Quality of Organic vs. Conventional Food and Effects on Health

Report

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INTRODUCTION

Organic methods in farming are considered as environment friendly, mainly due to a fundamental principle of harmonious cooperation with nature and the lack of chemization. There is already a lot of evidence that the condition of the environment, soil and groundwater improves as a result of organic farming (Haas et al., 2000); it is also considered to improve crop quality. The regulations which specify organic plant and animal production are very strict, and adhering to them should result in high product quality. A similar situation concerns organic food processing. Although currently conventional processing allows several hundreds of different types of food additives (colourings, fixing agents, improvers, etc.), organic processing allows only several dozen such additives, mainly natural substances. This creates challenges for organic food processors as they have to preserve product durability without the use of chemical agents. However, this is fundamentally important for consumers who are increasingly searching for healthy food.

Organic production methods are regulated in Europe by Council Regulation (EC) No. 834/2007 of June 28, 2007 on organic production and labelling of organic products, repealing Regulation (EEC) No. 2092/91. The Commission Regulation (EC) No. 889/2008 as of September 5, 2008 established particular principles of implementing the Regulation (EC) No. 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control.

Quoting Regulation No. 834/2007, organic production is defined as 'an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards and a production method in line with the preference of certain consumers for products produced using natural substances and processes'. Moreover 'organic farming should primarily rely on renewable resources within locally organized agricultural systems. To minimize the use of non-renewable resources, wastes and by-products of plant and animal origin should be recycled to return nutrients to the land.

A food product is considered organic when it has been produced under the guidelines of Regulation No. 834/2007 or both the guidelines of the Regulation and the directives of various organic farming associations (e.g. IFOAM). Under Regulation No. 834/2007, an organic product must be labelled with an identification number (code) and the European organic farming logo (the number and logo can be used after a certification process). The Regulation declares that the aim of organic production is to receive high quality food products, however, the Regulation does not specify a definition of high quality. Law-makers probably assume that a product which has been obtained under controlled conditions – in accordance with the guidelines of the Regulation, i.e. without chemical agents for plant protection and artificial mineral fertilisers, but using natural animal fertilisers and composts as well as crop rotation, and with the ban on using genetically modified organisms and ionising radiation – must be a high quality product. Currently, organic food is becoming more and more popular all over the world, and the European organic products market has been developing very intensively since the early ’90s. According to the report on organic farming, prepared by the Swiss FiBL – the Research Institute of Organic Agriculture and IFOAM – International Federation of Organic Agriculture Movements (FiBL and IFOAM, 2011) in 2009, the value of the European organic food market amounted to 18.4 billion euros (figure 1) (Willer, 2011) and still has a vast and unused potential. An unquestionable leader in the organic food market is Germany with the outlet of 5.8 billion euros (figure 2). The organic food market is very well-developed in France, the UK and Italy as well (Schaack et al., 2011).

The growth of the organic products’ market results from, among other things, decreasing consumer confidence in the conventional food dominating the market, produced by intensive methods, with the use of synthetic fertilisers, chemical agents for plant protection and growth regulators, and with the use of preservatives, synthetic flavouring and aromatic substances during processing. An intensive farming system may have negative impact not only on environment, but also on food quality and safety. Recent crises concerning food safety at different stages of the agricultural and food chain has induced consumers to look for safer and more authentic food, contributing to the increase in demand for organic products as well. Major food scandals of the last decade (e.g. BSE – mad-cow disease, FMD – food and mouth disease, and food contamination by dioxins or bacteria causing food poisoning) have resulted in consumers turning toward safer and better controlled production methods, such as organic production.

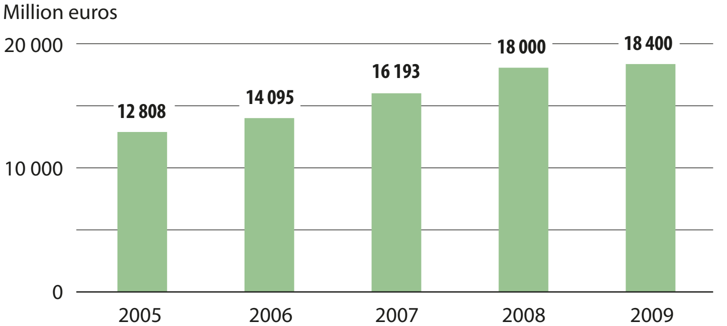

Figure 1. Growth of the European market for organic food 2005–2009 (FiBL, 2009; Willer, 2011).

Consumers actively searching for organic food develop the market. According to studies, the people who buy organic food are mainly women, families with children and the elderly (Hughner et al., 2007). These groups are linked mainly by their concern for their own or their relatives' health, due to a particular physiological condition and the associated awareness of the importance of healthcare. Hughner et al. (2007) also mentioned the reasons why consumers are interested in the purchase of organic products. A key motive, given by many consumers of organic food – both so-called 'regular' and 'occasional' ones – as the most important, is concern about health, i.e. the conviction that organic products are healthier and safer than conventional ones. In addition, surveyed consumers mentioned such organic food characteristics as: better taste (sensory properties), care for the natural environment, greater food safety, animal welfare, social factors (supporting local market and traditions). To sum-up, consumers prefer organic food for its greater nutritional value, its better taste, its safety for health, and because its production does not endanger the environment.

Consumers expect a higher health and nutritional quality from organic produce, and there have been many studies comparing crop quality obtained from the organic system and others, such as integrated or conventional ones. Comparable food must be produced in the same conditions of soil, location etc. The time and methodology of analyses and the comparable varieties and breeds have to be the same. The only differing factor has to be the production system (organic, conventional, integrated etc.) which has to be strictly defined. Several overviews, reports and meta-analyses have been conducted to analyse and summarise the results of previously carried out organic vs. conventional food studies (Woëse et al., 1997; Worthington, 2001; Bourn and Prescott, 2002; Winter and Davis, 2006; Rembialkowska, 2007; Benbrook et al., 2008; Dangour et al., 2009; Lairon, 2009; Rembialkowska and Srednicka, 2009; Lima and Vianello, 2011).

Many publications have concentrated only on the nutritional quality of organic vs. conventional food and have provided variable and controversial results. However, a true comparison of the quality, safety and health effects of food from different production systems can only be achieved by an integral holistic

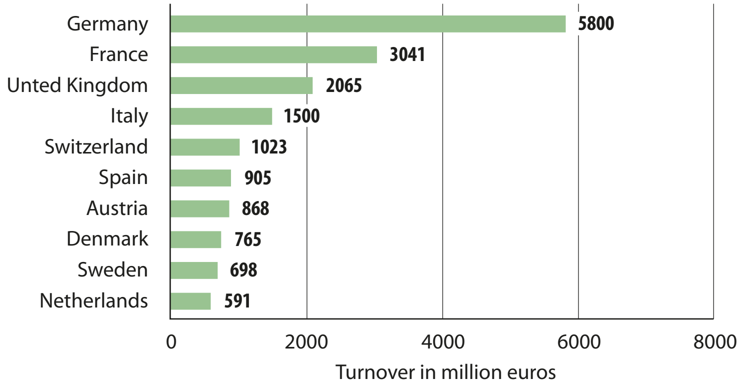

Figure 2. The ten European countries with the largest markets for organic food and beverages 2009 (Schaack et al., 2011).

approach which also considers other important health-related aspects, such as pesticide residues, nitrates, artificial additives etc. It is important to understand that many chemicals used in agriculture and food processig can be harmful to human health. Consumption of healthy food or the use of raw materials for the production and development of functional foods to prevent or treat some diseases, necessitates the elimination of potentially hazardous substances to avoid other health problems.

This report analyses the nutritional quality of organic and conventional food as well as the health effects of pesticide residues, nitrates, mycotoxins and artificial additives and gives an overview of animal and human experiments.

1. QUALITY OF FOOD

A definition of food quality is still developing and changing. At first, the focus was mainly on quality as represented by quantifiable and measurable parameters, but now attention is increasingly being paid to a more comprehensive holistic approach. Luning et al. (2005) has extended the Evans & Lindsay model proposed in 1996, and called it the model of 'quality viewpoints'; it includes five different groups of criteria: assessment (a comparison of a product's properties), product-based criteria (a function of specified measurable variables/reflection of qualitative dependence between specified measurable parameters), user-based criteria (determined by the consumer's needs), value-based criteria (a proportion of price to satisfaction received) and production-based criteria (quality as a desired result of production practices or compliance with standards). By organizing and developing this model, Luning et al. (2005) proposed a distribution of food quality features into internal (directly associated with a product, measurable, resulting from its physical and chemical characteristics) and external (connected with a product indirectly). Among internal characteristics there are: safety and the product's health aspects, sensory properties and durability as well as product reliability and the convenience of use. External quality characteristics include production characteristics (depends on the adopted production method, e.g. organic vs. conventional), environmental aspects and marketing.

A similar distribution of food quality aspects, nevertheless more developed and enriched by the aspects necessary for the food quality assessment, was adopted by Vogtmann (1991); according to the justification, while conducting the assessment of the organic food quality all aspects and possible viewpoints should be considered, applying so called 'holistic model of the quality assessment' (also corresponding to consumer's picture/expectations which should be met by a high quality organic product).

Figure 3 presents ecological criteria of food quality, divided into analytical and holistic criteria groups. The analytical criteria have long been known but the holistic group is newer and connected with the development of organic awareness and farming. The analytical criteria group includes: technological, nutritional and sensory values, whereas the holistic criteria group contains: authenticity, biological value, ethical aspects and holistic methods of food quality assessment.

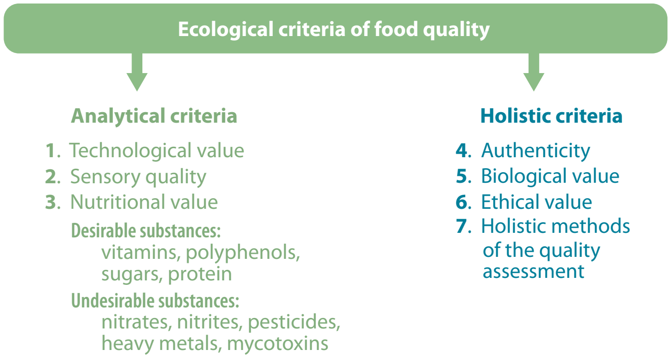

Figure 3. Ecological criteria of food quality (Vogtmann, 1991).

1. TECHNOLOGICAL VALUE. A technological value of food products refers to their distinctive features in the light of requirements of different interest groups. For specific participants of the food production chain, producers, processors, distributors and consumers, the most important may be completely different discriminants, dependant on a specific purpose that a given product is designed for. Among technological aspects is storage capacity; this feature is critical from the processing viewpoint e.g. juice production capacity, while for the consumer the technological value may be, for example, its use in cooking.

2. SENSORY QUALITY. Sensory quality includes such features of a product which are assessed by a human by the means of special tests and the organs of taste, smell, touch, sight and hearing. Among these criteria, a crucial role is played by the appearance of raw materials and finished products (colour, size, freshness, firmness and cleanliness) as well as other important organoleptic properties, such as taste, smell and texture. Sensory quality is very important to the selection process while shopping for food.

3. NUTRITIONAL VALUE. Nutritional value may be interpreted as the minimum content of impurities in food (residues of pesticides, nitrates, heavy metals, etc.) at optimum content of valuable components (vitamins, mineral elements, proteins, etc.). Many studies of organic plant raw materials indicate that they contain less nitrates and pesticide residues, but more dry matter, vitamin C, secondary substances, total sugars, certain mineral components and essential amino acids, but less β-carotene (Zadoks, 1989; Rembiałkowska, 2000; Worthington, 2001).

Vitamins, phenolic compounds and mineral compounds. The nutritional value of food depends mainly on it having the appropriate content of compounds necessary for the proper functioning of the human body. There is growing evidence that secondary plant metabolites have a critical function for human health and may be significant from the nutritional point of view (Lundegårdh and Mårtensson, 2003).

In the human body, vitamin C plays a fundamental role for several metabolic functions, primarily because it ensures proper functioning of the immune system. Besides, the higher content of vitamin C in organic crops is very important for health because vitamin C inhibits creation of carcinogenic nitrosamines, consequently reducing the negative impact of nitrates on the human body (Mirvish, 1993).

Plant phenolic metabolites are particularly interesting because of their potential antioxidant activity and medical characteristics, including anticancerous activity (Brandt and Mølgaard, 2001).

Mineral compounds, including iron, magnesium and phosphorus are vital for the human body. According to Worthington (2001), a possible reason for the higher content of mineral elements in organic raw materials is linked to the higher micro-organism content in organic farming, who help to make compounds more accessible.

Total sugars. The content of total sugars in plant raw materials not only results in better taste, but is also an important element of technological quality, e.g. in sugar beet. The studies clearly show a higher content of total sugars in organic vegetables and fruit, such as carrot, sugar beet, red beet, potatoes, spinach, kale, cherries, red currant and apples (Zadoks, 1989; Rembiałkowska, 2000).

Proteins. According to Worthington (2001), nitrogen from every type of fertilisers influences the amount and quality of the plant-produced protein. A great amount of nitrogen available for a plant increases protein production. A number of experiments analysed in review papers (Rembiałkowska, 2000; Worthington, 2001) indicate that the amount of total proteins is lower in organic than conventional crops, but that protein quality – measured by the content of basic amino acids – is higher in organic crops.

Nitrates and nitrites. Nitrates are essential nutrients for plant growth. Many data show a significantly higher content of nitrates and nitrites in conventional than in organic crops. This results from the former being fertilised with synthetic, easy-dissolvable nitrogen fertilisers; they absorb a lot of these compounds by their roots, with consequent accumulation of nitrates in the leaves and other plant organs. In the organic system, organic fertilisers (compost, manure) are used; these also include nitrogen, but it is organically-bound. When it is necessary, nitrogen compounds are absorbed by plant from the humus in a specific quantity, therefore, there is marginal possibility of excessive nitrates accumulation in plant organs (Vogtmann, 1985).

Pesticides (herbicides, fungicides, insecticides). In agriculture, herbicides are used to kill unwanted plants, fungicides against fungal diseases and insecticides to protect plant against pests. To reduce the negative impact of pesticides on human health, the so-called Maximum Residue Level/Limit (MRL) has been introduced for use with food. MRL is usually established by testing pesticides on rats. It is believed that pesticide consumption below the MRL is not risky for health. However, even at low concentrations, pesticides are known to or suspected of causing many diseases and health problems, including inborn defects or tumours (BMA, 1992; Howard, 2005). A fundamental problem is that the MRL for pesticides is generally established by testing specific remedies (separately) on rats for a relatively short period of time. Little is known about the effects of consumption of hundreds of different pesticides during a life cycle. According to the great English toxicologist, Professor Howard (2005) from the University of Liverpool, the most recommended method of protection is avoidance of pesticide consumption, particularly when by pregnant and breastfeeding women, and young children under three years old. The levels of pesticide residues found in organic plant raw materials are considerably lower than in conventional plants (Baker et al., 2002). A diet based on organic products should therefore result in a lower level of pesticides in human milk and tissues.

Heavy metals. Heavy metals, such as cadmium, lead, arsenic, mercury and zinc enter the food chain from numerous sources: industry, transportation, municipal waste and farming. For example, mineral nitrogen fertilisers used in conventional farming may bring cadmium into plant crops, but also metal industry and transportation cause soil and crop cadmium contamination. Therefore, studies have not shown distinct differences in the heavy metal content between organic and conventional raw materials; some have found a higher level of heavy metals in conventional raw materials, while others show the opposite (Rembiałkowska, 2000).

Contamination with natural fertilisers and zoonotic bacteria. Composted animal manure is the most often used fertiliser in organic farming. Composting considerably reduces the pathogen level, although composted manure is not entirely bacteria-free. EU experts (Kouba, 2003) reported that organically farmed eggs, poultry and pork had an increased rate of Salmonella infections compared to conventional. However, this has not been borne out by other research; comparisons of the microbiological safety of organic and conventional produce (Mukherjee et al., 2004; Johannessen et al., 2005; Oliveira et al., 2010) indicate differences from different production methods but not a higher microbiological risk from certified organic produce than conventional. Good hygiene practices must be implemented by producers and processors in order to prevent contamination with spoilage and pathogenic bacteria.

Mycotoxins are poisonous compounds produced by the secondary metabolism of poisonous fungi (moulds) – Aspergillus, Penicillium and Fusarium, which occur in food products (Kouba, 2003). They have a negative impact on human health, i.e. are carcinogenic and disabling to the immune system. Mycotoxin production is mainly dependent on temperature, humidity and other favourable environmental conditions. Recent studies have not shown that organic food is more susceptible to mycotoxin contamination than conventional food (Kouba, 2003; Benbrook, 2006; Lairon, 2009).

4. AUTHENTICITY. An authenticity criterion of food product may be interpreted in two ways. First of all, there is traceability, i.e. the ability to check whether the characteristics of the product examined actually correspond with the features attributed to it; for example, checks on whether products offered on the market as organic actually come from organic production (Kahl et al., 2010). More and more people are looking for safe food, locally produced by a producer they know. Nowadays, food products are remotely transported – from the production area, through a processing stage to reach the sales point. On route, products can lose their authenticity. Consequently, many consumers seek minimally processed products, from familiar and safe sources, e.g., bought locally and directly from a farmer.

5. BIOLOGICAL VALUE. The biological value of food identifies how food influences human and animal health; it derives from the holistic approach towards food quality and the belief that it is not sufficient to know the chemical composition of food to determine dependence between the food consumed and human and animal health. Health is regarded not only as absence of diseases, but also as well-being, fertility and vitality. Therefore, it should be taken into account that the whole product means more than the total of its separate components; a product has an effect on the whole human body (proportions and interactions between particular substances), and its impact on health may be properly assessed only by conducting research on the influence of the entire product on a living organism. Research has shown a tendency towards more favourable parameters of fertility and immunity of small mammals fed with organic pasture compared to conventionally fed animals. Nevertheless, further thorough studies in this field are necessary (Williams, 2002; Padel, 2005).

6. ETHICAL VALUE. The ethical value of food quality is made up of three aspects: environmental impact, social and economic aspects and animal welfare. One of the main factors affecting product quality is the quality of the environment.

Every form of human activity, including farming, has a negative impact on the natural **environment**. Farming, particularly intensive farming, is a branch of the economy, which along with industry, contributes to degradation of the environment. Organic production methods protect against pressures agriculture exerts on different aspects of the environment. Tyburski and Żakowska-Biemans (2007) have compared the impacts of organic and conventional farming. They note that organic farming is less energy-intensive, which is highly important particularly nowadays due to the world's energy crisis; organic farming has lower energy consumption, because, among other aspects, it does not use artificial fertilisers and pesticides, the production of which requires high energy inputs. Besides, conventional farming leads to water eutrophication and contamination with, among others, pesticide residues, whereas organic farming protects ground and surface water.

Natural environment diversity resulting from landscape spacious complexity in organic farming plays also three important roles: ecological, production and aesthetic and health functions. The ecological function consists in maintaining biodiversity and homeostasis, i.e. balance and optimum species number. Organic farms create an existence basis for many plant and animal species, not only those designed for production purposes, but also accompanying species. The production function is based on prophylaxis, i.e. the use of prevention, not control, protecting plants against weeds, pests and plant diseases. This helps maintain biological balance, i.e. homeostasis of whole landscape. The aesthetic and health function of organic farming recognizes that people are an integral part of the environment and can only exist in harmony with nature.

