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Organic food quality and impact on human health

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Abstract. During the last decades consumers' trust in food quality and safety has drastically decreased, mainly due to several food scandals and growing ecological awareness. Consumers have started to look for safer foods, produced in environmentally friendly, authentic and local systems. Organically produced foods are believed to satisfy these demands.

Organic crops contain less nitrates and pesticide residues, but more dry matter, vitamin C, phenolic compounds, essential amino acids and sugars than conventional ones. Organically produced milk contains usually more dry matter, fat, calcium, selected vitamins and beneficial conjugated linoleic acids (CLA) compared to conventional milk from high input systems. Meat from organically raised cattle, pigs and sheep was found to contain less total fats and saturated fatty acids but higher content of unsaturated fatty acids and better n-6/n-3 fatty acid ratio.

The health effects of organic vs. conventional foods have been investigated in several studies. In vitro analyses indicated better repair of bacterial DNA and decrease of cancer cells proliferation on organic vs. conventional plant materials. Animal studies indicated better fertility indexes and increased immune parameters in organically fed animals. The effects of organic foods on human health are still not well known. However, according to PARSIFAL study children representing antrophosophic lifestyle, including biodynamic and organic food, had less allergies and lower body weight, while KOALA study associated consumption of organic dairy products with lower eczema risk in children.

The overall number of studies analyzing the quality and safety of organic foods and investigating the health effects of organic food consumption is growing. However, the results are still insufficient to formulate the explicit conclusions.

Key words: organic food, food quality, health

INTRODUCTION

During the last decades consumers' trust in food quality and safety has drastically decreased, mainly due to several food scandals and growing ecological awareness. Consumers have started to look for safer and better controlled foods, produced in more environmentally friendly, authentic and local systems. Organically produced foods are widely believed to satisfy the above demands.

The overall number of studies analyzing the quality and safety of organic vs. conventional foods is growing rapidly. This paper presents the literature review of the organic food quality and the health effects of organic food consumption.

Quality of organic plant products

Since the beginning of the 1980s until the end of 2007 nearly 100 studies comparing the nutrient content of organic vs. conventional plant foods have been published.

The content of plant secondary metabolites beneficial for human health was the topic of great interest in recent years. 72% of studies (Benbrook et al., 2008) indicated higher level of total polyphenols in organically produced plant foods in comparison with conventionally produced ones (e.g. Carbonaro et al. 2002; Young et al., 2005; Abu-Zahra et al., 2007). Polyphenols represent a large class of plant secondary metabolites with potential antioxidative properties. Moreover, there is a large number of studies reporting the neuroprotective, cardioprotective and chemopreventive actions of these substances (Frei & Higdon, 2003; Carlson et al., 2007; Kampa et al., 2007; Ortuno et al., 2007). The important group of polyphenols identified in higher contents in organic plants are flavonols (Caris-Veynard et al., 2004; Rembiałkowska et al., 2005), which were found to diminish the incidence of heart disease, cancer, gastrointestinal, neurological and liver diseases, atherosclerosis, obesity and allergies (Frei & Higdon, 2003; Fresco et al., 2006; Ramos, 2007; Shankar et al., 2007).

According to Ren et al. (2001) juices from organic spinach, welsh onion and chinese cabbage had 50–120% higher antioxidant activity than juices from conventionally produced vegetables. Antioxidant activity of currants grown organically was also 30% higher according to Kazimierczak et al. (2008). These results were confirmed by 88% of all the previously published studies describing higher antioxidant capacity of organically produced plant foods (Benbrook et al., 2008).

According to the meta-analysis made by Benbrook et al. (2008) organic crops, compared to conventional ones, contain also more beneficial substances, such as quercetin (acc. to 87% of studies), kaempferol (55%), vitamin C (63%), vitamin E (62%) and phosphorus (63%). They are also known to contain more sugars (Stertz, 2005; Hallmann & Rembiałkowska, 2006) what is probably one of the reasons of better sensory quality of organic produce.

85% of published papers (Benbrook et al., 2008) indicated lower protein content in organic vs. conventional plant foods. On the other hand, Magkos et al. (2003) described the quality of proteins (measured as essential amino acid content) in some organic cereal crops and vegetables as higher than in conventionally produced ones.

Harmful substances, such as nitrates, are found in lower contents in organic crops comparing to conventional ones according to 83% of previously published studies (e.g. Abu-Zahra et al., 2007). Organic crops contain also significantly lower residues of pesticides (Baker et al., 2002) which are known to exert carcinogenic, mutagenic, neuro-destructive, endocrine and allergenic effects.

To assume, organic plant-based foods present on average higher nutritional quality and safety in terms of compounds which have been previously measured.

