during the food production process combined with an understanding of the likelihood of natural and accidental contaminating agents in that food chain, the HACCP (Hazard Analysis and Critical Control Points) principles[17,18.19]. In 1972, the agency developed a guarantee scheme based on a democratic process of consultation with all the agents involved in organic production. This process resulted in a structure called the Organic Guarantee System, whose content is divided into (1) basic standards, (2) criteria for accreditation, (3) accreditation program, and (4) seal. Certification audit process is the mechanism most widely used to protect organic farming from fraud. Public or private accredited certification bodies use internationally recognized criteria and procedures for conformity assessment such as the ISO 65, recognized by IFOAM, and the European standard CEC 2091/91, in addition to the technical requirements established by the specific country legislation for organic agriculture, if needed. The basis of the certification audit is that the conformity assessment has to be made by an independent body with no direct link with anyone who buys or produces. After approval, the certification body is responsible for including the producer in the official register list and allows him or her to use the label. The certifying bodies draw up an institutional framework that can be called 'self-regulation,' since adherence to their respective certification programs is voluntary. This logic allows some standardization of the requirements so that there are legitimacy and trustworthiness among agents in the market, particularly consumers, producers, traders, and certifiers themselves[20].

6. Organic Food

Organic produce by definition must come from organic soil without the use of fungicides, pesticides and synthetic fertilizers[21]. The term "organic food" today can be referred back to the year 1942 when J. I Rodale highlighted in his newly launched magazine called Organic Gardening. Organic foods can be defined as "the product of a farming system which avoids the use of man-made fertilisers, pesticides, growth regulators and livestock feed additives[22]. Environmentalists have sought to encourage consumers to buy 'environmentally-friendly' products, which is known as green marketing[23]. Indeed, consumers perceive foods labeled as organic to be healthier[24]. However, in recent times the profit interests have undermined the use of the adjective natural, as well as the term organic, leading consumers to a generalized mistrust understanding that it does not necessarily mean safe[25]. On the other hand, objective analyses of environmental benefits of organic farming are not so clear. In this way, while there is evidence that smaller-scale production is more efficient in terms of

energy use, it generally involves lower productivity than either large-scale agriculture or non-farm work[26]. Thus, since the yields obtained by organic farming are lower compared with conventional farming, the overall environmental benefits are strongly reduced or even disappear after correcting for these lower produced quantities per hectare[27]. In a similar way to what occurs with functional foods, several studies have concluded that consumers would not sacrifice organoleptic properties for potential health benefits[28]. Furthermore, consumers are also willing to pay only a small amount extra for products with the organic label, and there is no evidence showing that this amount is enough to cover the decrease in productivity, mainly due to the perception of overpricing[29]. Indeed, as shown in Table 1 (USA data), there is a big difference between the prices of both kinds of products at the retailer level. In some cases, such as poultry, this difference may represent nearly a 200% increase. On the contrary, overpricing is less important in imported foodstuff: organic bananas were only 25% more expensive than conventional ones.

Table 1. Average prices of organic and conventional food products in the USA [30].

Product	Source	Unit	Price ($US)	
			Conventional	Organic
Milk	Retail	Half gallon	2.28	4.43
Eggs	Retail	Dozen	1.35	3.99
Rice	Retail	Pound	0.93	2.35
Carrots	Retail	Pound	1.59	2.21
Salad mix	Retail	Pound	3.85	8.14
Spinach	Retail	Pound	4.45	8.59
Strawberries	Retail	Pound	3.23	5.14
Poultry	First receiver	Pound	0.80	2.37
Broccoli	Wholesale market (Boston)	16 count bunches	14.06	32.30
Apple	Wholesale market (San Francisco)	Carton tray pack	32.61	45.89
Banana (imported)	Wholesale market (San Francisco)	40 pounds carton	19.57	24.48
Orange	Wholesale market (San Francisco)	7/10 bushel carton	13.87	27.24
Pear	Wholesale market (San Francisco)	4/5 bushel carton	30.13	47.08
Raspberry	Wholesale market (San Francisco)	12 6-oz cups	20.75	24.03
Sweet potato	Wholesale market (San Francisco)	40 pounds carton	23.57	36.54
Pea	Wholesale market (San Francisco)	10 pounds carton	17.32	43.75
Tomato	Wholesale market (San Francisco)	10 pounds carton	13.92	24.81

Moreover, it must be considered that since 2009 the economic recession has strongly affected the demand for organic products, for example in the United Kingdom, where it declined by 13.6% in 2010 and by 5.9% in 2011[31]. In this country, the most affected products were chilled convenience foods with a decrease of 36% in 2011, followed by bread (-20.6%), fresh fish (-16.0%) and breakfast cereals (-15.2%) (Table 2).

Table 2. Product share and value of the organic market in the UK[31].

Product	Share (%)	Value (thousand £)	Change 2010/2009 (%)
Dairy	30.5	528	-2.7
Fruit, vegetables and salad	23.2	402	-6.3
Baby food	7.8	135	+10.3
Beverages	7.5	130	-3.2
Fresh meat	4.8	83	-5.8
Confectionery	3.6	62	-8.3
Eggs	2.9	50	-9.4
Chilled convenience foods	2.2	38	-36.0
Fresh poultry	2.0	35	-13.2
Breakfast cereals	1.8	31	-15.2
Bread	1.2	21	-20.6
Fresh fish	0.7	12	-16.0
Other	11.8	204	-13.9

7. Organic Farming

Organic farming refers to agricultural activity where organic crops are grown without synthetic chemical inputs and organic livestock are raised and maintained on organic feed. "Organic crops are raised without using most conventional pesticides, petroleum-based fertilizers or sewage-based fertilizers. Animals raised on an organic operation must be fed organic feed and given access to the outdoors. The main aim of organic farming is to produce food in an environmentally respectful manner. Organic farmers try to achieve this by avoiding synthetic fertilizers, herbicides and pesticides. They rely on nutrient inputs from manures and mulches, biological nitrogen fixation, crushed minerals and microbial preparations[32,33,34,35].