Social and economic aspects. EU consumers are increasingly selecting agricultural products produced, processed and sold under conditions of social equality and justice. The principles of fair trade with developing countries are crucial. By boycotting companies which do not follow social and economic principles, consumers may have an impact on decreasing social inequalities; currently, such inequalities exist in production, processing and sale of agricultural products, particularly in tropical countries.

Animal welfare. Currently, ecologically-aware consumers are increasingly considering animal rearing methods in their decision to purchase a product. One reason is animal suffering, e.g. very unfavourable rearing conditions, not adjusted to the animals needs (crowd, aggression, and diseases).

The food ethical value is becoming a more important criterion, since consumers more often pay attention to the environment, social and humanitarian aspects. High ethical advantages of organic food result from the fact that its production allows maintenance of biodiversity which is vanishing from the Earth; besides it supports a fair production and distribution chain (fair trade), and cares about farm animal welfare.

7. HOLISTIC METHODS OF FOOD QUALITY ASSESSMENT. The studies on organic food with the use of holistic criteria are not as numerous as those applying analytical methods, however, they arouse great interest, because – as mentioned – it is believed that a sole comparison of food chemical composition is not sufficient to explain its potential impact on human and animal health. The use of holistic methods is complementary to other methods of quality assessment and they represent one aspect of the complex concept of food quality. As with biological value, holistic methods of quality assessment attempt to answer the question on the quality of food interpreted not as a set of chemical compounds, but as a whole, which cannot be described only by chemical composition analysis. At their current status of development, holistic methods have potential to distinguish product origins, but it is not ascertained which quality aspect regarding the impact on human health they cover, and dependence between human health and these methods has not been defined yet.

Copper chloride biocrystallization. Biocrystallization was developed by Ehrenfrid Pfeiffer in the '20-ies of the last century. Biocrystallograms are created as a result of submitting a mix of the sample to be examined and copper chloride to the crystallisation process, and as with every imaging method they are characteristic of the sample examined. In the preparation of food samples (juices, extracts), no chemical agents are used; instead a gentle processing method minimally integrates into the product matrix. Biocrystallograms are traditionally assessed, based on different morphological features and with the use of such techniques as indexing or ranking, which were submitted to standardisation under ISO standards applied in sensory analysis (Huber et al., 2010). In 2001, there was established an initiative associating three centres from Germany, the Netherlands and Denmark, the aim of which is joint cooperation on the biocrystallization method (and on imaging chromatography, as described below). Thanks to testing various parameters under the ISO 17025 standard, this method may now be successfully used in every laboratory for food quality studies (Busscher et al., 2010). Figure 4 shows that biocrystallization method allows a clear differentiation of organic and conventional raw material. Figure 5 indicates that a computer biocrystallogram processing allows a clear differentiation of organic wheat from the wheat of other cultivation systems.

Imaging chromatography. The method of imaging chromatography was developed in the '20-ies of the last century (Kolisko and Kolisko, 1923). Although it relies on chromatography, it is not aimed at separating specific substances included in a sample, as it is in traditional chromatography.

As for all holistic methods, the purpose of this method is a total depiction of living organisms' capacities to form structures and maintain a high level of matter arrangement. The most popular version of the method is the vertical chromatography of the WALA company. It produces colourful images, typical of the sample examined (figure 6).

According to Balzer-Graf (Balzer-Graf and Balzer, 1991), who has researched the imaging chromatography method for over 20 years, the created image, typical of the product, reflects the entire plant's 'biography'. The method of imaging chromatography under WALA was documented and standardised by Załęcka (2006). Under ISO standards, applied in products sensory assessment, a statistical presentation of the results obtained is possible (Załęcka et al., 2010).

Figure 4. The biocrystallogram image of organic (on the left) and conventional (on the right) carrot (Meelursarn, 2006).

Figure 5. Computer texture analyses; organic wheat (green), conventional wheat (yellow), wheat – control sample, no fertilising (grey) (Kahl, 2006).

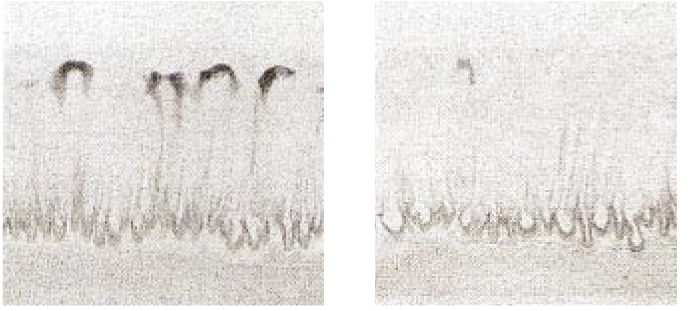

Figure 6. Chromatograms (colourful in original) of conventional (on the left) and organic carrot (on the right) (Balzer-Graf and Balzer, 1991).

Circular paper chromatography. The method of circular paper chromatography was developed in 1953 by Pfeiffer as a quality test for examining soils, composts and biological substrates (Pfeiffer, 1984). The purpose was to test and demonstrate the quality differences, which had not been found by chemical analysis methods. Contrary to research on the soil and compost quality, there are hardly any publications on the use of circular paper chromatograms for the assessment of quality of food products (Gelin, 1987; Geier, 2005).

Biophoton emission measurement. Since 1978, Fritz Albert Popp has been dealing with dependences between biophoton emission and food quality. Biophotons are very weak but long-lasting visible radiation (light quantums) of the spectrum from 200 to 800 nm, emitted by living organisms. It is believed that a primary source of biophoton emission is DNA. Measurement of these emissions of the sample examined is conducted in a special apparatus for emission measuring, which strengthens the radiation emitted. During an experiment, natural biophoton emission as well as reemission are measured; the latter is caused by irradiating the sample using a defined source, e.g. light, microwave, heat etc. The number of quantums emitted by the sample in time intervals is recorded (from several milliseconds, minutes and up to several hours) and submitted to mathematical and statistical analysis by computer programmes. According to Popp's observations (1991), the lower the biophoton emission intensity, the higher the quality of the examined product.

Kirlian photography. Researchers at the FiBL institute (the Research Institute of Organic Agriculture) in Switzerland have been conducting studies on the Kirlian photography method, i.e. gas discharge visualisation (GDV) for many years. An experiment is held in a dark room. The examined sample, entirely in natural state, is placed on a plate – an electrical conductor, to which a high voltage current is connected. As a result, gas and plasma discharges occur on the edges of the examined sample. A picture of these discharges is called a 'corona' which is fixed by the use of digital photography. However, to date it has been difficult to give unequivocal answers due to the complexity of the problem discussed (Beweise…, 2006).

Drop picture method. The drop picture method was developed in 1967 by Schwenk (1991) to assess water quality and used at the Institute of Flow Sciences in Switzerland (Institut fuer Stroemungswissenschaften). Water is essential for many physiological functions of the human body. As a medium of organism permanent changes, water is therefore the medium of life processes, and regeneration processes, it is possible to compare water from different sources, considering differences in flow of separate samples.

Electrical efficiency – P-value measurement. Measurement of the P-value of food products takes into account three electrochemical parameters associated with food quality and the state of health of the organism. To facilitate their complex interpretation, an integrating formula based on the Nernst equation was developed (Hoffman, 1991):

$$P = [29.07\ \text{mV}\ (\text{rH} - 2\text{pH})]^2 \times \text{rho}^{-1},$$

where P – value of electrical efficiency [μW]; rH – redox potential; pH – acidity level; rho – electrical resistance [Ω]. pH value is the measurement of the concentration of free hydronium or hydroxide ions in water solutions, and it specifies the acidity and alkalinity levels of the solutions.

Apart from the experiments on the P-value use for determining: an optimum harvest time, an optimum nitrogen fertilising level, an optimum number of fruit on a tree, a weather impact on apple quality, Hoffman also tested a cultivation method impact on apple quality. Hoffman compared the influence of conventional, organic and biological dynamic farming on two apple varieties – 'Golden Delicious' and 'Cox-Orange'. According to the author, appropriate variety selection considering cultivation conditions is very important to crop quality. In case of both apple varieties, organic apples reach average P-values, whereas conventional and biological dynamic fruit have extreme P-values. The lowest P-values (i.e. high quality) were recorded for 'Cox Orange' variety of biological dynamic apples, and for 'Golden Delicious' variety of conventional apples.

Conclusions

Ecological criteria of food quality are much wider than strictly analytical. They comprise not only the composition of the food, but also the production system in its environmental, social and ethical context. World agriculture plays many roles, not only food production, so ecological and holistic criteria should be used when considering the food production chain and food quality.

Some holistic criteria (for example copper chloride biocrystallization, imaging chromatography) are very promising for the future, so they should be developed and investigated in the longer studies. Some novel analytical techniques, as metabolomics or genomics can be useful to describe the holistic aspects of the food, therefore such methods should be developed.

2. COMPONENTS IN FOOD THAT CAN BE HARMFUL TO HUMAN HEALTH

PESTICIDES

Pesticides are the only group of synthetic compounds which are not found naturally in the environment (i.e., xenobiotics); they are introduced into biocenosis as a result of a deliberate decision made by man. They are used in the production of the most critical resource for mankind – food. They are applied to increase crop production and improve crop quality as well as protect them against loss, caused by diseases and pests during cultivation and storage. Their most important role is to support the supply of human nutritional needs, and consequently, to improve general health. Considering the above mentioned, one should realize that there have been made some attempts to achieve this purpose by the means of chemical compounds of remarkable bioactivity towards animals, plants and microorganisms. It is not a flawless and completely safe method, however, its major asset is effectiveness.

The use of pesticides by farmers enables them to increase crop profitability, protecting them against insect feeding, fungal diseases, mycotoxins and bacterial infections. However, the applied chemical compounds do not only affect the target organisms – their residues in plants accumulate and move along the food chain, penetrating – more or less – a consumer's body. The effects on human health are varied, depending on the dose absorbed by a human along with the contaminated food.

Data specifying a global scale of acute pesticide poisoning are mainly based on estimated calculations. The first assessment took place in 1973, when the WHO determined that 500,000 cases of poisoning occurred per year. According to data presented in 2002 by Richter (2002), there are about 220,000 deaths around the world caused by acute pesticide poisoning annually, the total number of which is estimated as 26 million cases a year. More recent data on Asian industrial regions show the number of 300,000 deaths a year (Eddleston et al., 2008). Developing countries, where the awareness of the chemical compound risk is still relatively low, represent the area where exposure to their harmful effects is the highest.

In particular, children are more exposed to toxic pesticide effects, since their immune system has not yet developed proper defence mechanisms against such xenobiotics. But a serious risk to consumer health is also represented by chronic poisoning, which is caused by long-term exposure to a low dose of the toxic compound. One-time exposure to a high dose of pesticide results in minor negative effects on health compared to regular exposure to small amounts. Then, the compound may accumulate in a body, giving symptoms only after some time. It often happens that body pathological lesions, which have been caused due to such exposure, are irreversible. That kind of poisoning is the most dangerous. Effect of multiple pesticide residues in food is not studied and unclear. If to look pesticide residues monitoring data in Europe and member states, then it is clear that part of samples with multiple residues is increasing. For supporting food safety, monitoring of pesticide residues are carrying out.

Typically, in each European reporting country two monitoring programmes are taking place: a coordinated European programme for which clear guidance is given on which specific control activities should be performed by the Member States and a national control/monitoring programme (designed by each country). The monitoring aims to detect samples exceeding the EU harmonised Maximum Residue Limits (MRL). Samples with pesticide residues below the MRL level are considered safe for human consumption but the problem is that, in many cases, samples have multiple residues and how these compounds might interact is not clear. In Europe, the percentage of samples of fruits, vegetables and cereals with multiple residues (i.e., single samples which contain residues of more than one pesticide) has increased over time, from 15% in 1997 to 26% in 2007. In 2008, residues of two or more pesticides were found in 27% of the analysed samples of fruits, vegetables and cereals (figure 7). Multiple residues were found in over 50% of samples of oranges, lemons, grapefruits, blackberries, raspberries, blueberries, strawberries and grapes. Multiple MRL exeedances were reported by 28 countries. The highest number of exceedances in a single sample (number of pesticide residues over the MRL) was 8 in peppers, 6 in tomato and in herbal infusion samples (EFSA, 2010).

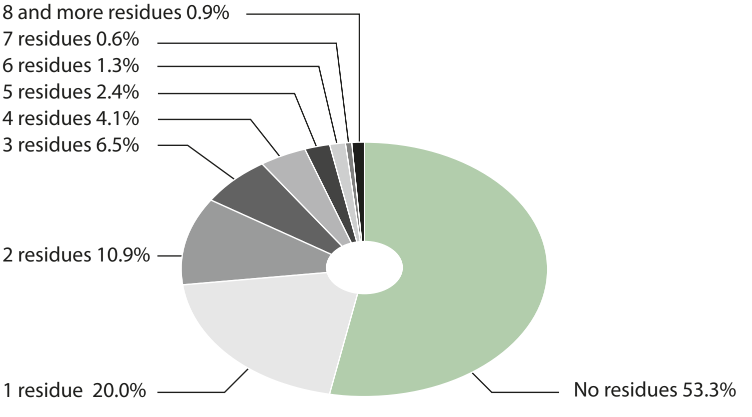

Figure 7. The number and occurrence of pesticide residues (EU coordinated and the national programmes) in 2008 (EFSA, 2011).

The highest numbers of different pesticides in a single sample have been 23 in 2005, 29 in 2006, 22 (in pear) in 2007, and 26 (in a table grape sample) in 2008 (figure 8).

In the 2008 EU coordinated pesticide monitoring programme, samples were analysed for 78 pesticides. In 37.9% of the samples one or more residues were detected and 2.2% of the samples exceeded the MRL (figure 9).

Thus, in the European average 30.8% oranges were without detectable residues, but the Estonian National pesticide residues monitoring programme showed that all samples of citrus fruits (oranges, lemons etc.) on the Estonian

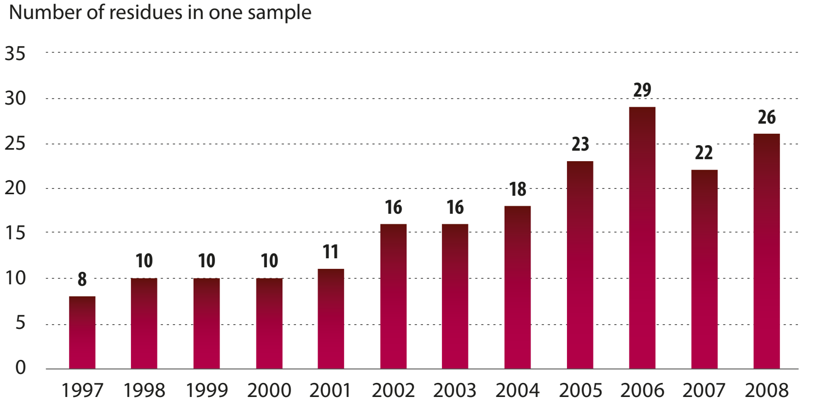

Figure 8. Highest reported number of different pesticides in a sample from 1997 to 2008 in fruit, vegetables and cereals (Commission of..., 2008; EFSA, 2010).

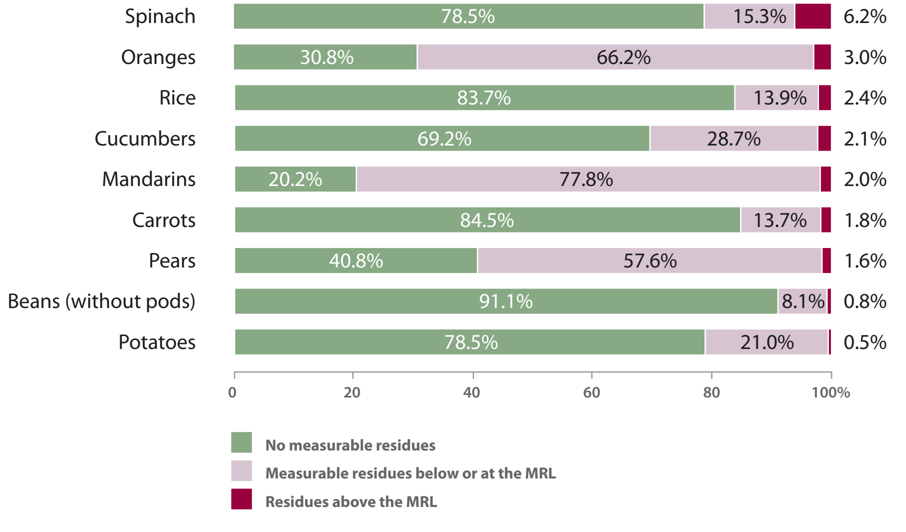

Figure 9. Percentage of samples with no measurable residues, with measurable residues below or at the MRL and with residues above the MRL (national or EC MRL) for the nine food commodities analysed in the 2008 EU coordinated monitoring programme. Total number of samples: 11,610 (EFSA, 2010).

market in 2008 and 2009 had pesticide residues. By contrast, in 2008, Estonian monitoring of domestic fruit and vegetable samples showed 72.6% of samples to be without residues with none exceeding the MRL. Of imported fruit and vegetable samples only 31.3% were without residues, 2.6% exceeded the MRL. Samples of rice exceeded pesticide residues 5.8 times over the MRL, nectarine from China exceeded pesticide residues 3.3 times over the MRL, samples of broccoli (Spain) and lemon (Turkey) exceeded residues 2.5 times. The highest number of different pesticides in a single sample was 9 (3 of them under measurable level) in mandarin from South-Africa Republic. In 2009, 67.2% of the Estonian domestic samples did not have detectable residues, 33.8% samples contained residues under the MRL. Of vegetable and fruit samples imported into Estonia, only 15.6% did not have detectable residues and 7.3% samples had a residues content above the MRL and contained more than one residue (Toome, 2011). In 2008, 21.2% of samples monitored in Estonia contained multiple pesticide residues and, in 2009, 24.7%.

In Europe in 2008, the results of a total of 3,131 samples of organic origin were reported by 22 countries. For organic fruit and vegetables, a lower rate of MRL exceedances (0.9%) in comparison to conventionally grown fruit and vegetables (3.7%) was found (EFSA, 2010). In Estonia, pesticide residues have not been found in domestic organic product samples in recent years (Toome, 2011).

Significantly lower content of residues in organic food was shown also in different studies. In 1994–1999, Baker et al. (2002) in the USA analysed the content of pesticides in fruit and vegetables from three production systems – conventional, integrated (in-between organic and conventional ones) and organic. The percentage of organic raw materials with the confirmed pesticide residues was about three times lower than in conventional fruit and vegetables, and about twofold lower than in integrated raw materials. Among conventional raw materials, the greatest number of samples including pesticide residues was found in such vegetables as celery and spinach, and among fruit – in pears and apples.

Similar large-scale studies (excluding integrated production) were carried out in 1995–2001, in Belgium (AFSCA-FAVV, 2001). According to their results, the percentage of pesticide-contaminated organic crops amounted to 12%, compared to 49 % in conventional farming. Studies conducted in Sweden, in 2002–03 (The Swedish…, 2003; 2004) confirmed this tendency, finding pesticide residues in 3% of organic raw materials, 11% of integrated ones and 44% for conventional production.