Quality of organic animal products

The impact of organic farming methods and organic feed on the nutritional quality of animal products has been investigated in several studies. There is strong evidence that poultry and livestock that consume animal feeds and pastures grown using organic methods produce meat, milk, and eggs that has modestly higher levels of protein, more of some vitamins and minerals, and elevated levels of heart-healthy n-3 fatty acids and CLA (Benbrook et al., 2008).

Milk is one of the most important nutritional sources, especially in the nutrition of children. It is reported that the composition of organic milk compared to conventional milk from high input systems can be very different, especially while comparing the antioxidant and the fatty acid profile. Organic milk has a higher content of CLA, n-3 fatty acids and a better n-6/n-3 fatty acids ratio (Kusche & Baars, 2007; Butler et al, 2008). Dietary intake of certain unsaturated fatty acids, in particular CLA and n-3 fatty acids, has been linked to potential health benefits (Connor, 2000; Parodi, 2003). CLA and n-3 fatty acids have been shown to counteract the negative physiological effects of saturated fatty acids, and CLA has also been linked to anticancer properties, reduced risk of type 2 diabetes and enhanced immune function (Pariza, 2003; Lock & Bauman, 2004; Wahle et al., 2004).

Factors for a beneficial milk fatty acids composition are outdoor grazing, high biodiverity in pastures, low levels of concentrates and no silage feeding (except red clover) (Kusche, 2009). Apart from polyunsaturated fatty acids, α-linolenic acid (the main n-3 fatty acid in milk), and CLA, dairy products from certified organic dairy production systems have been reported to contain higher concentrations of fat-soluble antioxidants (e.g., α-tocopherol, carotenoids) than those from high-input conventional production (Butler et al., 2008). Moreover, organically produced milk compared to conventionally produced one was found to contain more dry matter, calcium, vitamin C, less somatic cells, but more coliform bacteria (what indicates worse hygiene regime during milking) (Lund & Algers 2003).

Meat (beef, pork and lamb) from the organically raised animals is generally characterized by lower content of total fat (Hansson et al., 2000). At the same time organic pork and lamb were found to present higher intramuscular fat content (Fisher et al., 2000; Sundrum et al., 2000). Organic meat contains usually more unsaturated and less saturated fatty acids. Moreover, n-6/n-3 fatty acid ratio in organic beef was reported to be much lower comparing to the conventional beef (Pastushenko et al., 2000). Higher weight of breast and thigh muscles in poultry carcasses (Castellini et al., 2002), and sirloin and ham in pork carcasses (Sather et al., 1997) were found in the organically raised animals. Organic meat has also better sensory quality in most cases (Hansson et al. 2000, Pastuschenko et al. 2000, Olsson et al. 2003). Organic lamb was found to present better eating quality than conventional lamb in terms of juiciness (attributed to the higher intramuscular fat content) and flavour (attributed to the higher level of linolenic acid and total $n-3$ fatty acids) (Angood et al., 2008).

With regard to food safety, organic meat production scores as equally well as conventional production. However, droppings from organic pigs and broilers showed, as a positive, a much lower incidence of antibiotic resistant bacteria comparing to conventionally raised animals (Hoogenboom et al., 2008).

Impact of the organic feeds on laboratory animals

As it was previously described, there is a number of scientific results supporting the theory that organic foods may have potentially positive influence on mammal's health, due to higher contents of beneficial substances and lower levels of contaminants in comparison to conventionally produced food products. Moreover, some results of *in vitro* studies indicated better repair of bacterial DNA and decrease of cancer cells proliferation on organic vs. conventional plant materials (Ren et al., 2001; Olsson et al., 2006).

During the last fifty years several animal dietary intervention studies have been conducted to investigate the health effects of organic vs. conventional food consumption. Most of these studies confirmed beneficial impact of organic feeds on development rate and reproductive abilities of rats, mice, rabbits and hens (Gottschewski, 1975; McSheehy, 1977; Aehnelt & Hahn, 1978; Edelmuller, 1984; Staiger, 1986; Plochberger, 1989; Velimirov et al., 1992). Study conducted by Staiger (1986), including three generations of rabbits, showed stable fertility rate of organically fed animals and at the same time decreasing fertility in subsequent generations of rabbits fed conventional feed. Velimirov et al. (1992) indicated higher percent of young born alive and superior body weight gain during and after lactation period in organically fed female rats. Another research, concerning reproductive abilities of male rats, was a Danish experiment (Jensen, 2004). In the above-mentioned study no statistically significant differences were found between groups fed on organic and conventional feed in relation to: epididymis weight, number of degenerative changes in testicles and sperm density. However Jansen's study did not include qualitative analysis of rat sperm, which may be of great significance in determining fertility of the studied rats as the number of non-deformed spermatozoa is the main factor determine the ability to insemination.