8. Organic Food Industry

Organic food industry refers to the various activities from research, agricultural farming and retailing and also includes the consumer demand. The close regulation of organic food production within the European Union has resulted in an increase in consumer confidence and a clear set of standards that can be adhered to by new companies entering the organic food industry. Nowadays organic food industry is considered to be one of the most dynamically developing worldwide. By the end of 2011 the organic global market turnover was more than $60 billion. According to experts' predictions the market is expected to exceed $88 billion by 2015[35].

9. Recent studies in humans

9.1. Observational studies

To our knowledge, only a few observational studies investigating the health effects on humans of organic compared with conventional foods have been performed in recent years. According to one of these studies, commonly named the PARSIFAL study (14,000 children, 5 European countries), children representing an anthroposophical lifestyle (including biodynamic and organic food) were found to have less allergies and a (not statistically significant) lower body weight compared with a group consuming conventionally produced foods[36]. At the same time the results of the KOALA Birth Cohort Study in the Netherlands (about 2700 newborns) associated the lower eczema risk in children at the age of 2 years with the consumption of organic dairy products[37]. Moreover, organic dairy consumption resulted in higher CLA levels in breast milk of their mothers[38]. There is scientific evidence that dietary exposure of children to organophosphorus pesticides, measured as the level of pesticide metabolites in urine, is much lower on an organic than on a conventional diet[39].

9.2. Availability

Lack of availability is often cited as a barrier to the purchase of organic products[11]. Lyons et al. (2001) found that organic products in Australia were only available in limited quantities and were not easily accessible

to consumers. They showed that organic products were offered in smaller selections, had greater variation in consistency and generally shorter shelf lives than conventional products[12].

10.Review on consumer perceptions towards organic food

Demographic variables as well as lifestyle and environmental attitudes define the organic consumer profile. Regular consumers of organic food tend to be educated, affluent and of higher social class[40]. Awareness of food hazards and knowledge of food hazards were higher among females and individuals with more education and income[40]. With respect to absence of pesticides and fertilisers in organic production, organic fruits and vegetables have more biochemical energy to synthesise beneficial secondary plant metabolites such as polyphenolic antioxidants as well as naturally occurring toxins[41].

11. Nutritional quality of organic foodstuffs

11.1. Dry matter content

The available data mostly refer to vegetables and fruit. For leafy vegetables as well as root vegetables and tubers, a trend for higher dry matter contents in organic foodstuffs has been found while no significant difference has been identified for fruit vegetables and fruit[42].

11.2. Mineral contents

The most important mineral elements are calcium (Ca), magnesium (Mg), potassium (K), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), selenium (Se) and iodine (I). Phosphorus (P) and sodium (Na) are generally found in sufficient quantity. Fruit and vegetables. 22 scientific publications were considered in the AFSSA report (2003)[42].

11.3. Vitamin contents

The number of studies dedicated to vitamin contents is limited to some fruits and vegetables and eggs. Regarding water-soluble vitamins, the most studied one has been Vitamin C (ascorbic acid), a key vitamin for which higher daily intakes are recommended[42].

11.4. Other phytomicronutrients

Fruit and vegetables contain a large variety of microcompounds which are secondary metabolites in plants to have drastic regulatory effects at cellular level and are thus involved in prevention of certain diseases such as cancers, chronic inflammation and other pathologies. Some of them are phytoalexins which are produced in plants as a response to external stress such as fungal disease. While several factors can modulate their plant level such as cultivar, maturity, light or temperature, some studies have compared the levels of some of these phyto-microcompounds in fruit or vegetables depending on the cropping system[43]. Table 3 highlights the key items of nutritional and sanitary value of organic compared with conventional food.

Table 3. Key items of nutritional and sanitary value of organic compared with conventional food[43].

Increased contents	Reduced contents	Comparable contents
Dry matter in vegetables	Pesticide residues in all food (mostly absent)	Mycotoxins in cereals & milk
Some minerals (iron, magnesium) in vegetables	Nitrates in vegetables	Most minerals in fruit, vegetables & cereals
Anti-oxidants in crops: Vitamin C (potatoes) Polyphenols in fruit & vegetables, Salicylic acid in vegetables		Beta-carotene in fruit & vegetables
Polyunsaturated fatty acids in meat and milk	Saturated fatty acids in meat	
Most nutrients in wholegrain organic cereals and derivatives	Protein content in grains	

12. Conclusion

Agri-food systems comprise complex technologic, social, economic and environmental linkages that require integrated research approaches. In recent times, consumers' concerns about the social and environmental consequences of their consumption attitudes, as well as the growing preoccupations about living healthier lifestyles, have led to severe changes throughout the whole food chain, including all the agents from the producer to the retailer. Consequently, food supply chains have had to give response to the feedback signals of market trends. Among those trends, functional and organic products are currently two of the most in-fashion ones, involving strong modifications in the primary production, food processing industry and food-related scientific research. In addition, the difference in price between conventional and functional/organic food is often too large for consumers to change their shopping habits, and objective and productivity-corrected analyses of environmental benefits of organic farming are not clear. Modeling those changes in land use presents several challenges, particularly in integrating biophysical and socio-economic data and the heterogeneity that these data entail. The success on these challenges will only be possible if future research approaches consider the different aspects such as technical, social, environmental and economic ones as a whole thing, in a similar way to how integrated production systems have met the balance point to optimize food production in farms.

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