The levels of pesticide residues in crops are divergent depending on plant species and the active substance which has been used. Each of these chemical compounds has a different toxicity level; therefore, a comparison of their levels does not allow proper conclusions to be drawn. For that reason, it is relevant to compare the pesticide content in raw materials from different production systems, on the basis of which health risk assessment can be performed. Such comparison between organic and conventional products was undertaken by Baker et al. (2002). The analysis included a range of fruit and vegetables examined from the perspective of specific active substances. The greatest difference – to organic farming advantage – occurred in the case of pears. An average level of orthophenylphenol residues (fungicide) in conventional pears turned out to be over

22 times higher than its average level in organic fruit. A huge difference was also observed for strawberries in the case of iprodione (also a fungicide), with an average level in organic fruit 7 times lower than in conventional fruit. However, in the case of a few raw materials the average level of pesticide residues was higher in organic products – in sweet pepper, spinach, celery and grapes (Baker et al., 2002). Finally, averaging the contents of all examined active substances in fruit and vegetables from both production systems, the authors found that the average level of pesticide residues in conventional raw materials is about 1.7 times higher than in organic crops.

The impact of pesticides on health

The use of pesticides in farming, however, does not only result in the presence of these chemical compounds in agricultural products, but also xenobiotic movement along the food chain. At the end of the chain is the human whose health and life have major importance for the assessment of food safety. For that reason, some studies were conducted which allowed researchers to state what amount of chemical agents for plant protection is absorbed by a human body depending on the type of diet. One such study was undertaken by Aubert (1987) who analysed the content of chlorinated hydrocarbons in the breast milk of women on different diets. Diet differences consisted in the percentage of organic products in total food consumed. The study unequivocally showed that the more organic products were consumed by a woman, the lower content of chlorinated hydrocarbons (components of numerous pesticides) was found in the milk which she fed to her child (figure 10).

Similar studies were carried out in the USA, but with nursery school children, and a comparison was based on the content of organophosphorus pesticide metabolites in urine (Curl et al., 2003). Before the samples were taken, children in one group ate only certified organic products, and children in another group – conventional products. Significant differences were observed in case of dimethyl metabolites – their concentration in urine of the children eating conventional food was nearly 6 times higher compared to the organic group children. The percentage of the samples with dimethyl metabolites was also considerably higher in case of the children on the conventional diet.

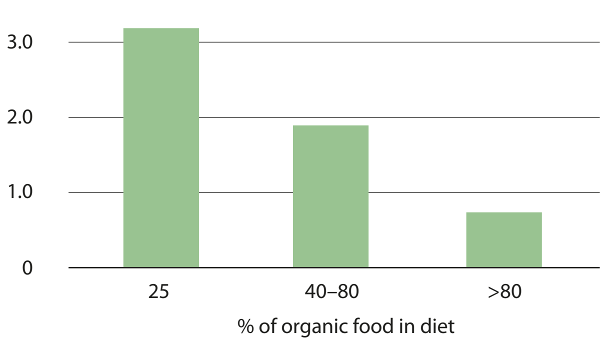

Figure 10. Total content of chlorinated hydrocarbons in human milk (mg/kg milk fat) (Aubert, 1987).

In turn, Lu et al. (2006) conducted a study on a group of school children, in three separate stages. During the first three days the participants consumed conventional food, for the following five days – organic food, and for the next seven days they were on conventional diet again. Urine samples were taken twice (in the morning and evening) every day of the study, and analysed for content of organophosphorus pesticide metabolites. The average contents of the metabolites MDA (malathion dicarboxylic acid, metabolite of malathion) and TCPY (3,5,6-trichloro-2-pyridinol, metabolite of chlorpyrifos) in urine was found to decrease to an undetectable level just after switching to the organic diet, and to remain at this level until participants returned to the conventional diet. Malathion and chlorpyrifos are most commonly used in modern farming. The levels of other organophosphorus pesticide metabolites were also lower during the second, i.e., 'organic' stage of the study, but they were not detected often enough to make differences statistically significant (Lu et al., 2006). It should be underlined that the analysed organophosphorus pesticides are very toxic to children – they have teratogenic effects, impairing foetal development, and contribute to central as well as peripheral nervous system disorders, and they can cause ADHD (attention deficit hyperactivity disorder) (Abdel Rasoul et al., 2008).

Pesticides impair the immune system and negatively affect the operation of the nervous system. They also contribute to the development of tumours. Currently, several pesticides, shown to have an adverse impact on the human immune and hormonal systems, are still in use (Ansar Ahmed, 2000).

Many pesticides have similar chemical structure to human hormones, and consequently, they influence the decrease in fertility both of men and women (Howard, 2005). An example of such impact is the nonylphenol effect, an active substance of several pesticides. Its chemical structure is very similar to the major woman's reproductive hormone, i.e., oestrogen. Women who consume products including nonylphenol may have a disturbed reproductive cycle, since the compound partly dislodges oestrogen from metabolic processes (Odum et al., 1997).

Howard (2005) pays attention to the changes of man's sperm quantity as a result of the pesticide appliance in plant cultivation. Since the 50-ies of 20th century, i.e., when chemical agents for plant protection were introduced to the market, there has been observed a downward tendency in quantity and quality of the sperm of the European residents. The problem appears in such countries as: Germany, France, Italy, the UK, Sweden or Greece. The infertility problem concerns about 15–20% of all pairs who want to have a baby. With regard to growing scale of the occurrence, the WHO has acknowledged infertility as a social disease (WHO, 2010). Pesticides are not the only factor reducing men's fertility, but it may be assumed that they are one of the factors facilitating this occurrence (Howard, 2005).

Recently Orton et al. (2011) tested in vitro widely used pesticides for anti-androgenic activity (inhibiting effect on androgens). Results showed that, out of 37 pesticides tested, 23 were identified as anti-androgenic (14 with previous evidence of androgen receptor antagonism) and 7 compounds were classified as androgenic.

Guilette et al. (1998) conducted an interesting experiment, which consisted

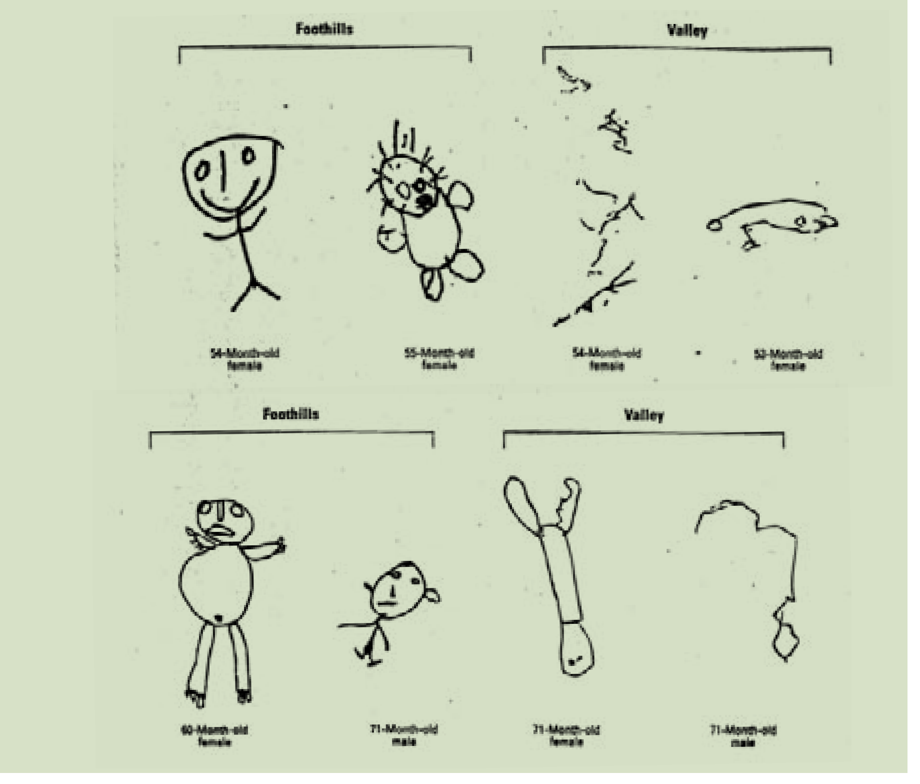

Figure 11. Pictures made by children from valley (area of pesticide risk) and foothills (contamination-free area) in Sonora, Mexico (Guilette et al., 1998).

of comparing pictures made by children from two neighbouring areas – the area of chloroorganic pesticide risk (valley) and the contamination-free area (foothills). The representative pictures present quite meaningfully the compounds impact on development of young children (figure 11).

Every person has a higher or lower amount of synthetic compounds in his or her body, including pesticides. Gilman et al. (1997) compared the content of some pesticides in plasma of the women from the subarctic zone. The study shows irrefutably that some chemical compounds, which are used for crop protection, accumulate in the human body. The contents of organo-chlorine persistent fat soluble pesticides, confirmed in plasma of women from separate countries, are shown in table 5. The results indicate that although DDT use has been prohibited since the 70-ies of the 20th century, considerable amounts of DDT derivatives are still found in women's plasma. Besides, surprisingly high levels of the derivatives are confirmed in the plasma of women who live in – by all appearances – pollution-free countries, like Greenland or Iceland. The toxicity mechanisms of individual substances are generally well known, but in the human body they form a mix which may develop completely new properties. So far, a method of examining the toxicity of the mix has not been invented, so the mix effects have not been sufficiently recognized yet.

To define the level of pesticide poisoning risk to children, Pennycook et al. (2004) assessed it on the basis of the consumption of apples and pears by the youngest residents of the UK. As a result, it was determined what number of 1.5–4.5-year children is daily exposed to consumption of such pesticide quantity which exceeds a maximum permissible dose (ARfD – acute reference dose). Dithiocarbamates, phosmet and carbendazim were considered. Depending on the type of chemical compound and the year when the crops were harvested, the number amounted to 10–226 children a day. It emphasises how the raw material contamination with pesticides is divergent. In some cases, its level exceeded the ARfD by almost six times.

Organic farming is an alternative to reduce the risk of pesticide residues in crops. It is a legally protected system, which assumes, among others, a complete rejection of the use of synthetic chemical agents for plant protection. In the framework of organic farming, there are allowed only some natural plant protection methods, e.g., the use of natural enemies of pests or allelopathy. Thanks to that, the level of organic crop contamination is considerably lower compared to conventional raw materials, commonly available on the market. This fact is borne out by the results of different authors' studies.

Conclusions

It is well proved that pesticide intake with food causes many disturbances, malformations and diseases (including cancers) in humans. There are evidences that conversion into organic food decreases significantly a level of pesticide residues in human breast milk and children urine. From analysis of the above studies we can conclude that organic food consumption significantly reduces body exposure to pesticide poisoning. Organic raw materials are not and will never be 100% pesticide residue-free; this is not always the farmer's fault. Chemical agents for plant protection have been commonly used for years all over the world, and for all that time their considerable quantities have accumulated in the environment where they can move. However, being aware of how negative effects are connected with excessive pesticide-related risks, every attempt to reduce and eliminate this danger should be undertaken and supported. In this respect, organic farming is really effective, and therefore, it should increase its share of national and world markets.

NITRATES AND NITRITES

Although nitrates themselves cause relatively little harm, they are transformed into very toxic nitrites in the body. Under the influence of intestinal microflora about ¾ of nitrates absorbed in the diet may be reduced to nitrites which are 6–10 times more toxic than nitrates (Szponar and Kierzkowska, 1990). The transformation of nitrates into nitrites may also take place during a production process and as a result of inappropriate conditions of food product storage and transportation (Szponar and Traczyk, 1995).

It is critical for human health, since nitrates are transformed into nitrites which may cause a dangerous disease called methaeminoglobinaemia of newborn babies, small children and the elderly (Mirvish, 1993). Since the 60-ies there have been – mainly in children – cases of nutritional methemoglobinaemia caused by the large amount of nitrates in some parts of spinach and carrot (Świątkowski, 1980; Derache, 1986; Duchań and Hady, 1992; Stolarczyk and Socha, 1992).

Moreover, nitrites may react with amines, creating nitrosamines – carcinogens and mutagens, which cause alimentary canal tumours and leukaemia (Szponar and Kierzkowska, 1990). This process is dangerous not only for small children, but also for adults, regardless of the age. Epidemiologic studies conducted in different countries showed considerably more cases of stomach cancer in regions where the population had received more nitrates in their food and drinking water (Hill et al., 1971; Janicki, 1991). The effects of nitrate poisoning are also disorders of other organs, e.g., thyroid (Pogorzelska et al., 1990).

Researchers have been discussing whether and in what concentration nitrates are dangerous to human health. For many years, an excess of nitrates has been considered harmful to health. However, recently it has been claimed that nitrates and nitrites may also play a positive role in a human body, protecting against hypertension and supporting the circulatory system (Hord et al., 2009). Other authors indicate that there is poor scientific evidence of the nitrate and nitrite impact on methemoglobinaemia in babies and tumours in adults, and that further dietary intervention studies on humans are necessary (Katan, 2009). It should be kept in mind that the same substance may influence a human body in different ways, depending on the dose: in small doses it can be necessary or even obligatory, but in large doses it can be dangerous to health. For example, this occurs with some trace elements, such as copper, zinc or manganese. It may also occur with nitrates and nitrites (Katan, 2009).

Nitrites can also reduce the nutritional value of food, decreasing assimilation of protein, fat and beta-carotene, causing decomposition of the B group vitamins and reducing the content of vitamin A (Szponar and Kierzkowska, 1990; Szteke, 1992; Rejmer, 1997).

The nitrates content of crops depends on many factors. For potatoes, Cieślik (1995a) mentions the following factors: species and variety, fertilisation, climate and soil conditions, and harvest time. According to the author, an agrotechnical factor of the strongest effect is nitrogen fertilisation. The papers by Redy et al. (1993) and Frydecka-Mazurczyk and Zgórska (1990) presented a significant linear increase of the nitrate content in tubers, proportional to the growth of N-mineral doses. Among crucial climate and weather conditions are temperature and irrigation of potato crops in a vegetation period. According to some studies, sufficient irrigation has an impact on lower nitrate accumulation in tubers, but drought can increase the nitrate content (Joergensen and Edlefsen, 1987). The five-year studies of Cieślik (1995b) also show that if average high air temperature and low rainfalls occur during the potato vegetation period, then the high nitrate content in tubers can be expected.

In conventional farming, mineral easy-dissolvable fertilisers in the form of mineral salts of nitrogen, phosphorus, potassium etc. are used. Nitrate and ammonium ions in the form of water solution come into the soil, where the plant roots (namely root hairs) absorb them easily. For millions of years of evolution plants have not developed any mechanisms which regulate the absorption of such solutions, and therefore they absorb too high volumes of easy-accessible ions, e.g. nitrate ions. As a result, nitrates are only partially used to build tissues, and the excess absorbed are accumulated in plant leaves, stems and roots. There are various techniques which slightly reduce these negative effects, such as the use of fertiliser in two doses – pre-sowing and top-dressing, the use of foliar fertiliser etc. However, these techniques do not change significantly the nature of mineral fertilisation.

Organic fertilisation is totally different for a plant from a physiological viewpoint. Natural organic fertilisers, such as manure, compost or green manure, are delivered to the soil. Organic matter is processed in the soil by living organisms; it is decomposed by bacteria, fungi and Actinomycetales as well as soil life, i.e., soil fauna with earthworms at the top. A sorption complex is created, being the basis of solid soil fertility; organic and mineral compounds form chelations, out of which a plant is able to absorb necessary elements when it needs them most, i.e., in an intensive growth period. Nitrogen compounds are absorbed as well, but more slowly and systematically; therefore nitrates are not accumulated in plant tissues. Many studies indicate a different physiological mechanism of nitrogen release when compost and mineral fertiliser are used, and a quality advantage of compost over mineral fertiliser in vegetable cultivation (Vogtmann, 1985). The experiments also point out varietal differences: under the same growing conditions, different varieties had different levels of nitrates. This shows that selection of varieties which accumulate lower contents of nitrates and other impurities is possible. This is important with respect to all kinds of cultivation, but in particular to organic cultivation.

Many studies have shown significant higher content of nitrates in conventionally produced potatoes, carrots, cabbage, beetroot, celery, leek and parsley than organic ones (Lairon et al., 1984; Mäder et al., 1993; Rembialkowska, 1998, 2000; Rutkowska, 1999; Wawrzyniak et al., 2004; Guadagnin et al., 2005; Hajslova et al., 2005; Bender et al., 2009). It is typical that the highest nitrates levels have been found in cabbage, lower for carrot, and the lowest for potato. It confirms a general rule that leafy vegetables accumulate more nitrates, followed by root vegetables and potatoes, respectively.

In addition, a comparative review by Worthington (2001) indicates a lower content of nitrates in organic vegetables than in conventional ones. Out of 176 comparisons (all together 18 studies), 127 showed a lower level of nitrates in organic crops, 34 indicated a higher level of nitrates in organic crops and 6 comparisons did not find any differences.

Conclusions

Excessive intake of nitrates is dangerous to human health. It may cause methemoglobinaemia in small babies and cancers in adults. Organic vegetables are safer than conventional ones in terms of their nitrate content and from the consumer's viewpoint.

MYCOTOXINS

In recent years, more attention has been paid to the toxins, which are metabolic products of fungi, growing on many common agricultural products and processed food. They are called mycotoxins. Some of them are very dangerous because they have a toxic effect on human, animals and plants. Consumption of food or feed contaminated by mycotoxins causes many diseases. Ingestion of even small quantities of mycotoxins can cause serious, sometimes irreversible changes in the body, leading to cancer and other serious diseases. Mycotoxins have strong toxic properties, and they can get into the body not only through food but also through the respiratory system and the skin (Stepien et al., 2007; Horoszkiewicz, 2004; Budak, 1998). Major food commodities affected are cereals, nuts, dried fruit, coffee, cocoa, spices, oil seeds, dried peas and beans and fruit, particularly apples. Mycotoxins may also be found in beer and wine, because of the use of contaminated barley, other cereals and grapes in their production. Mycotoxins also enter the human food chain via meat or other animal products such as eggs, milk and cheese as a result of livestock eating contaminated feed. It is very difficult to remove a mycotoxin once formed; this means that the best method of control is prevention (Chełkowski, 1985, 1994).

Currently, several hundred mycotoxins are known. The discovery of mycotoxins (60s of the twentieth century) is the explanation for a series of diseases which were unexplained. This happened thanks to the development of analytical techniques. The appearance of thin-layer chromatography allowed the detection of mycotoxins in food, which became the explanation for many previously unexplained illnesses and health problems. Then with time more modern technology appeared – high performance liquid chromatography and gas chromatography, especially useful for the analysis of mycotoxins (Desjardins, 2006).

Mycotoxins are secondary metabolites of fungi, which occur in nature, under favorable conditions like high temperature, humidity and organic matter. The main fungal species producing mycotoxins are Fusarium, Aspergillus and Penicillium. Their toxicity and carcinogenicity has been observed in humans and animals.

Moulds are visible, when growing on the surface of a product, but we should be aware that when they are inside they can be difficult to discern. This is the same with mycotoxins, they cannot be seen. They are stored in the mycelium, from where they can be secreted into the food and feed. Removal of the spoiled part of the product does not solve the problem, since mycotoxins penetrate into the product and remain toxic even after heat treatment (Stepien et al., 2007).