Animal studies published in recent years indicated increased immune parameters in organically fed lab animals. Finamore (2004) in a dietary study with protein shortage indicated higher stimulated lymphocyte proliferation in a group of rats fed organic vs. conventional feed. Lauridsen et al. (2005) showed a higher level of IgG in blood serum of organically fed rats, demonstrating a higher immune system reactivity of these animals. A pilot experiment of Barańska et al. (2007) showed higher splenocyte proliferation in male rats fed organically. According to a recent study in the Netherlands (Huber, 2007) chickens on organic diet had a lower body weight, a higher immune reactivity and significantly better catch-up growth after a challenge.

At the same time several studies have proven the negative influence of a few pesticides used in conventional farming on the fertility rates of laboratory animals. Examples of the above-mentioned studies are experiments estimating a genotoxic effect of pyrethroid in mice (Bhunya et al., 1988) and a toxic effect of cypermethrin pesticide on the fertility parameters in rats (Elbetieha et al., 2001). These results were obtained with a significantly higher amount of chemical agents than permissible concentrations of single pesticide residues in fruits and vegetables. However, very little is known about the consequences of long-term dietary exposure to various mixtures of pesticide residues present in foods (Carpy et al., 2000; Reffstrup, 2002). It cannot be excluded that pesticides even in small, officially permitted doses disturb the hormonal balance in the body, which has a great impact on its proper development and functions, including fertility (Howard, 2005).

Studies presented above on the health effects of organic vs. conventional feeds are sparse, moreover there is a lack of systematic and long-term investigations in this scope. Therefore only preliminary conclusions can be formulated. There is a noticeable tendency of better fertility indexes, survival rate of the young and better functioning of the immune system. However, further, well-planned experiments are necessary in order to evaluate overall health status of laboratory animals fed on feeds from different agricultural production systems.

Impact of the organic food on human health

The effects of organic foods on human health are still not very well known. In the so called 'Monastery Study' (Fuchs et al., 2005) improvement of physiological and of psychological parameters was found among seventeen nuns eating biodynamic foods for one month. Nuns on biodynamic diet had lower blood pressure and better immune status. They also evaluated their physical fitness, intellectual acuity and overall well-being much better in this period. Moreover, they declared less headaches and presented better ability to handle stress. However, this was not a blinded study.

According to PARSIFAL study (14,000 children, 5 European countries) children representing antrophosophic lifestyle, including biodynamic and organic food, were found to have less allergies and lower body weight in comparison to group consuming market, conventionally produced foods (Alfven et al., 2006). At the same time the results of the KOALA Birth Cohort Study in the Netherlands (3,000 mothers and children) associated the consumption of organic dairy products with lower eczema risk in children (Kummeling et al., 2008). Organic dairy consumption resulted at the same time in higher CLA's levels in breast milk of mothers (Rist, 2007).

According to one of studies evaluating different aspects of organic and conventional food consumers' lifestyle (Rembiałkowska et al., 2008) consumers of organic foods assessed their health state significantly better than other consumers. However, apart from organic diet, it was connected with differences between several aspects of consumers lifestyle (e.g. nutritional pattern, living conditions, physical activity, ways to manage stress). Therefore, it can be concluded that promotion of overall ecological lifestyle, including organic food consumption, can influence positively the nutritional pattern and the self-assessed health state of consumers.

As it was previously described, pesticide residues belong to dangerous food contaminants, known to exert carcinogenic, genotoxic, neuro-destructive, endocrine and allergenic effects and found usually in higher contents in conventionally produced plant foods. There is scientific evidence that dietary exposure of children to organophosphorus pesticides, measured on the basis of the level of pesticide metabolites in urine samples, is much lower on organic than on conventional diet. It can be concluded that consumption of organic foods provides a protective effect against exposure to organophosphorus pesticides commonly used in agricultural production (Curl et al., 2003; Lu et al., 2006).

Conclusions

To conclude, the overall number of studies comparing the quality and safety of organic vs. conventional foods is growing rapidly. It is also possible to observe increasing interest in investigating the health effects of organic food consumption. Results indicating higher nutritional quality and safety of organic foods in terms of many measured compounds, as well as the results of in vitro and animal dietary intervention studies, showing the positive impact of organic foods on reproductive and immune status of animals, are promising. The first experiments investigating health impact of organic foods on humans brought also promising overview. However, the results are still insufficient to formulate the explicit conclusions. Therefore, several important problems still need to be investigated in the coming years: environmental, bacterial and fungal contamination of the organic crops, and the most essential problem – the impact of the organic food consumption on human health.

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