Formation of mycotoxins may be closely related to the so-called harvest diseases of cereal grains, oilseeds, fruits and vegetables. Another important factors causing mycotoxin formation is improper storage of plant products after harvest and transportation.

For several years, in European countries, the problem of fusarium ear rot disease has been growing; this paralyzes mainly crops of wheat, barley, maize and contributes to the reduction of yield, grain quality deterioration, and also leads to infection of these crops by mycotoxins. Major mycotoxins posing food safety and health risk are: aflatoxin, ochratoxin, patulin, deoxyniwalenol and zearalenone, produced by Aspergillus, Fusarium and Penicillum fungi.

Table 1. Comparison of mycotoxins occurrence in organic and conventional products

Mycotoxin	Producing fungi	Product	Higher contamination	References
Aflatoxins	*Aspergillus flavus, Aspergillus parasiticus*	Milk, Italy	In organic	Ghidini et al., 2005
Ochratoxin A	*Aspergillus ochraceus, Aspergillus alutaceus, Penicillium verrucosus*	Cereales, Poland	1997 In organic 1998 In conventional	Czerwiecki et al., 2002a,b
Patulin	*Aspergillus clavatus, Penicillium expansum , Byssochlamys nives*	Apple based juice, Italy	In conventional	Spadaro et al., 2008
		Apple based juice, Italy	In conventional	Spadaro et al., 2008
		Apple based juice, Italy	In conventional	Versari et al., 2007
		Apple based juice, Italy	In organic	Ritieni, 2003
		Apple juice, Belgium	Similar	Baert et al., 2005
Deoxynivalenon	*Fusarium graminearum, Fusarium culmorum*	Wheat flour, Germany	Similar	Shollenberger et al., 2002
Fumonisins	*Fusarium moniliforme, Fusarium proliferatum*	Sweet maiz, Belgium	In conventional	Delis et al., 2003

Nowadays, more and more studies and researches are performed on this subject because consumers are more aware of food safety issues. The case of mycotoxins in organic products is widely discussed worldwide, because in organic farming there is prohibition of use of fungicides. On the other hand, in organic production, plants strengthen their resistance to diseases. Several reviews and reports summarizing the studies show that occurrence of mycotoxins in organic products is on the same level or in some cases even lower than in conventional ones (Benbrook, 2005; Lairon, 2009). Even if the amount of mycotoxins in organic products is larger the difference is very small and does not exceed an admissible limit (Jestoi, 2004; Pussemier, 2006; Gottschalk et al., 2007; Mäder et al., 2007). Table 1 indicates that higher contamination with mycotoxins can be in both organic and conventional system.

Conclusions

Mycotoxins are toxic metabolites formed by specific fungi under favorable conditions (high humidity and temperature). They are dangerous to humans, animals, plants and microorganisms. Both organic and conventional food can be contaminated by mycotoxins and their concentration in crops depends not only on the production system (organic vs conventional) but also on the field production and storage conditions.

The content of mycotoxins is an important indicator of food quality. It has been often suggested that the mycotoxin contamination of organic crops was higher because of the ban on the fungicide use. However many studies have shown that such claims are not proven.

ARTIFICIAL ADDITIVES

Organic processing standards prohibit the use of chemicals, many synthetic preservatives, artificial colourings and sweeteners and other food additives, which are widely used in the processing of conventional foods (Beck et al., 2006). Organic processing aims to minimize the use of additives. Conventional food processing allows several hundreds of different types of food additives while organic processing allows only around 40 different additives and they are mostly natural substances. In organic processing 3 colourings, 4 preservatives, 13 antioxidants and other miscellaneous acids, salts, emulsifiers and stabilisers from plant and animal origin are permitted for use. Flavor enhancers and non-sugar sweeteners are forbidden (Commission Regulation…, 2008).

Artificial colors

Food dyes are used in countless foods to stimulate the colour of fruits or vegetables. Food dyes, synthesized originally from the coal tar and now petroleum, have long been controversial. Many dyes have been banned because of their adverse effects on laboratory animals. Kobylewski and Jacobson (2010) reported in their comprehensive review that many other currently approved dyes can raise health problems. In the last 50 years a number of studies and case reports have been published describing intolerance reactions to synthetic food colours (TemaNord, 2002) and effects on the behaviour of children (Overmeyer and Taylor, 1999). The use of food additives at their regulated concentrations is believed to be relatively safe, however a number of latest studies show that food colorings can cause headache, migraine, hyperactivity, concentration and learning difficulties etc., others show that not all people or animals are sensitive to chemicals in food.

A comprehensive meta-analysis by Schab and Trinh (2004) of the medical literature concluded that artificial dyes affect children´s behaviour. Out of references, 15 unique double-blinded placebo-controlled trials evaluating the behavioural effects of artificial food colourings among 219 subjects with diagnosis of hyperactivity have been graded, were identified. Schab and Trinh (2004) found that previous science shows that childrens´ behaviour improves when artificial colourings are removed from their diet and worsens when it is added to their diets.

A randomised double-blinded placebo-controlled crossover trial was carried out to test whether intake of synthetic food colors and additives affected child behaviour. 153 3-year old and 144 8–9-year old children were included in this study. The tested children were from the general population, not only from those sensitive to dyes. Observations in the classroom and ratings of behaviour were made independently by teachers and by parents at home. Results showed that the mixture of additives commonly found in children´s food increased the mean level of hyperactivity in children (McCann et al., 2007). These findings were consistent with results from a previous study by Bateman et al. (2004).

The genotoxicity of 39 commonly used food additives were determined. Dyes, colour-fixatives and preservatives, antioxidants and sweeteners were tested on male mice. Of all the additives, dyes were the most toxic. They induced dose-related DNA damage in the glandular stomach, colon and/or urinary bladder and induced DNA damage in the gastrointestinal organs at a low dose (Sasaki et al., 2002).

The study conducted by Amin et al. (2010) evaluated the toxic effect of the azo dyes Tatrazine and Carmoisine used in food products on renal, hepatic function, lipid profile, blood glucose, body weight gain and biomarkers of oxidative stress in young male rats. Food colourings were administered orally in two doses, one low and the other high dose for one month. The conclusion of this study was that these food dyes adversely affect and alter biochemical markers in vital organs e.g., liver and kidney, not only at a high doses but also at low doses.

Lau et al. (2006) examined, *in vitro*, the neurotoxic effects of four common artificial food additives in combinations of two – food dye and flavour enhancer, food dye and sweetener (Brilliant Blue and L-glutamic acid, Quinoline Yellow and Aspartame) to assess potential interactions. Study showed synergistic effects to inhibit neuronal cell differentiation. Food dye and sweetener showed greater synergy than food dye and flavour enhancer, however, the results indicated that both combinations are potentially more toxic than might be predicted from the sum of their individual compounds.

Pestana et al. (2010) studied the effect of the widely used synthetic food colouring, Tatrazine, on atopic subjects with allergic rhinitis, asthma, urticaria or pseudo-allergic reactions to non-inflammatory drugs. No significant differences between the administration of 35 mg of Tatrazine and placebo groups were observed with respect to cutaneous, respiratory or cardiovascular reactions.

In Ireland, researchers tested two mixes of seven additives on hyperactivity of 594 children and 441 teenagers. Results showed that no child or teenager achieved the overall intakes used in the study linking food additives with hyperactivity (Connolly et al., 2010).

Artificial flavor enhancers

Monosodium glutamate (MSG) is a substance widely used as a flavouring agent in the whole world. According to the Bellisle (2006) sensory evaluation tests have shown that both traditional and novel foods get higher palatability ratings if MSG is added at an appropriate dose. MSG is found in a wide variety of packaged foods, also used in restaurants and cafeterias.

Despite many studies carried out since the middle of the last century to the present day on laboratory animals fed with monosodium glutamate showing many harmful results, it is considered to be innocuous by the health agencies of Europe and other world. Many early studies have demonstrated brain damage and stroke (Robinzon et al., 1975; Rascher and Mesters, 1980), inducing neurotoxicity (Tóth et al., 1987), abnormalities of the reproductive system including female sterility (Olney, 1969; Lamperti and Blaha, 1976), neuroendocrine disorders including triggering obesity (Nemeroff, 1981), diabetes (Komeda et al., 1980), stunting (Cameron et al., 1976), behavioural aberration and possible learning deficits (Pradhan and Lynch, 1972; Iwata et al., 1979), eye cell damage (Reif-Lehrer, 1975; Sisk and Kuwabara, 1985), convulsions (Aruaz-Contreras and Feria-Velasco, 1984) etc.

Monosodium glutamate is widely used to create obese test subjects in laboratory. To examine, for example, new diet and diabetes drugs and treatments on obese subjects, the test group must be 100% replicable. For guaranteed results, researchers use injections of MSG subcutaneously on test subjects. After achieving appropriately obese test groups, researchers begin to test materials on them. These replicable findings has been given the names ´monosodium glutamate obese rats` or `MSG treated rats`. Hundreds of studies have used the rodent scientifically categorized as the MSG treated rat (Erb, 2006). But not all rodent species become obese with MSG ingestion, some just get diabetes (Komeda et al., 1980). In the study of Komeda et al. Chinese hamsters showed no sign of obesity, but apparently developed a diabetic syndrome. Nagata et al. (2006) created obese type 2 (non-insulin dependent) diabetes mellitus mice who were useful as experimental animals for examining diabetes.

The fact is that people can be allergic to a very small amount of MSG and this small amount can harm them. No study to determine the least amount of processed free glutamic acid (MSG) needed to trigger a reaction in MSG-sensitive people has been ever done.

In recent years, there have been many new studies. The literature analyzing MSG and consumption of ration are conflictive. Many studies demonstrate a risk of diabetes, a rise of appetite and the risk of obesity with administration of MSG, although some do not show any adverse effects.

A cross-sectional study involving 752 people (aged 49–50 years, 48.7% women) randomly sampled from three rural villages in China was conducted by He et al. (2008). This research data showed that prevalence of overweight was significantly higher in MSG users than in nonusers. The study showed that MSG intake may be associated with increased risk of becoming overweight independent of physical activity and total energy intake in humans.

The effects of the oral administration of two dosages of MSG during the second half of pregnancy and all the developmental process of offsprings on appetite control and various hormones has been analysed in rats by Fernandez-Tresguerres Hernández (2005). Effects have been compared with the neonatal parental administration of the same compound. It turned out that oral administration of MSG during pregnancy and development in rats is able to significantly affect hypothalamic control of various hormones and increases appetite.

In 2005, the study determined the effects of adding MSG to a standard diet and a fiber-enriched diet on glucose metabolism, lipid profile, and oxidative stress in rats. 8 male rats were fed a standard diet (control), a standard diet supplemented with 100 g of MSG per kilogram of rat body weight, a diet rich in fiber, or a diet rich in fiber supplemented with 100 g of MSG per kilogram of body weight. After 45 days of treatment, rats were analyzed for concentrations of insulin, leptin, glucose, triacylglycerol, lipid hydroperoxide, and total antioxidant substances. Results showed that MSG added to a standard diet increased food intake. Overfeeding induced metabolic disorders associated with oxidative stress in the absence of obesity. In the MSG group, an increase in glucose, insulin, leptin, and triacylglycerol levels were observed, whereas the fiber-enriched diet prevented these changes. Because the deleterious effects of MSG, i.e., induced overfeeding, were not seen in the animals fed the fiber-enriched diets, it was also concluded that fiber supplementation is beneficial by discouraging overfeeding and improving oxidative stress that is induced by an MSG diet (Diniz et al., 2005).

The impact of MSG on the regulation of appetite was tested on 30 pregnant rats and their offspring. Pregnant animals either received no extra MSG, or 2.5 g MSG, or 5 g MSG per day, up to the end of the weaning period. After weaning, MSG feeding was continued in the offspring. The animals fed 5 g MSG per day increased water uptake threefold, and food uptake by almost two-fold. The study demonstrated that a widely used nutritional monosubstance, the flavouring agent MSG, at concentrations that only slightly surpass those found in everyday human food, exhibits significant potential for damaging the hypothalamic regulation of appetite, and thereby determines the propensity of obesity (Hermanussen et al., 2006).

In a study with 36 young men and women weekly tests of free intake of experimental foods with 0.6% MSG showed that subjects ate progressively more and faster, indicating increasing palatability with repeated exposure. The conclusion of this study was that MSG can act as a flavour enhancer, but it should be utilized cautiously (Bellisle et al., 1991)

MSG has been shown in rats to overstimulate the pancreas resulting in hyperinsulinemia. The excess insulin in the blood increases the conversion of glucose into adipose tissue (body fat) (Erb, 2006). Macho et al. (2000) found an increase of plasma insulin in 3 month old rats treated with MSG during the postnatal period and Niijima et al. (1990) recognized that even just adding MSG to the mouth of a rat, after 3 min can trigger an increase in insulin release.

Chevassus et al. (2002) conducted a double-blind placebo-controlled cross-over study with 18 healthy volunteers (19–28 years old). 10 g MSG was given orally. The MSG enhanced glucose-induced insulin secretion in healthy volunteers in a concentration-dependent manner.

Macho et al. (2000) investigated the late effects of postnatal administration of MSG on insulin action in adult rats. They demonstrated that, early after birth, administration of MSG exerts an important effect on glucose metabolism and insulin action in fat cells of adult animals. The results indicated an attenuation of insulin effect on glucose transport due to a lower insulin binding and lower content of GLUT4 (insulin-regulated glycose transporter) protein in MSG-treated rats.

In 2002, Ohguro et al. (2002) found that rats fed 10 g. of sodium glutamate (97.5% sodium glutamate and 2.5% sodium ribonucleotide) added to a 100 g. daily diet for 3 months, had a significant increase in the amount of glutamic acid in vitreous, had damage to the retina, and had deficits in retinal function.

Ajinomoto Company Inc., the largest MSG producer in the world, investigated the effect of the spontaneous ingestion of a 1% MSG solution and water on food intake and body weight in male rats fed diets of varying caloric density, fat and carbohydrate contents. Rats given free access to MSG and water showed a high preference for the MSG solution, regardless of the diet they consumed. The results indicated also that MSG ingestion reduced weight gain, body fat mass and plasma leptin levels (Kondoh and Torii, 2008).

Artificial sweeteners

Artificial sweeteners, also called sugar substitutes, alternative sweeteners, or non-sugar sweeteners, are substances that are used instead of sucrose (table sugar) to sweeten foods and beverages or to lower their calorie content. Artificial sweeteners are many times sweeter than table sugar and due to that, smaller amounts are needed to create the same level of sweetness.

The most widely used are saccharin, aspartame, acesulfame potassium (acesulfame-K), sucralose, neotame and cyclamate. A lot of studies have been carried out to examine their effects on health. Questions about artificial sweeteners and its safety arose when early studies showed that cyclamate mixed with saccharin caused bladder cancer in laboratory animals. However, results from subsequent carcinogenicity studies (studies that examine whether a substance can cause cancer) of these sweeteners have not provided clear evidence of an association with cancer in humans. Further studies showed consistent evidence that in utero (state of the embryo or foetus) and immediate post utero exposure of rats to the artificial sweetener saccharin results in an increase in bladder tumours when compared with adult exposure only (Taylor et al., 1980), and that in second-generation saccharin-exposed male rats there is a dose-dependent increase in the incidence of bladder tumours (Schoenig et al., 1985).

Subsequent studies in rats have shown an increased incidence of urinary bladder cancer at high doses of saccharin, especially in male rats (Renwick and Sims, 1983). However, mechanistic studies (studies that examine how a substance works in the body) have shown that these results apply only to rats.

S.K. Van den Eeden et al. (1994) found, in his study, connections between aspartame and headaches. This experiment provides evidence that, among individuals with self-reported headaches after ingestion of aspartame, a subset of this group report more headaches when tested under controlled conditions.

In 2005, a laboratory study found more lymphomas and leukemias in rats fed high doses of aspartame. This study by Italian researchers presented the first results showing that aspartame caused a statistically significant, dose-related increase in lymphomas and leukaemias in females. No significant increase in malignant brain tumours was observed among animals (Soffritti et al., 2005). In the same year, the same research team provided the first compelling experimental evidence for the carcinogenic effects of aspartame at a dose level within range (even less) of human daily intake (Soffritti et al., 2006). Next year, Soffiritti et al. (2007) confirmed and reinforced the first experimental demonstration of aspartame's multipotential carcinogenicity at a dose level close to the acceptable daily intake for humans. Furthermore, the study demonstrated that when life-span exposure to aspartame begins during foetal life, its carcinogenic effects are increased. This experiment had a long observation period and comprehensive assessment of aspartame's carcinogenic potential. Although recent epidemiologic studies have not found an association between aspartame and human cancers, these studies were not designed to measure cancer risks associated with foetal exposures.

The results of the studies of Soffritti´s group attracted the attention of the scientific community, consumers and industry associations, and the national and international agencies responsible for food safety (Soffritti, 2006). Magnuson from the University of Maryland and Williams from New York Medical College doubted these findings (Magnuson and Williams, 2008). They indicated also several methodologic and conceptual weaknesses. But it is important to point out that Magnuson and Williams received payment from the Burdock Group during the preparation of an expert review of the safety of aspartame and the Burdock Group managed the independent review, which was financially supported by Ajinomoto Company Inc., a producer of aspartame. As these allegations were made by people who had competing financial interests, this fact should be considered.

On the other hand, Karstadt from Drexel University School of Public Health found the findings of Soffritti´s group interesting and pointed out the need for more long-term adequate and independent carcinogenicity testing of the artificial sweetener acesulfame-K (Karstadt, 2006).

Weihrauch and Diehl (2004) concluded in their review article of carcinogenic risk of artificial sweeteners that saccharin induces bladder cancer in rats and heavy artificial sweetener use leads to an increased relative risk of bladder cancer in humans.

There have been published several directly contradictory animal trials which did not show any carcinogenic effect of aspartame (Jeffrey and Williams, 2000; Butchko et al., 2002; National..., 2003). The objectivity of first two experiments is questionable, because of connectivity with producer companies of sweeteners. A population-based case-control study found a null association between childhood brain tumours and aspartame ingestion among both children and their mothers during pregnancy and lactation (Gurney et al., 1997). Lim et al. (2006) did not find increased risk of brain cancer in humans either.

The study with restrained female showed that total energy intake is not automatically reduced when sucrose-sweetened drinks are replaced by ´diet´ drinks containing aspartame. On the contrary, data suggests that energy intake may even increase during the subsequent day (Lavin et al., 1997). This research was supported by The Sugar Bureau.

Conclusions

In conventional food processing several hundreds of different synthetic additives are permitted for use, while in organic food processing only around 40 natural substances are allowed.

Artificial colours have been shown to cause several adverse health effects in experimental animals (rats, mice) – DNA damage in the bladder and gastrointestinal track – and in humans – allergies, headache, migraine, hyperactivity, concentration and learning difficulties (mostly in children).

MSG (monosodium glutamate) use is permitted in non-organic foods, however, dozens of published studies show ailments and side effects of ingestion of MSG, such as disturbance of rat and human metabolism, hyprinsulinemia, increased food intake and overweight/obesity. Considering the previously mentioned, there is reason to be unsure that consumption of industrial monosodium glutamate is completely safe.

Artificial sweeteners have been linked to adverse health outcomes such as higher energy intake, headaches, cancers etc. As many artificial sweeteners are combined in today´s products, the carcinogenic risk of a single substance is very difficult to assess. Artificial sweeteners are promoted as safe non-caloric sugar replacers. However the experimental and epidemiological data currently available to evaluate the risks or the safety are insufficient and old and therefore the safety of artificial sweeteners is questionable.

Taking into consideration the above facts, organically processed food products are much safer for consumers than conventionally processed ones.

3. NUTRITIONAL VALUE OF ORGANIC vs. CONVENTIONAL PLANT PRODUCTS

FRUITS AND VEGETABLES

The market for organic produce continues to grow (FiBL, 2009; Willer, 2011), as consumers are alienated by nutritional scandals from products manufactured by industrial methods and seek safe and controlled food products (Hughner et al., 2007). Health awareness is increasing, and the eating habits of consumers are changing; many believe that organic products are not only safer but also richer in the components necessary to maintain proper health.

The variation in composition between organic and conventional produce is dependent on differences in the production practices typical for organic and conventional crops. On organic farms, the crops are grown without the use of synthetic plant protection products and readily soluble mineral fertilizers. In organic farming, animal manures, green manures, compost and a varied crop rotation are applied instead of readily soluble mineral fertilizers, which leads to optimal soil biological activity. Due to the exclusion of the use of chemical protection products in organic farming, activation of natural mechanisms of plant defence system against diseases and pests takes place. Natural protective substances in plants are so called secondary metabolites, which also represent an essential element of daily human diet.

Research comparing the content of bioactive substances in organically and conventionally produced plant products has been carried out by many authors since the early 1980s. There is a growing evidence that plant secondary metabolites play a critical role for human health and may be important in terms of nutritional value (Lundegårdh and Mårtensson, 2003). Plant metabolites in the form of phenolic compounds are of particular interest because of their potential antioxidant activity and cardioprotective, neuroprotective and chemoprotective properties, including those that may prevent cancer (Brandt and Mølgaard, 2001; Frei and Higdon, 2003; Kampa et al., 2007; Carlson et al., 2007; Ortuno et al., 2007). The content of the secondary substances from the phenolic compound group in plant products is therefore of great interest, and has led to more scientific studies comparing their contents in organic and conventional produce.

Plant secondary metabolites are substances naturally synthesized by the plant, but usually they do not take direct part in the creation of its cells. They are typically produced as a plant reaction to various external stimuli, acting as regulators of physiological changes in the event of an attack by pests or other stress factors (Brandt and Mølgaard, 2001). For a human, they are an important source of antioxidant compounds, so called antioxidants, which protect the body against the influence of many external factors and limit the spread of lifestyle diseases (Di Renzo et al., 2007). Plant secondary metabolites can be divided into compounds containing no nitrogen: phenolic acids, flavonoids and terpenoids (e.g. tetraterpenes: carotenoids, xanthophylls), and nitrogen-containing compounds (alkaloids, amines, non-protein amino acids, glycosides, glucosinolates).

Most studies comparing organic and conventional raw materials in terms of content of secondary metabolites, have measured total polyphenols, without distinction between individual compounds belonging to this group. Although some

Table 2. The content of polyphenols in fruits and vegetables from organic and conventional production

Fruit/ Produce	Bioactive substances	Higher/lower/similar content in organic fruit or vegetable compared to conventional	Author
TOTAL POLYPHENOLS			
Peach	Polyphenols	Higher in organic	Carbonaro and Mattera, 2001
Peach	Polyphenols	Higher in organic	Carbonaro et al., 2002
Pear	Polyphenols	Higher in organic	Carbonaro et al., 2002
Marionberry	Polyphenols	Higher in organic	Asami et al., 2003
Frozen strawberry	Polyphenols	Higher in organic	Asami et al., 2003
Frozen corn	Polyphenols	Higher in organic	Asami et al., 2003
Apple	Polyphenols	Higher in organic	Weibel et al., 2000
Apple juice	Polyphenols	Higher in organic	Rembiałkowska et al., 2006
Apple sauce	Polyphenols	Higher in organic	Rembiałkowska et al., 2006
Blueberry	Polyphenols	Higher in organic	Wang et al., 2008
Orange peel	Polyphenols	Higher in organic	Faller and Fialho, 2010
Papaya peel	Polyphenols	Higher in organic	Faller and Fialho, 2010
Chinese cabbage Pac Choi	Polyphenols	Higher in organic	Young et al., 2005
Tomato puree	Polyphenols	Higher in organic	Caris-Veyrat et al., 2004
Yellow plum	Polyphenols	Lower in organic	Lombardi-Boccia et al., 2002
Tomato	Polyphenols	Lower in organic	Barrett et al., 2007
Pear	Polyphenols	Similar content	Carbonaro and Mattera, 2001
Apple	Polyphenols	Similar content	Briviba et al., 2007
Lettuce	Polyphenols	Similar content	Young et al., 2005
FLAVONOIDS			
Apple	Flavonoids	Higher in organic	Weibel et al., 2004
Tomato	Flavonoids	Higher in organic	Rembiałkowska et al., 2003b
Chinese cabbage	Flavonoids	Higher in organic	Ren et al., 2001
Welsh onion	Flavonoids	Higher in organic	Ren et al., 2001

Continued

authors have expressed the content of individual substances, such as quercetin, tannic acid, kaempferol or antocyanins in plant products. Polyphenol content is usually compared by some authors in terms of dry matter of the product, but in most cases as the content in the fresh matter of the product.

The majority of studies comparing the **polyphenol** content in plant products from different farm systems indicated a significant advantage of organic fruits and vegetables (Weibel et al., 2000; Carbonaro and Mattera, 2001; Carbonaro et al., 2002; Lombardi-Boccia et al., 2002; Asami et al., 2003; Caris-Veyrat et al., 2004; Young et al., 2005; Rembiałkowska et al., 2006; Wang et al., 2008; Faller and Fialho, 2010) (table 2). However, some authors have found a lower or similar level of phenolic compounds in organically grown vegetables and fruits (Häkkinen and Törrönen, 2000; Mikkonen et al., 2001; Lombardi-Boccia et al., 2002; Young et al., 2005; Anttonen et al., 2006; Chassy et al., 2006; Barrett et al., 2007; Briviba et al., 2007).

Table 2. *Continued*

Fruit/ Produce	Bioactive substances	Higher/lower/similar content in organic fruit or vegetable compared to conventional	Author
Spinach	Flavonoids	Higher in organic	Ren et al., 2001
Green pepper	Flavonoids	Higher in organic	Ren et al., 2001
Apple	Flavonols quercetin/	Higher in organic	Rembiałkowska et al., 2003a
Red pepper	Flavonols	Higher in organic	Hallmann et al., 2005
Onion	Flavonols/ quercetin	Higher in organic	Hallmann and Rembiałkowska, 2006
Black currant	Flavonols	Similar content	Mikkonen et al., 2001
Strawberry	Flavonols	Similar content	Häkkinen and Törrönen, 2000
Tomato	Quercitin	Higher in organic	Mitchell et al., 2007
Strawberry	Quercetin	Similar content	Anttonen et al., 2006
Yellow plum	Quercitin	Lower in organic	Lombardi-Boccia et al., 2002
Tomato	Quercetin	Lower in organic	Chassy et al., 2006
Tomato	Kaempferol	Higher in organic	Mitchell et al., 2007
Yellow plum	Kaempferol	Higher in organic	Lombardi-Boccia et al., 2002
Tomato	Kaempferol	Higher in organic	Chassy et al., 2006
Strawberry	Kaempferol	Lower in organic	Anttonen et al., 2006
Tomato	Naringenin	Higher in organic	Mitchell et al., 2007
Tomato	Naringenin	Higher in organic	Bender et al., 2009
Apple	Anthocyanins	Higher in organic	Rembiałkowska et al., 2003a
Apple	Anthocyanins	Higher in organic	Rembiałkowska et al., 2004
Blueberry	Anthocyanins	Higher in organic	Wang et al., 2008
Blood orange	Anthocyanins	Higher in organic	Tarozzi et al., 2006
Strawberry	Anthocyanins	Higher in organic	Tõnutare et al., 2009
Onion	Anthocyanins/ delphinidin	Higher in organic	Hallmann and Rembiałkowska, 2006
Currant	Antioxidant activity	Higher in organic	Kazimierczak et al., 2008
Blueberry	Antioxidant activity	Higher in organic	Wang et al., 2008
Strawberry	Antioxidant activity	Higher in organic	Tõnutare et al., 2009

The main area of interest are **flavonoids**, which constitute a large group of several thousand different compounds; they play an important role in maintaining health, performing many functions in the human body (Bidlack 1998; Frei and Higdon, 2003; Ramos, 2007; Fresco et al., 2006; Shankar et al., 2007). Flavonoids have strong antioxidant and metal chelating activity, influence the neutralization of free radicals, e.g. by inhibiting the development of cancer, counteract atherosclerosis, decrease the risk of obesity, strengthen blood vessel walls preventing the formation of microbleeding and stroke and reduce blood clot formation decreasing the risk of stroke. They act as protectors in relation to vitamin C, increasing its effectiveness, supporting the immune system, preventing some bacterial and viral infections and some have astringent properties, soothing irritation of mucous membranes (Bidlack, 1998).

Several studies have confirmed an elevated content of different flavonoids in organic produce (Lombardi-Boccia et al., 2002; Rembialkowska et al., 2003a; Rembiałkowska et al., 2003b; Rembiałkowska et al., 2004; Weibel et al., 2004; Hallmann et al., 2005; Anttonen et al., 2006; Chassy et al., 2006; Hallmann and Rembiałkowska, 2006; Tarozzi et al., 2006; Mitchell et al., 2007; Wang et al., 2008; Bender et al., 2009; Tõnutare et al., 2009). As far as antioxidant activity is concerned, Ren et al. (2001) indicated an increased value of flavonoids in juice made of organic Chinese cabbage, welsh onion and spinach (increase of 50–120%). According to Kazimierczak et al. (2008), organic currants showed 30% higher antioxidant activity and according to Wang et al. (2008) organic blueberries had higher antioxidant activity than conventionally grown ones. Previous studies concerning organic crops confirmed this elevated capacity (Benbrook et al., 2008).

Another group of secondary metabolites of plants, characterized by their strong antioxidant properties, are **carotenoids**. In the nature, there are over 600 pigments called carotenoids, which give the plants yellow, orange and red colour. Carotenoids are also found in green leafy vegetables, but their colour is masked by green chlorophyll. The best-known carotenoid is beta-carotene found in many orange and yellow fruit as well as green leafy vegetables. Lycopene gives tomatoes their vivid red colour. Lutein and zeaxanthin stain corn in yellow. Carotenoids play an important role for human health. They lower blood cholesterol levels, and thus favourably affect the heart. They assist in enhancing the immune system of the body, particularly beta-carotene which stimulates the increase in the number of lymphocytes. They also exhibit anti-tumour activity, mainly due to their antioxidant properties and neutralization of free radicals (Stracke et al., 2008).

Studies comparing the content of carotenoids in organic and conventional plant products have given variable results. Several authors have confirmed elevated levels of these substances in organic carrots, sweet peppers and tomatoes (Abele, 1987; Rembiałkowska et al., 2003a; Caris-Veyrat et al., 2004; Hallmann et al., 2005; Hallmann et al., 2007; Hallmann and Rembiałkowska, 2007a; Pérez-López et al., 2007; Hallmann and Rembiałkowska, 2008a; Hallmann et al., 2008; Bender et al., 2009; Juroszek et al., 2009; Rickman Pieper and Barrett, 2009), while others have demonstrated quite different results in case of tomatoes and carrots (Warman and Havard, 1997; Hallmann et al., 2005, Rembiałkowska et al., 2005; Toor et al., 2006; Hallmann and Rembiałkowska, 2007b; Hallmann et al., 2007; Hallmann and Rembiałkowska, 2008a; Rossi et al., 2008; Stracke et al., 2008). It must be kept in mind though, that the content of carotenoids depends on many factors, such as genotype, soil parameters, weather, pesticides and fertilizers used.

Some results showing the content of the carotenoids in the organic and conventional produce are presented in table 3.

The group of powerful antioxidants also includes **vitamin C**, which also plays a fundamental role in several metabolic functions of the human body. It ensures the proper functioning of the immune system, interacts in the biosynthesis of collagen, accelerates the process of wound healing and bone coalescence. In addition, it participates in the metabolism of fats, cholesterol and bile acids, regenerates vitamin E and other low-molecular antioxidants, such as glutathione,

Table 3. Comparison of the content of carotenoids in organic and conventional vegetables

Raw material	Substance	Higher/lower/similar content in organic vegetable compared to conventional	Author
TOMATO			
Tomato	Lycopene	Higher in organic	Caris-Veyrat et al., 2004
Tomato juice	Lycopene	Higher in organic	Hallmann and Rembiałkowska, 2008a
Tomato	Lycopene	Lower in organic	Bender et al., 2009
Tomato	Lycopene	Lower in organic	Rossi et al., 2008
Tomato	Lycopene	Lower in organic	Toor et al., 2006
Tomato	Lycopene	Lower in organic	Rembiałkowska et al., 2005
Tomato	Lycopene	Lower in organic	Hallmann and Rembiałkowska, 2007b
Tomato	Lycopene	Lower in organic	Hallmann and Rembiałkowska, 2008a
Tomato	Lycopene	Similar content	Rickman Pieper and Barrett, 2009
Tomato	Lycopene	Similar content	Juroszek et al., 2009
Tomato	β-carotene	Higher in organic	Caris-Veyrat et al., 2004
Tomato	β-carotene	Higher in organic	Rembiałkowska et al., 2003a
CARROT			
Carrot	β-carotene	Similar content	Abele, 1987
Carrot	α- and β-carotene	Similar content	Stracke et al., 2009
Carrot	β-carotene	Lower in organic	Warman and Havard, 1997
PEPPER			
Pepper	Total carotenoids	Higher in organic	Perez-Lopez et al., 2007
Pepper	Total carotenoids	Higher in organic	Hallmann et al., 2005
Pepper	Total carotenoids	Higher in organic	Hallmann et al., 2007
Pepper	Total carotenoids	Higher in organic	Hallmann and Rembiałkowska, 2007a
Pepper	Total carotenoids	Higher in organic	Hallmann et al., 2008
Pepper	Total carotenoids	Higher in organic	Hallmann and Rembiałkowska, 2008b
Pepper	Lycopene	Lower in organic	Hallmann et al., 2005
Pepper	Lycopene	Lower in organic	Hallmann et al., 2007
Pepper	β-carotene	Higher in organic	Hallmann et al., 2005
Pepper	β-carotene	Higher in organic	Hallmann et al., 2007
Pepper	Lutein	Higher in organic	Hallmann et al., 2005
Pepper	Lutein	Higher in organic	Hallmann et al., 2007

and has a stabilizing effect in relation to the flavonoids. Vitamin C is characteristic of bacteriostatic and even bactericidal properties against some pathogens. It facilitates the assimilation of non-haem iron and is involved in the production of red blood cells. Further, it inhibits the formation of carcinogenic nitrosamines in the body, thus reducing the negative impact of nitrates (Mirvish, 1993).

For the majority of plants, it has been demonstrated that organic raw mate-

Table 4. Comparison of the content of vitamin C in organic and conventional raw materials

Raw material	Higher/lower/similar content in organic produce compared to conventional	Author
TOMATO		
Tomato	Higher in organic	Caris-Veyrat et al., 2004
Tomato	Higher in organic	Chassy et al., 2006
Tomato	Higher in organic	Rembiałkowska et al., 2005
Tomato	Higher in organic	Hallmann, 2005
Tomato	Lower in organic	Rossi et al., 2008
Tomato	Lower in organic	Barrett et al., 2007
Tomato	Lower in organic	Rembiałkowska et al., 2003b
POTATO		
Potato	Higher in organic	Schuphan, 1974
Potato	Higher in organic	Petterson, 1978
Potato	Higher in organic	Fischer and Richter, 1984
Potato	Higher in organic	Rembiałkowska and Rutkowska, 1996
Potato	Higher in organic	Rembiałkowska, 2000
Potato	Higher in organic	Hajslova et al., 2005
OTHER VEGETABLES		
Spinach	Higher in organic	Schuphan, 1974
Spinach	Higher in organic	Vogtmann et al., 1984
Celery	Higher in organic	Schuphan, 1974
Celery	Higher in organic	Leclerc et al., 1991
Savoy cabbage	Higher in organic	Schuphan, 1974
White cabbage	Higher in organic	Rembiałkowska, 1998
White cabbage	Higher in organic	Rembiałkowska, 2000
Pepper	Higher in organic	Hallmann, 2005
Pepper	Higher in organic	Hallmann et al., 2007
Onion	Higher in organic	Hallmann and Rembiałkowska, 2006
Lettuce	Higher in organic	Schuphan, 1974
Leek	Higher in organic	Lairon et al., 1984
Swiss chard (leaves)	Higher in organic	Moreira et al., 2003
Frozen corn (grain)	Lower in organic	Asami et al., 2003
Broccoli	Similar content	Wunderlich et al., 2008
FRUITS AND BERRIED		
Aapple	Higher in organic	Rembiałkowska et al., 2003b
Orange	Higher in organic	Rapisarda et al., 2005
Yellow plum	Higher in organic	Lombardi-Boccia et al., 2002
Black currant	Higher in organic	Kahu et al., 2009
Peach	Higher in organic	Carbonaro et al., 2002
Pear	Higher in organic	Carbonaro et al., 2002
Strawberry	Similar content	Kahu et al., 2010

rial is characterized by a higher content of vitamin C (Schuphan, 1974; Petterson, 1978; Fischer and Richter, 1984; Lairon et al., 1984; Vogtmann et al., 1984; Leclerc et al., 1991; Rembiałkowska and Rutkowska, 1996; Rembiałkowska, 1998; Rembiałkowska, 2000; Carbonaro et al., 2002; Lombardi-Boccia et al., 2002; Moreira et al., 2003; Rembiałkowska et al., 2003b; Caris-Veyrat et al., 2004; Hajslova et al., 2005; Rapisarda et al., 2005; Rembiałkowska et al., 2005; Chassy et al., 2006; Hallmann and Rembiałkowska, 2006; Hallmann et al., 2007; Kahu et al., 2009) (table 4). There are several studies though, showing lower or similar levels of vitamin C in organic plant produce, mainly in organic tomatoes (Asami et al., 2003; Rembiałkowska et al., 2003a; Barrett et al., 2007; Rossi et al., 2008; Wunderlich et al., 2008; Kahu et al., 2010).

According to the studies listed in the table 4, vitamin C content is on average is higher for organic raw materials, with the biggest difference demonstrated for onion.

A comparative review by Worthington (2001) indicates a higher content of **mineral components** (iron, magnesium and phosphorus) in organic vegetables than in conventional ones (table 5). She analysed 41 studies and considered a possible cause of the higher content of mineral elements in organic raw materials to be related to the higher content of microorganisms in organically cultivated soil. These microorganisms produce many compounds that help plants by introducing substances, such as citrate, which binds with the soil minerals, thus becoming more readily available to plant roots.

No differences were observed in the content of minerals and trace elements between organic and conventional vegetables from the 8 studies reviewed by Woëse et al. (1997). The only exception was iron: in half of the studies, the content of iron was similar in organic and conventional produce, in the other half, organically produced vegetables had higher contents. In a recent study by Bender et al. (2009) the concentration of magnesium, phosphorous, potassium and calcium in organic and conventional carrots did not show any differences.

Studies of fruits have not given any clear conclusion. Some have reported no differences between mineral contents in fruits (Woëse et al., 1997; Bourn and Prescott, 2002), although Smith et al. (1993) found significantly higher micronutrient concentrations in organically cultivated apples, pears and pineapples than in conventional ones.

Table 5. Differences in the content of mineral components in organic and conventional vegetables (Worthington, 2001)

Type of vegetable	Nutrient *		
	Iron	Magnesium	Phosphorus
Lettuce	+17	+29	+14
Spinach	+25	–13	+14
Carrot	+12	+69	+13
Potato	+21	+5	0
Cabbage	+41	+40	+22

* – 'Plus' and 'minus' signs mean a difference in the content of a given component in organic vegetables in relation to conventional ones. For example, the level of Iron is 17% higher in organic lettuce (conventional 100%, organic 117%).

Table 6. Content of total sugars in organic and conventional raw materials

Raw material	Higher/similar content in organic produce compared to conventional	Author
Sugar beet	Higher in organic	Zadoks, 1989
Carrot	Higher in organic	Rembiałkowska, 1998
Potato	Higher in organic	Stertz et al., 2005
Tomato	Higher in organic	Rembiałkowska et al., 2005
Onion	Higher in organic	Hallmann and Rembiałkowska, 2006
Pepper	Higher in organic	Hallmann et al., 2007
Apple	Higher in organic	Rembiałkowska et al., 2004
Vegetables	Similar content	Woëse et al., 1997

The content of **sugars** has been examined in a few studies. Several have reported a higher content of total sugars in organic fruit and vegetables than in conventional ones (Zadoks, 1989; Rembiałkowska, 1998; Rembiałkowska et al., 2004; Rembiałkowska et al., 2005; Stertz et al., 2005; Hallmann and Rembiałkowska, 2006; Hallmann et al., 2007) (table 6). Woëse et al. (1997) reported in their review no clear trend in the level of total sugar content in organic vegetables compared with conventional ones.

Higher sugar content means not only better technological quality, as in sugar beet, but also better tasting fruits and vegetables, i.e. higher sensory value. In tests performed with the participation of both consumers and a trained panel, vegetables and fruit from organic production are often rated better in terms of their sensory properties (Rembiałkowska, 2000).

The higher technological value of organic plant products is determined, e.g. by higher dry matter content, thanks to which organic products have better storage quality (Bulling, 1987; Rembiałkowska, 2000). Tõnutare et al. (2009) found higher dry matter content in organic strawberries. Samaras (1978) showed in his studies that the main influence on the amount of mass lost during storage, is the type of material the plants were fertilized with. All root vegetables (carrots, kohlrabi, beets and potatoes), tested by Samaras (1978), which had been fertilised with organic manure, were characterized by much lower storage losses. The higher storage losses of vegetables grown with mineral fertilizers may be associated with a higher content of water absorbed by the plant together with readily soluble mineral compounds. When mineral fertilizers were used, the average storage losses amounted to 46.4% of the initial mass, and with the application of organic manure – 28.9% of the initial mass. Potatoes turned out to be the least sensitive to storage losses (Samaras, 1978).

Bulling (1987) listed studies comparing storage losses of organic and conventional vegetables and fruits. Mean values for raw materials tested in 53 studies showed 10% lower losses for the benefit of organic farming.

GRAINS

Cereals play an important part in human nutrition, and because of the large scale of consumption, they may provide a wide range of nutrients and biologically active compounds. According to epidemiological data, regular consumption of whole-grain and bran products may contribute to the prevention of cardiovascular diseases, diabetes and certain forms of cancer, especially of the digestive system (Jacobs et al., 1995; Meyer et al., 2000; Moore et al., 2005). Beneficial health effects are usually attributed to the presence of dietary fibre, micronutrients, and bioactive secondary metabolites.

The level of different **phenolic acids** and flavonoids in a plant species depends on the stage of development, tissue, variety and environmental stresses such as UV radiation, drought, irrigation, soil conditions, tillage, pest infestation, use of pesticides and fertilisers (Dixon and Paiva, 1995). Therefore, different food production methods may result in differences in the content of secondary metabolites.

Phenolic acid concentration in organically and conventionally cultivated spring and winter wheat was investigated by Zuchowski et al. (2010). Organically produced spring and winter wheat had significantly higher concentrations of the total phenolic acid content than conventional wheat, however, the differences were not large. To the contrary, the experiment conducted by Dimberg et al. (2005) with organic and conventional oats did not show any differences in phenolic compound concentration.

Kalinova and Vrchotova (2011) measured the level of **flavonoids** in common buckwheat groats. The results showed that differences in agricultural practices will not affect all plants and all secondary metabolites equally - two of four types of flavonoid content were slightly higher in organic production, other concentrations were similar. The differences varied with variety.

Scientists in Germany measured a **metabolite profile** of grains grown under comparable organic and conventional conditions. Relative levels of a set of 52 different metabolites were determined including amino acids, organic acids, sugars, sugar alcohols, sugar phosphates, and nucleotides from wheat grains. The statistical analysis of the data showed that the metabolite status of the wheat grain from organic and conventional farming did not differ in concentrations of 44 metabolites. This result indicates no impact or a small impact of the different farming systems; in conclusion no large differences in metabolite composition and quality of wheat grains were detected (Zörb et al., 2006).

Magkos et al. (2003) showed in their review that organic wheat, rye and corn tend to contain a lower amount of amino acids, but at the same time a higher proportion of essential amino acids. These results showed eight analysed studies, however, one study failed to reach such a conclusion.

In a 21 year field experiment of Mäder et al. (2007) no statistically significant differences were found in wheat between the farming systems in the content of amino acids (of the 18 amino acids), phosphorus, potassium, calcium, zinc, molybdenum and cobalt. The authors concluded that organic farming can produce reasonable wheat yields of high quality in the long term, using far fewer external inputs in the form of biological fertilizers and plant protection agents. The legume in the rotation is important for stable wheat yields of high quality in organic farming. The present results of that experiment have shown better soil fertility, higher biodiversity, energy and nutrient efficiency in the organic system.

Grain **mineral concentrations** under organic and conventional management were examined by Ryan et al. (2004). Conventional management greatly increased yields but reduced colonisation by mycorrhizal fungi. While only minor variations occurred in grain N, K, Mg, Ca, S and Fe concentrations, organic grain had higher Zn and Cu but lower Mn and P than conventional grain. In conventional farming, soluble P fertilizer was used which increased P uptake but reduced mycorrhizal colonisation and thereby reduced Zn uptake but enhanced Mn uptake. Dilution of Cu in heavier crops and past lime applications on the organic farm decreased Mn availability. These variations in grain minerals had nutritional implications primarily favouring the organic grain, however, organic management did not induce dramatic increases in grain mineral concentrations. A study conducted by Alföldi et al. (1996) showed similar results: no marked differences but a trend for higher levels of Ca, Cu and Zn in organic barley.

Camerini et al. (2011) found no differences between 8 cultivars of organic and conventional durum wheat either, where several quality parameters such as ashes, sodium dodecyl sulfate (SDS), yellow index, total antioxidant capacity (TAC) and DON (mycotoxin) content were analysed in two locations of Italy.

The majority of studies (Mäder et al., 2007; Mazzoncini et al., 2007; Tamm et al., 2009) and reviews (Woëse et al., 1997; Heaton, 2001, Worthington, 2001; Magkos et al., 2003) show a decreased **protein** content in organic cereals, whereas protein quality was found to be higher in organic than conventional cereals (Woëse et al., 1997; Heaton, 2001; Worthington, 2001; Magkos et al., 2003; Mäder et al., 2007; Tamm et al., 2009). However, a recent study doesn't confirm this theory (Camerini et al., 2011). Increased protein level in conventionally grown crops is probably a result of higher nitrogen fertilization, prohibited in the organic farm system. A further trend indicates that the quantity of protein may be less but the quality may be better in organic than in conventional crops.

Several researches have indicated better **baking quality** in non-organically grown cereals (Heaton, 2001; Mazzoncini et al., 2007), whereas Mäder et al. (2007) detected that the quality of baked products obtained from conventionally and organically grown wheat was equally good. Ingver et al. (2009) reported that wheat which had used nitrogen of organic origin behaved differently in the baking process and the differences between varieties in dough development time and stability were more stable in organic wheat. Organoleptic evaluation has been in favour of organic production (Mazzoncini et al., 2007).

The summarized results of the studies showing the quality parameters in organic compared to conventional grain have been placed in table 7.

Conclusions

The nutritional value of food depends largely on its composition being appropriate for the proper functioning of the human body. According to the studies analyzed in this chapter, organic plant products contain generally more vitamin C and phenolic compounds. However, the level of carotenoids is often higher in conventional plant products. Studies show also higher content of dry matter,

Table 7. Differences in quality parameters in organic compared to conventional grain

Substance	Higher/lower/similar content of substances or better/worse properties in organic compared to conventional production	Author
Phenolic compounds	Higher in organic	Zuchowski et al., 2010
Phenolic compounds	Similar content	Dimberg et al., 2005
Flavonoids	Similar content	Kalinova and Vrchotova, 2011
Metabolite profile	Similar content	Zörb et al., 2006
Amino acids	Lower in organic	Magkos et al., 2003
Amino acids	Similar content	Mäder et al., 2007
Essential amino acids	Higher in organic	Magkos et al., 2003
Mineral concentration (P, K, Ca, Zn, Mo, Co)	Similar content	Mäder et al., 2007
Mineral concentration (Cu, Zn, Ca)	Higher in organic	Alföldi et al., 1996
Mineral concentration (Cu, Zn)	Higher in organic	Ryan et al., 2004
Mineral concentration (Mn, P)	Lower in organic	Ryan et al., 2004
Mineral concentration (N, K, Mg, Ca, S and Fe)	Similar content	Ryan et al., 2004
Ahes, SDS, yellow index, TAC, DON	Similar content	Camerini et al., 2011
Protein content	Lower in organic	Magkos et al., 2003
Protein content	Lower in organic	Heaton, 2001
Protein content	Lower in organic	Woëse et al., 1997
Protein content	Lower in organic	Worthington, 2001
Protein content	Lower in organic	Tamm et al., 2009
Protein content	Lower in organic	Mazzoncini et al., 2007
Protein content	Lower in organic	Mäder et al., 2007
Protein content	Similar content	Camerini et al., 2011
Protein quality	Higher in organic	Woëse et al., 1997
Protein quality	Higher in organic	Worthington, 2001
Protein quality	Higher in organic	Tamm et al., 2009
Protein quality	Higher in organic	Heaton, 2001
Protein quality	Higher in organic	Magkos et al., 2003
Baking quality	Worse in organic	Heaton, 2001
Baking quality	Worse in organic	Mazzoncini et al., 2007
Baking quality	Similar content	Mäder et al., 2007
Organoleptic properties	Better in organic	Mazzoncini et al., 2007

total sugars and mineral components in organic plant products, but due to the limited number and variable results of the studies it is difficult to make general conclusions.

It can be concluded that organic grains have a lower amount, but a higher quality of proteins compared to conventional grains. The limited number of studies and different results prevent any general conclusions regarding the phenolic compounds, amino acids and mineral concentration of organically and conventionally grown cereals.

Due to increasing anthropogenic environmental pollution, more and more people suffer from so called lifestyle diseases, which include, e.g. allergies, diabetes, obesity, atherosclerosis, cancer. However, one of the reasons for the development of lifestyle diseases is also improper lifestyle and unhealthy eating habits. In addition, the nutritional value of food continues to deteriorate. For best results, adherence to a healthy diet should be linked with the consumption of food with the highest quality. Most of the studies show certain higher quality parameters of organic products compared to conventional ones and this indicates that organic produce may significantly contribute to the promotion of health.

4. NUTRITIONAL VALUE OF ORGANIC vs. CONVENTIONAL ANIMAL PRODUCTS

MILK

Milk and dairy products, due to their high dietary value, play a very important role in human nutrition. Unfortunately, their consumption by residents of developed countries has decreased over the last few years (Haug et al., 2004), mainly due to the numerous reports on the harmful effects of milk on human health. This is because it contains large amounts of saturated fatty acids, contributing to obesity and heart diseases (Pfeuffer and Schrezenmeir, 2000; Michalski, 2007). The reference to these publications should be made with caution, however, because milk is also a valuable source of bioactive substances that play a beneficial role in the fight against atherosclerosis, hypertension and diabetes (Severin and Wenshui, 2005; Palmquist et al., 2006). Consumption of milk and its products is therefore a prophylactic measure against lifestyle diseases. Differences in researchers' opinions on its impact on the human body primarily result from differentiation of the market milk quality in terms of the content of biologically active compounds. These are their amounts and proportions which determine the value of the raw material.

The quality and composition of milk are influenced by several factors (Fennema, 1996). First of all, there is genetic predisposition, such as animal species and their breeds. Currently, different breeds of cattle are mainly the result of selection made by human, aiming at the target use of such an animal as well as adaptation to local conditions. This has led to a very wide diversity in terms of milk yield and composition. However, for the last 100 years the selection has led to a reduction of variation between the characteristics of milk from different breeds of cattle. Individual deviations may be also grater within one breed than between individuals of different breeds.

The second group of factors is physiological aspects. The most important among them is the stage of lactation as well as the age of the animal. The content of many components of milk slightly decreases along with the cow's age. Factors, such as oestrous or pregnancy, do not affect the composition of milk; what depends on them is only milk yield of a cow in that state.

Properties of milk are mainly conditioned by environmental factors

(Ng-Kwai-Hang et al., 1984). Among them, a nutrition method is essential, since it affects the content of fat, especially its composition. Climatic conditions are of little impact unless they are extreme and may cause animal stress. In addition, milking practice may involve changes in many ways in the composition of milk. The shorter the milking interval, the lower the cow's productivity, and the milk contains more fat (Weiss et al., 2002). Therefore, milk from the evening milking is fattier than from the morning one (Quist et al., 2008).

Organic milk has an advantage over conventional milk in terms of nutrient content during the season of pasture grazing, and throughout the year it has a greater security for consumers (Butler et al., 2008). One of the reasons is the ban of the use of synthetic pesticides in organic farming. In conventional milk production the use of over a thousand different pesticides is permitted for the plant protection. Research conducted by the USDA (United States Department of Agriculture) has detected the presence of pyrethroid pesticides in 27% of conventional milk samples and among organic samples, only one sample has a low content of these substances (Benbrook, 2005). In conventional farms the antibiotics are often routinely and prophylactically given to animals. The question of the impact of antibiotic use in conventional cows' husbandry on the increase in the resistance of the human body to these measures is being discussed. In certified organic farms such practices are prohibited. The use of synthetic hormones and genetically modified ingredients in feed is also not allowed in the organic system. The analysis of heavy metals in both types of milk showed no differences between them, detecting low contamination of all samples (Gabryszuk et al., 2008).

The chemical composition of milk is an indicator of quality, not only for its consumers, but also for processors. High protein content is important in the production of cheese, while high fat content is essential in butter manufacturing. Beta-carotene increases the intensity of butter colour, so it is also considered in the assessment of technological quality. For many dairy products, an important role is played by the antioxidant level, which avoids undesirable losses caused by excessive oxidation of fats (Abrahamsen et al., 2008). The degree of saturation of fatty acids, in turn, affects the hardness, texture and flavour of dairy products, especially cheese and butter (Chen et al., 2004). The presence of long chain saturated fatty acids increases the hardness of butter, while the milk with a high content of unsaturated fatty acids gives softer products (e.g., better spreadability of butter) (Butler et al., 2008).

Milk obtained from organic farms represents about 2% of total milk production in the EU (Agra Europe, 2007). A strong demand for such milk is also observed in the United States (Hale, 2006).

Dry matter and proteins

The dry matter of milk mainly consists of proteins and peptides. The largest share (80%) among these compounds belongs to casein, which is responsible for clot formation, making it possible to digest milk in the stomach and to transfer phosphorus and calcium (Haug et al., 2007). They also regulate blood pressure, have anticoagulation, hypnotic, immunomodulatory and anti-bacterial effects (Kitts, 2005). Whey proteins are considered to be the second largest fraction of proteins, important in a human diet due to the immunostimulatory (Korhonen et al., 2000), anticancer (Parodi, 2007), antioxidant (Pihlanto, 2006) and bacteriostatic activities (Kitts, 2005).

So far, several studies have compared the quality of milk from different production systems (table 8, pp. 56–57). Zadoks (1989) and Lund (1991) found in their studies that organic milk contains more dry matter, while Guinot-Thomas et al. (1991) reported this concentration comparable in both systems. For protein content, results of the studies have been also variable – the majority of the studies have shown the decreased content of protein in organic milk compared with conventional (Guinot-Thomas et al., 1991; Luukkonen et al., 2005; Roesch et al., 2005; Słoniewski et al., 2005). However, Lund (1991) showed higher content of proteins in organic milk and Zadoks (1989) found no differences between the systems.

Fatty acids

Dietary milk fats, on account of their higher content of saturated fatty acids (SFA), have long been associated with a variety of human diseases (Parodi, 1977), such as atherosclerosis and increased levels of blood cholesterol, which contributes to cardiovascular diseases (Pfeuffer and Schrezenmeir, 2000). However, recent studies have focussed on the healthy components of milk fats (Parodi, 1977). In terms of fat content, cow's milk is very variable. The fraction is made up of approximately 95% of triacylglycerols, composed of fatty acids, whose chain length and saturation degree condition the nutritional value of milk fat. Among the unsaturated fatty acids, omega-3 polyunsaturated fatty acids (PUFA) have beneficial effects on the human body. They positively impact the nervous system as well as reduce the risk of diabetes and cardiovascular diseases (Horrobin, 1993; Hu et al., 1999). The proportion between the amount of omega-3 and omega-6 fatty acids is also important. If the acid content of the latter group is too high, it causes an increase in the risk of inflammation, thrombosis and autoimmune symptoms.

Among the n-3 (omega-3) fatty acids, the most important is alpha-linolenic acid (LNA), whereas among the n-6 (omega-6) fatty acids linoleic acid (LA) occurs in the largest quantities. As for monounsaturated fatty acids (MUFA), there should be mentioned oleic acid, which is about one quarter of the total mass of fatty acids. It acts protectively towards the omega-3 and omega-6 fatty acids, preventing them from oxidation, as well as lowering cholesterol level and has anticancer effects (Ip, 1997; Kris-Etherton et al., 1999; Mensink et al., 2003).

An important part in the composition of cow's milk is occupied by conjugated linoleic acid (CLA). The cow's milk is the main source of the compound isomers in the human diet (Haug et al., 2004). The most important of them (representing approximately 90% CLA) is cis-9 trans-11 isomer, because it prevents the development of tumours, heart diseases, and stimulates the immune system (Whigham et al., 2000). It is called rumenic acid, since the rumen is where it is synthesised from linoleic acid. Other CLA isomers (trans-7 cis-9, trans-10 cis-12 and trans-9 cis-11) counteract obesity (by reducing fat and increasing muscle mass) and help to treat diabetes (Taylor and Zahradka, 2004). The content of CLA in milk fat is affected by a number of factors. First of all, it is the feed animals are fed with (Parodi, 1999), then seasonal variations (Parodi, 1977), endogenous synthesis from trans-vaccenic acid (TVA) (Griinari et al., 2000) and free-radical oxidation of linoleic acid (LA) during processing (Ha et al., 1989).

The differences in the composition of fatty acids have been analysed by several authors. In accordance with the results of the studies by Ellis et al. (2006), organic milk was characterized by a significantly higher content of polyunsaturated fatty acids (PUFA), including omega-3 acids (the difference with respect to conventional milk was over 60%). The ratio of omega-6 : omega-3 acids was therefore lower, i.e. more beneficial from a health point of view; there was also a greater amount of polyunsaturated fatty acids compared to monounsaturated ones. Butler and Leifert (2009) also arrived at such conclusions, on the basis of the studies conducted in Western Europe. In addition to the conclusions mentioned above, they stated that the value of the omega-6 : omega-3 ratio in organic milk does not exceed 1.25, while in conventional milk it is not less than 2.5.

Factors associated with the feeding of cattle, and particularly the content of pasture green forage in the feed, are most likely responsible for differences in the proportions of fatty acids contained in milk. Dewhurst et al. (2003) demonstrated that the content of desirable unsaturated fatty acids in organic milk was higher by ⅔ compared to its conventional counterpart.

Collomb et al. (2008) compared the quality of the milk of cows from organic and integrated husbandry in Switzerland. Samples from the two production systems did not differ significantly in terms of content of SFA and trans fats. The organic milk, however, contained higher levels of PUFA (including omega-3 acids), branched chain fatty acids and CLA. The higher contents of MUFA and omega-6 acids were found in the conventional milk. These differences are thought to result from the increased share of grass and lower content of cereal mixtures in organic feed.

Qualitative changes in milk, resulting from the use of the organic production system, are also manifest in the concentration of CLA (Bergamo et al., 2003; Szente et al., 2006). The studies by Butler et al. (2008) showed that its amount may be higher by up to 60% compared to its content in non-organic milk. Several other studies have confirmed an increased level of CLA in organic cow's and buffalo's milk and dairy products (Chin et al., 1992; Lin et al., 1995; Jahreis et al., 1997; Prandini et al., 2001; Słoniewski et al., 2005). As in previous studies, this difference is explained by the greater share of grazing and roughage in the feed ration (Collomb et al., 2008). However, there are studies that have not shown any differences in CLA between milk from different production systems (Toledo et al., 2002; Nielsen et al., 2004; Ellis et al., 2006), and therefore it is important to conduct further and more accurate studies, consistent with the needs of the consumer.

The fatty acid profile in organic and conventional cow´s milk was compared in Estonia (Skvortsova et al., 2008). The results of the study showed that composition of fatty acids varied between production systems. Organic milk contained more omega-3 acid and CLA, but less omega-6 acids than conventional milk. The ratio of omega-6:omega-3 was in favour of organic milk. The authors concluded that the composition of fatty acids in milk depends greatly on the nutrition of animals, as well as on season and breed.

Vitamins

Milk contains also other healthy components for the human body, such as beta-carotene, vitamins A, D (Parodi, 1999), and vitamins E and C (Lindmark-Mansson and Akesson, 2000). The presence of vitamins A, D and beta-carotene is significant for a consumer, while they have an anticancer potential (Van Poppel, 1993; Parodi, 1999). Vitamins C and E act as antioxidants (Lindmark-Mansson and Akesson, 2000), vitamin E prevents the development of tumours and cardiovascular diseases (Meydani, 2000).

Bergamo et al. (2003) was first to investigate the differences between the contents of fat-soluble vitamins in dairy products from organic and conventional production. These studies showed higher contents of alpha-tocopherol (TH; vitamin E form), CLA, linolenic acid (omega-3 acid), beta-carotene in organic buffalo milk and mozzarella cheese (figure 12). The ratio of CLA/LA and the content of trans-vaccenic acid (TVA) were about twice as high in organic samples. However, in the milk and cheese from conventional production, higher levels of retinol (vitamin A form) and linoleic acid (omega-6 acid) were found. Total fat content was similar in both systems.

This study reveals that changes in the production of milk and its products do not change its total fat content, but substantially affect the proportions of its components. An important factor, which enables distinguishing products from different systems, is the ratio of CLA/LA whose values turned out to be radically different depending on the product's origin. It can therefore serve as a reliable indicator for the identification of milk and its products from the organic production system.

Antioxidants, especially vitamin E and carotenoids, represent another argument for the consumption of milk from organic production. Their contents, found in organic cows' milk, were higher, which again results from the fact that

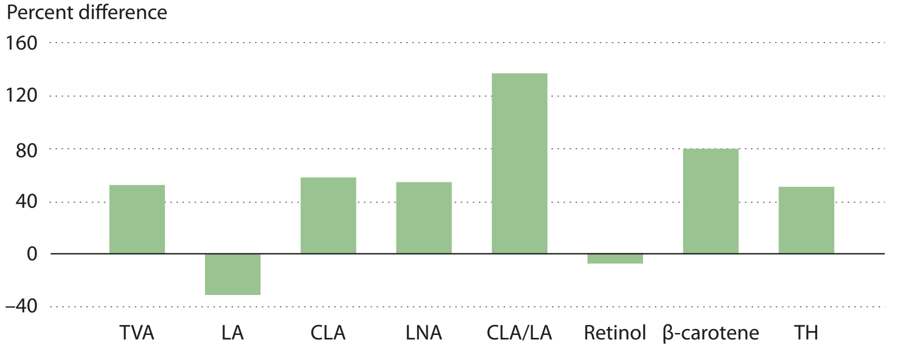

Figure 12. Mean percent of fatty acid, CLA/LA ratio and fat-soluble vitamin content in organic compared to conventional products. The percent differences of individual fatty acids (TVA, LA, CLA, C18:3), fat-soluble vitamin concentrations (TH, retinol, β-carotene) and CLA/LA level between organic and conventional products were computed (organic value–conventional value/conventional value×100) and used to evaluate which of the measured parameters best characterised organic milk fat (Bergamo et al., 2003).

feeding of these cows is based on green pasture forage (Nielsen et al., 2004; Butler et al., 2008). This is confirmed by the results of research conducted under the QLIF program (Quality Low Input Food), according to which the level of antioxidants in organic milk was almost double compared to conventional milk (QLIF, 2008). As far as vitamin C is concerned, Lund (1991) found its higher level in organic milk compared to conventional.

Differences in the contents of individual vitamins have not been clearly ascertained. Swedish studies (Emanuelson and Fall, 2007), which included winter feeding of organic and conventional herds, showed no significant differences in the amount of vitamins contained in cow's milk. The experiment, however, was based on very similar feed rations (a mixture of clover and grass with large quantities of concentrated feed), which resulted in similar performance in both groups. Bergamo et al. (2003) and Butler et al. (2008) found differences in the amount of fat-soluble vitamins, but they resulted from the use of grazing pasture, which took place in organic and extensive farming, in contrast to the conventional system. This comparison does not concern as much farming systems as the method of feeding the animals.

Minerals

Milk is the main source of calcium in the human diet. This element is an essential factor for the proper functioning of the skeletal system, prevention of hypertension and formation of kidney stones and breast and colon tumours (McDowell, 2003). In addition, milk contains large quantities of magnesium, which prevents arteriosclerosis, oxidative stress and renal diseases. Milk is also an important source of the microelements, zinc, iodine and selenium.

Organic production prohibits of the use of conventional mineral supplements, making the content of these components generally higher in conventional milk. The studies by Coonan et al. (2002), indicating a shortage of copper, selenium, zinc, iodine and molybdenum in organic milk. Hermansen et al., (2005) reported lower levels of Ba, Eu, Mn and Zn in organic than conventional milk. Guinot-Thomas et al. (1991) found in their study that content of Ca, K, Fe, Cu is comparable in both systems and content of Zn, N is lower in organic than in conventional milk. However, some studies found higher calcium content (Zadoks, 1989; Lund, 1991) and higher molybdenum content (Hermansen et al., 2005) in organic milk.

Somatic cells and microbiological quality

A good indicator of the quality of milk, as well as an indicator of health of cows, is somatic cell count – SCC. A high count indicates the presence of udder inflammation and lower milk quality. The study results in terms of somatic cell count in milk from organic production are varied. Studies conducted in Denmark showed no differences in this respect between conventional and organic milk whereby the longer the cows were reared in an organic system the lower the SCC indicator was (Bennedsgaard et al., 2003). Norwegian studies (Hardeng and Edge, 2001) also showed no differences in the SCC, but in the organic herd there were less frequent udder inflammations. In turn, the studies by Tikofsky et al. (2003), conducted in New York, by Toledo et al. (2002) and Sato et al. (2005) showed that milk from organic cows contained fewer somatic cells compared to conventional herds. It is believed that lower milk productivity of organic cows can result in less frequent occurrence of mastitis, because the frequency of metabolic disorders, such as ketosis and milk fever, is much lower in organic herds (Vaarst and Enevoldsen, 1997; Hardeng and Edge, 2001). In contrast, the results of the studies of Luukkonen et al. (2005), Roesch et al. (2005), Ellis et al. (2006) and Nauta et al. (2006) showed a higher somatic cell count in organic milk.

Karwowska (1999) conducted a study of microbiological quality of milk from Polish organic and conventional farms. She recorded the number of bacteria of greatest concern to consumers. The experience showed that the most pathogenic groups of bacteria: *Streptococcus agalactiae* (causing loss of cows' milk) and *Streptococcus aureus* (responsible for milk coagulation) occurred in greater amounts in conventional milk. However, conventional milk contained the lower number of *E. coli* and *Neisseria* sp. (Karwowska, 1999).

The comparisons of microbiological indicators in milk samples from both production systems were also made in the Netherlands (Zadoks, 1989). The milk of cows from conventional husbandry contained significantly higher amounts of the bacteria resistant to high temperatures, butyric acid bacteria, aerobic bacteria and the bacteria responsible for mastitis (*Mastitis streptococci*). However, organic milk contained significantly higher amounts of coli group bacteria, which may indicate the risk of other pathogenic bacteria.

Sensory quality

Studies of the sensory quality of milk clearly show the advantage of conventional milk. The research by Zadoks (1989) confirms this fact, showing a greater raw material acceptability among consumers. A specific odour of cow's milk is primarily responsible for this assessment – it is much more intense in the case of organic milk. Modern consumers are not accustomed to such properties, preferring 'carton' milk of neutral smell, commonly available on the market. Currently, there is also a tendency to consume milk with reduced fat content. Some studies show that organic milk tends to have a higher fat percentage (Zadoks, 1989; Lund, 1991; Ellis et al., 2006), which considering the fact that fat is the main carrier of flavour significantly affects its organoleptic characteristics. However, some studies have demonstrated a decreased fat content in organic milk (Luukkonen et al., 2005; Roesch et al., 2005; Słoniewski et al., 2005) or no differences between production systems (Guinot-Thomas et al., 1991; Bergamo et al., 2003).

Conclusions

Organic milk has a beneficial fatty acid composition (including a high content of CLA and omega-3 acids), high levels of vitamins and antioxidants, acting as an important part of human health prophylaxis. In most studies, organic milk has a better ratio of omega-6:omega-3 and the ratio of CLA/LA, which may serve as a reliable indicator, allowing the identification of the raw material origin.

Due to the ban on the use of mineral supplements and fertilizers in organic farming, milk from such production may be deficient in specific macro-and microelements. The milk of animals from the organic system is worse assessed by consumers due to the specific organoleptic characteristics, especially the odour.

Table 8. The comparison of selected quality indicators of organic and conventional milk

Indicators	Results	Author
Dry matter	Higher in ORG milk	Zadoks, 1989
	Higher in ORG milk	Lund, 1991
	Similar content	Guinot-Thomas et al., 1991
Protein	Higher in ORG milk	Lund, 1991
	Lower in ORG milk	Guinot-Thomas et al., 1991
	Lower in ORG milk	Luukkonen et al., 2005
	Lower in ORG milk	Roesch et al., 2005
	Lower in ORG milk	Słoniewski et al., 2005
	Similar content	Zadoks, 1989
Total fat	Higher in ORG milk	Zadoks, 1989
	Higher in ORG milk	Lund, 1991
	Higher in ORG milk	Ellis et al., 2006
	Lower in ORG milk	Luukkonen et al., 2005
	Lower in ORG milk	Roesch et al., 2005
	Lower in ORG milk	Słoniewski et al., 2005
	Similar content	Guinot-Thomas et al., 1991
	Similar content	Bergamo et al., 2003
Fatty acids	Higher level of CLA in ORG milk	Jahreis et al., 1997
	Higher level of CLA in ORG milk	Bergamo et al., 2003
	Higher level of CLA in ORG milk	Słoniewski et al., 2005
	Higher level of CLA in ORG milk	Butler et al., 2008
	Higher level of CLA in ORG milk	Lin et al., 1995
	Higher level of CLA in ORG milk	Chin et al., 1992
	Higher level of CLA in ORG milk	Prandini et al., 2001
	Higher level of CLA in ORG milk	Skvortsova et al., 2008
	Similar content of CLA	Nielsen et al., 2004
	Similar content of CLA	Ellis et al., 2006
	Similar content of CLA	Toledo et al., 2002
	Higher CLA/LA ration in ORG milk	Bergamo et al., 2003
	Higher level of PUFA in ORG milk	Dewhurst et al., 2003
	Higher level of PUFA in ORG milk	Słoniewski et al., 2005
	Higher level of PUFA in ORG milk	Ellis et al., 2006
	Higher level of n-3 acid in ORG milk	Bergamo et al., 2003
	Higher level of n-3 acid in ORG milk	Skvortsova et al., 2008
	Higher level of n-3 acid in ORG milk	Butler and Leifert, 2009
	Ratio n-6:n-3 lower in ORG milk	Butler and Leifert, 2009
	Ratio n-6:n-3 lower in ORG milk	Ellis et al., 2006
	Ratio n-6:n-3 lower in ORG milk	Skvortsova et al., 2008
	Lower level of SFA and MUFA, in ORG milk	Słoniewski et al., 2005
	Lower level of MUFA in ORG milk	Ellis et al., 2006
	Lower level of n-6 acid in ORG milk	Bergamo et al., 2003
	Lower level of n-6 in ORG milk	Skvortsova et al., 2008
	Higher level of trans-vaccenic acid in ORG milk	Bergamo et al., 2003

Continued

Table 8. *Continued*

Indicators	Results	Author
Minerals		
Ca	Higher level in ORG milk	Zadoks, 1989
Ca	Higher level in ORG milk	Lund, 1991
Ca, K, Fe, Cu	Similar content	Guinot-Thomas et al., 1991
Mo	Higher level in ORG milk	Hermansen et al., 2005
Zn, N	Lower level in ORG milk	Guinot-Thomas et al., 1991
Cu, Se, Zn, I, Mo	Lower level in ORG milk	Coonan et al., 2002
Ba, Eu, Mn, Zn	Lower level in ORG milk	Hermansen et al., 2005
Vitamins		
Alpha-tocopherol (vitamin E form)	Higher level in ORG milk	Bergamo et al., 2003
Alpha-tocopherol (vitamin E form)	Higher level in ORG milk	Butler et al., 2008
Vitamin E	Higher level in ORG milk in case of natural isomers, lower level in case of synthetic isomers	Nielsen et al., 2004
Vitamin C	Higher level in ORG milk	Lund, 1991
Retinol (vitamin A form)	Lower level in ORG milk	Bergamo et al., 2003
Carotenoids	Higher level in ORG milk	Nielsen et al., 2004
Carotenoids	Higher level in ORG milk	Butler et al., 2008
Beta-carotene	Higher level in ORG milk	Bergamo et al., 2003
Content of vitamins	Similar content in winter season	Emanuelson and Fall, 2007
Somatic cells	Lower level in ORG milk	Tikofsky et al., 2003
	Lower level in ORG milk	Toledo et al., 2002
	Lower level in ORG milk	Sato et al., 2005
	Higher level in ORG milk	Ellis et al., 2006
	Higher level in ORG milk	Nauta et al., 2006
	Higher level in ORG milk	Luukkonen et al., 2005
	Higher level in ORG milk	Roesch et al., 2005
	Similar content	Bennedsgaard et al., 2002
	Similar content	Hardeng and Edge, 2001
Microbiological quality	Lower counts of bacteria in ORG milk	Zadoks, 1989
	Higher content of Coli bacteria in ORG milk	Zadoks, 1989
	Lower number of *Streptococcus agalactiae* and *Streptococcus aureus* in ORG milk	Karwowska, 1999
	Higher number of E. *coli* and *Neisseria* sp. in ORG milk	Karwowska, 1999
Sensory profile	Lower acceptability of ORG milk	Zadoks, 1989

ORG – organic milk;
PUFA – polyunsaturated fatty acids;
CLA – conjugated linoleic acid;
n-6 – omega-6 fatty acids
MUFA – monounsaturated fatty acids;
SFA – saturated fatty acids;
n-3 – omega-3 fatty acids;

Analyzing the quoted results, it can be concluded that the biological value of milk to the greatest extent is conditioned by feeding the animals. Better properties – from a dietary point of view – are typical of the milk of animals grazed on pasture and fed with fresh green feed. The use of preserved roughage and concentrated feed results in lower levels of ingredients beneficial to consumers' health. Therefore, there should be emphasised a distinct advantage of organic and extensive farms, which promote pastoral grazing and less reduced feeding of concentrate. This conclusion is confirmed by the fact that the differences in the nutritional quality of milk from different production systems are much less pronounced during winter (Butler et al., 2008), when cows do not graze in any system and feed rations are similar. This has been shown by Butler and Leifert (2009), and Rosati and Aumaitre (2004), who point out that reliable comparative studies of the quality of milk from different production systems should take into account the feeding season (grazing or cowshed feeding) and the composition of the feed ration. Ignoring these circumstances, the authors of studies conducted in different countries and different periods can achieve contradictory results.

MEAT

Standards for organic livestock husbandry and its control method are of the legal provision rank. Currently, within this scope, in the European Union there are regulations included in the overall Council Regulation (EC) No 834/2007 as of 28 June 2007 on organic production, labelling of organic products, and in the detailed Commission Regulation (EC) No. 889/2008 as of 5 September 2008 laying down detailed principles for implementing Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. Principles of organic livestock husbandry relate to their welfare (density in a farm unit and access to an outdoor run, the presence of natural bedding, possibility of movement), feeding (use of organic feed, ban on synthetic additives), animal breeding and maintenance conditions (selection of breed, compliance with the age of weaning and slaughter). In addition, organic livestock production is carried out without the use of antibiotics (except to save the animal's life and the absence of other therapeutic agents), hormones, genetically modified organisms and their products. Feed is produced according to standards for organic crop production, in which, instead of pesticides and synthetic fertilizers, natural organic fertilizers (compost, manure), green manures and biological plant protection products are used. Processing of organic raw materials is carried out by using methods that protect their nutritional value, without the use of artificial preservatives, colourings and other additives.

According to data collected by Napolitano et al. (2009), the share of beef cattle from organic farming in the total stock within the European Union is 1.7% and amounts to approximately 1 million units (the most abundant stocks are in Austria and Italy). In the case of pigs, this share is much lower (0.4%), ca. 450 thousand, with the highest occurrence in Germany and France. Goats and sheep are the most represented group of animals in organic livestock production, as their share in the total stock within the EU is 2.4% with 2.4 million units.

Demand for organic meat among inhabitants of the European Union still exceeds supply. This situation is borne by high legal requirements placed on organic farms, which farmers have to adapt to. These requirements entail high financial outlays and difficulties that are not quite as onerous as in the case of crop production. The other reason is the small number of certified slaughterhouses, and therefore the processing of organic meat is limited.

For a modern consumer, who has a developed organic awareness, a basic discriminant of valuable food products is quality. This term has a complex nature as a sum of many factors. First of all, it is health safety specified by hygienic and toxicological indicators (content of environmental impurities, mycotoxins, bacteria and parasites). This is especially important for consumers, whose confidence in the sector of the food industry in recent years has been strained by crises. There are also other aspects like sensory discriminants (taste, smell, colour, and tenderness), physiological and nutritional parameters, and technological features of meat (Andersen, 2000; Cooper et al., 2007). The meat quality is conditioned by such factors as type of feed for animals, animal husbandry system (including a physical activity), breed, age and sex of animals as well as the course of post-slaughter activities (bleeding out, steaming and cooling of carcasses) (Troy, 1995; Kerry et al., 2000).

Beef

Ruminant meat is especially valuable, since numerous studies have shown that the ratio of polyunsaturated fatty acids n-6:n-3 (omega-6:omega-3) is much lower compared to other kinds of meat. The composition of fatty acids is a very important factor conditioning a nutritional value. Originally, meat consumed by man was naturally rich in n-3 acids, which are beneficial in terms of anti-inflammatory properties, reducing the risk of heart attack (Bucher et al., 2002), breast, prostate and colorectal cancer (Deckere, 1999; Augustsson et al., 2003).

However, in the past, the content of n-6 acids (increasing the risk of atherosclerosis lesions and development of cancerous lesions) was lower than in currently available meat of breeding animals. In a human diet, the proportion of n-6:n-3 acids amounted to approx. 1:1. Nowadays, due to industrial production of animal feed (based on numerous grains including n-6 acids), the proportion may come to 1:30 (Berrisch-Hempen, 1995). N-6 fatty acids appear in quantities significantly higher than n-3 acids (Enser et al., 1998).

Studies by Pastushenko et al. (2000) showed a lower concentration of saturated fatty acids (22.4%) in organic beef compared to conventional beef (40%). In the meat of animals fed with their mother's milk, and then pastured and hay-fed in winter, there was found a lower content of saturated fatty acids compared to the meat of heifers fed with a milk-substitute mix, feed concentrates and small amounts of hay.

In ruminant meat from organic farms the proportion of n-6:n-3, however, is much more favourable. It results from a high concentration of linolenic acid (omega-3), the high content of which can be found in grass (Wood et al., 1999 and 2003). This has been confirmed by the results of the studies by Marmer et al. (1984) and Matthesa and Pastushenko (1999), when a diet of animals was switched from a pasture system into grain mix. These changes caused a decrease in the content of polyunsaturated fatty acids (in particular linolenic acid) and consequently increase in the ratio of acids n-6:n-3.

Walshe et al. (2006) compared bull meat from organic and conventional farming. Organic meat samples were characterised by a considerably higher content of fat and consequently lower moisture than conventional ones. However, there were no significant differences observed between both kinds of meat in terms of the content of proteins, ash, beta-carotene, alpha-tocopherol, retinol as well as the content of fatty acids. However, the conventional meat showed a better storage quality, since its samples had better colour and lipid stability during storage compared to the organic meat samples. It probably results from the fact that organic bull meat included more fat, which caused more intensive oxidation of the samples.

Fat is the main carrier of flavour, so that differences in sensory evaluation of organic and conventional beef are mainly caused by different fatty acid composition. This evaluation is also influenced by the content of intramuscular fat (so called marbling of meat) and total fat which was higher in organic beef in the study of Woodward and Fernandez (1999). However, Fisher et al. (2000) and Hansson et al. (2000) found lower content of total fat in organic beef.

Pork

Recently the interest in pork from organic farms has been growing – especially in England, Germany and Denmark (Hamm and Gronefeld, 2004). However, there has been stated a great discrepancy within the quality of the meat obtained, the responsibility of which was borne by differentiation of feed admitted within the organic system, species changeability and slaughter methods. In this connection there were undertaken some efforts to define optimum husbandry conditions (under the guidelines by the International Federation of Organic Agriculture Movements), which would allow increasing capacity and maintainence of a high meat quality (Guy and Edwards, 2002).

An organoleptic assessment of pork – as in beef – is largely influenced by the content of intramuscular fat (Fernandez et al., 1999). However, the results of the studies, comparing swine carcasses from organic and conventional farms, are ambiguous. Hansen et al. (2006) showed that animals from both systems reached a similar mass, presented a similar fat-free body mass and content of intramuscular fat. Bee et al. (2004) reported different results, according to which fat-free body mass was higher in organic meat. Similarly, to Bee et al. (2004), in the studies of Sundrum et al. (2000; 2003) and Millet et al. (2004), fat-free body mass and marbling level of organic meat was higher. However, drawing conclusions is hindered by the fact that the animals in the above studies were fed differently. The experiment by Hansen et al. (2006) was based on organic feed, including 70% of concentrates and 30% of silage. In the experiments by Sundrum et al. (2000 and 2003) and Millet et al. (2004) the diet of animals from organic farms was more diverse, since it contained grains of wheat, barley, broad bean, pea and lupine, the share of concentrates in feed was small. It allows us to believe that a diet composition is responsible for the content of intramuscular fat of pork. However, the study by Olsson et al. (2003) found a lower content of intramuscular fat and lower fat-free body mass and higher content of total fat in the case of organic animals. It is believed that appropriate selection of animal breeds, adapted to local conditions, should sort out the problem of lower daily mass gains, which is being observed in the case of organic pigs.

The results of the studies indicate an advantage of organic pork in terms of a high level of polyunsaturated fatty acids and a lower content of saturated ones (Hansen et al., 2000; Nilzen et al., 2001; Hansen et al., 2006; Kim et al., 2009).

In terms of the technological quality of organic pork, the research findings are not consistent. According to Olsson et al. (2003), organic pork has a lower water holding capacity and a greater shear strength, which makes it more difficult to process. However, completely different results were obtained by Kim et al. (2009) whose studies showed organic pork to have a higher water holding capacity and lower shear strength.

Poultry

Castellini et al. (2002) and Combes et al. (2003a) analysed quality parameters of poultry from organic and conventional farms. The first study concerned a comparison of chicken meat. In organic farming, broilers had access to the outside, whereas in the conventional system they were raised in cages. Feed for organic chickens consisted of organic raw materials. Lower mass gains and lower post-slaughter mass from the breast and thigh meat were found with respect to organic chickens. But their meat was characterized by lower abdominal fat and higher levels of iron. In the researchers' opinion, the lower total body mass and lower mass gains of the organic chickens were caused by their greater activity (confirmed by the behavioural observations) and larger energy expenditures related to thermoregulation. Analyses of the chemical composition of poultry from both production systems showed a higher content of saturated and polyunsaturated fatty acids as well as lower content of monounsaturated ones in the organic meat. Significant differences were found especially in the amount of n-3 acids, including docosahexaenoic acid (DHA), the level of which was twice higher in organic than in conventional chicken meat. Most likely, this is caused by the grass present in the animals' diet.

Lower pH values and poorer organic poultry capacity for water-binding were linked to greater losses while cooking. The above mentioned dependence between a farming method and meat pH was not confirmed by the studies of Combes et al. (2003a). However, in both experiments a lower content of total fat in organic was found , which attests its higher nutritional value (Castellini et al., 2002; Combes et al., 2003a).

A study where a sensory panel had taken part revealed that the organic chicken breast meat was juicier, and generally tasted better than the meat from the same part of conventional chickens.

Mutton and lamb

Fisher et al. (2000) stated that both organic and conventional farming can give a similar slaughter yield, but that organic mutton has better quality properties. Mutton showed similar proportions of fatty acids as beef, in favour of organic meat; higher content of intramuscular fat and lower content of total fat. Three sheep breeds were submitted to the study (Welsh Mountain, Soyas and Suffolk), which showed that appropriate breed selection is responsible for gaining desirable yield.

Angood et al. (2008) compared the composition of fatty acids and a nutritional quality of organic and conventional lamb, offered on the British market. The study presented significant differences, i.e., organic meat had a higher content of n-3 polyunsaturated fatty acids and showed a better nutritional quality in terms of juiciness, tastiness and general acceptability compared to the lamb available on the market. A greater juiciness resulted from a higher content of intramuscular fat in organic lamb chops. A greater tastiness, preferred by the British consumers, can be attributed to the difference in the fatty acids composition, in particular a higher content of linolenic acid (18:3) and total content of n-3 acids in organic meat chops (as a result of pasture feeding). Conventional meat contained more linoleic acid (18:2) (n-6 acid), which probably resulted from concentrate predominance in the diet. Both kinds of meat, however, showed a favourable proportion of n-6:n-3 acids (Angood et al., 2008).

Rabbit meat

The quality of rabbit meat is quite rarely brought up in analytical and sensory studies. Nevertheless, it is hard to understand, since – according to many authors (Combes, 2004; Dalle Zotte, 2004; Combes and Dalle Zotte, 2005; Hernández and Gondret, 2006) – rabbit meat shows great nutritional value than other kinds of meat. Due to the fact that there are many rabbit breeds as well as breeding methods, a reliable comparison of the meat quality of rabbits from organic and conventional farms is really complicated. That is why there are very few publications on this topic.

In the studies by Lebas et al. (2002), rabbits of the same age from both systems were slaughtered. The analysis showed a slightly higher ratio of the cooled carcass weight to the pre-slaughter weight, a more alkaline reaction of the muscles and a higher fat content of organic rabbits.

Combes et al. (2003a) compared organic and conventional meat of the rabbit of similar weight but different age. Carcass weight ratio to the weight of the rear carcass was higher, and the fat content was lower in organic rabbits; cooking losses were lowest in the limbs of the organic doe-rabbit, and highest in conventional rabbits; the amount of inter-tissue meat in the organic meat was lower. In further studies, Combes et al. (2003b) compared organic and conventional rabbits of similar weight but different age in terms of sensory quality. A trained sensory panel was able to distinguish, using the triangle test, organic meat from conventional one (83.3% of correct answers). Evaluation of the central part of the meat, conducted by the trained sensory panel, showed that organic rabbit meat was more tender than conventional meat. Raw meat of the hind limbs of organic rabbits had a higher caloric content, toughness and shear strength.

Pla et al. (2007) analysed a composition of fatty acids in rabbit meat from organic and conventional husbandry systems. Hind leg meat of organic rabbits contained a higher content of polyunsaturated fatty acids and a lower level of monounsaturated ones compared to the same parts of conventional animals. The concentration of saturated fatty acids turned out to be similar for both types of meat. From the nutritional point of view, the advantage belonged to organic rabbit meat, since the ratio of polyunsaturated to saturated fatty acids was higher. The above differences in chemical composition are explained by dissimilar production systems where a crucial role is most likely played by diet and age of slaughter (Pla et al., 2007), because the animal breeds were the same in both groups.

In following research, Pla (2008) compared organic and conventional rabbits of different slaughter age and weight, raised under the national standard in Spain. According to the author, the age differentiation did not have any impact on differences found in the case of organic vs. conventional carcasses for the following parameters: organic meat contained more polyunsaturated and n-6 and n-3 fatty acids, but less saturated and monounsaturated fatty acids. The indicator of polyunsaturated to saturated fatty acids was higher in organic meat which is preferable from a nutritional point of view. However, the proportion of n-6:n-3 fatty acids was higher in organic meat, and therefore it was less favourable considering the nutritional value. Organic rabbit meat included less protein and a lower content of total fat. Sensory studies showed lower intensity of anise and grassy flavours in organic meat, but higher intensity of hepatic flavour (which in the light of consumer preferences can be detrimental – but so far studies have shown that the taste of meat can be modified by proper selection of feed).

Table 9 shows summarized results of the studies comparing organic and conventional meat.

Conclusions

Meat from organic farms is characterized by positive quality properties, such as the favourable ratio of fatty acids – higher content of omega-3 and lower content of saturated fatty acids. Better sensory evaluation of organic meat is conditioned by a higher intramuscular fat content than in conventional meat.

A key factor influencing the content of bioactive substances in meat is animal feeding – the nutritional value of meat is much higher if fresh green pasture forage dominates the feed rations.

Table 9. The comparison of selected quality indicators of organic and conventional meat

Kind of meat	Indicators	Results	Author
Beef	Fatty acids	Higher level of n-3 in ORG meat Lower level of n-6 in ORG meat Lower level of SFA in ORG meat Lower level of MUFA in ORG meat	Pastushenko et al., 2000
	Fatty acids	Higher level of n-3 in ORG meat Lower level of n-6 in ORG meat	Enser et al., 1998
	Fatty acids	Higher level of n-3 in ORG meat	Marmer et al., 1984
	Fatty acids	Higher level of n-3 in ORG meat	Matthesa and Pastushenko, 1999
	Fatty acids	Similar content	Walshe et al., 2005
	Protein	Similar content	
	Beta-carotene	Similar content	
	Alpha-tocopherol (vitamin E)	Similar content	
	Retinol	Similar content	
	Ash	Similar content	
	Storage quality	Worse in case of ORG meat due to worse colour and lipid stability	
	Total fat	Higher in ORG meat	
	Total fat	Lower in ORG meat	Hansson et al., 2000
	Total fat	Higher in ORG meat	Woodward and Fernandez, 1999
	Intramuscular fat	Higher in ORG meat	
	Carcass mass	Lower in ORG system	
Pork	Fatty acids	Higher level of PUFA in ORG meat Lower level of SFA in ORG meat	Hansen et al., 2000
	Fatty acids	Higher level of PUFA in ORG meat Lower level of SFA in ORG meat	Hansen et al., 2006
	Fatty acids	Higher level of PUFA in ORG meat Lower level of SFA in ORG meat	Nilzen et al., 2001
	Fatty acids	Higher level of PUFA in ORG meat	Kim et al., 2009
	Fat-free body mass	Higher in ORG meat	Sundrum and Acosta, 2003
	Fat-free body mass	Higher in ORG meat	Sundrum et al, 2000
	Fat-free body mass	Higher in ORG meat	Bee et al., 2004
	Fat-free body mass	Similar content	Hansen et al., 2006
	Fat-free body mass	Lower in ORG meat	Olsson et al., 2003
	Total fat	Higher in ORG meat	Olsson et al., 2003
	Intramuscular fat	Higher in ORG meat	Sundrum and Acosta, 2003
	Intramuscular fat	Higher in ORG meat	Sundrum et al., 2000
	Intramuscular fat	Higher in ORG meat	Millet et al., 2004
	Intramuscular fat	Similar content	Hansen et al., 2006
	Intramuscular fat	Lower in ORG meat	Olsson et al., 2003
	Water holding capacity	Lower in ORG meat	Olsson et al., 2003
	Water holding capacity	Higher in ORG meat	Kim et al., 2009
	Carcass mass	Lower in ORG meat	Olsson et al., 2003

Continued

Table 9. *Continued*

Kind of meat	Indicators	Results	Author
Poultry	Fatty acids	Higher level of PUFA in ORG meat Higher level of SFA in ORG meat Lower level of MUFA in ORG meat Higher level of n-3 acid (in particular DHA) in ORG meat	Castellini et al., 2002; Combes et al., 2003ab
	Abdominal fat	Lower in ORG meat	
	Total fat	Lower in ORG meat	
	Iron	Higher in ORG meat	
	Meat pH	Lower in ORG meat	
	Mass gains	Lower in ORG system	
	Post-slaughter mass	Lower in ORG system	
Mutton and lamb	Fatty acids	Higher level of n-3 in ORG meat Lower level of n-6 in ORG meat	Fisher et al., 2000
	Fatty acids	Higher level of n-3 in ORG meat No differences in n-6:n-3 ratio	Angood et al., 2007
	Intramuscular fat	Higher in ORG meat	Fisher et al., 2000
	Total fat	Lower in ORG meat	Fisher et al., 2000
	Sensory profile	ORG meat preferred	Fisher et al., 2000
	Sensory profile	Greater juiciness, flavour and general acceptability of ORG meat	Angood et al., 2007
Rabbit meat	Fatty acids	Higher level of PUFA in ORG meat Lower level of MUFA in ORG meat Comparable SFA concentration Higher PUFA:SFA ratio in ORG meat	Pla et al., 2007
	Fatty acids	Higher level of n-6 and n-3 in ORG meat Higher PUFA:SFA ratio in ORG meat Higher n-6:n-3 ratio in ORG meat Lower level of SFA in ORG meat Lower level of MUFA in ORG meat	Pla, 2008
	Total fat	Lower for ORG rabbits	Pla, 2008
	Total fat	Lower for ORG rabbits	Combes et al., 2003ab
	Total fat	Higher for ORG rabbits	Lebas et al., 2002
	Protein	Lower for ORG rabbits More Met and Cys in ORG rabbit meat	Pla, 2008
	Meat pH	Higher for ORG rabbits	Lebas et al., 2002
	Carcass mass	Higher for ORG rabbits	Combes et al., 2003ab
	sensory profile	More hepatic flavour and less anise and grassy flavours of ORG meat	Pla, 2008
	Sensory profile	More tender meat of ORG rabbits	Combes et al., 2003ab

ORG – organic meat;
PUFA – polyunsaturated fatty acids;
n-3 – omega-3 fatty acid;
MUFA– monounsaturated fatty acids;
SFA – saturated fatty acids fatty acids;
n-6 – omega-6 fatty acid.

EGGS

Eggs have been important in the human diet for thousands of years. Over the years, eggs have become an essential ingredient in many cuisines, owning many functional properties, such as water holding, emulsifying, foaming. It can be stated that egg is an ideal source of nutrients containing many high quality functional nutrients, such fatty acids, essential amino acids, proteins, cholesterol, vitamins, minerals etc., for the human body (McNamara and Thesmar, 2005). The primary aim of the laying hen is not to produce high-value food for human but to give rise to new life. Therefore, avian eggs contain the basic elements for life, and many of the egg compounds have so-called biological activity. Consequently, hen eggs are very good potential sources of raw materials for health-promoting, so-called functional foods, as well as for the traditional food and pharmaceutical industries (Huopalahti et al., 2007).

Layers can be kept in different systems. The majority of egg production is carried out using a battery cage system, where layers live in cages and cannot move freely. In barn systems, the hens are not kept in cages, but have freedom and space to move around, stretch and exercise within a building. Free-range hens live in buildings similar to the barn system, but hens must always have access to an outside area with adequate vegetation during the daytime.

According to the Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control, organic poultry has specific housing requirements. Organic poultry must be kept in a free range system and fed only organic feed. Laying hens must have free access to the outdoors. Organic egg producers cannot use antibiotics except during an infectious outbreak.

Different systems vary in how the birds are housed, fed and managed. Many studies have investigated how different housing systems affect the quality of eggs. Some studies have shown that the nutrition and husbandry system of the hens may significantly affect the quality of eggs.

Fatty acids

The content of essential fatty acids (FA) in eggs is not genetically encoded but rather reflects the hen's fatty acid diet. About 20% of total fat is comprised of essential fatty acids. This ratio depends significantly on the composition of the feed. A study by Sindelar et al. (2004) indicated that the consumption of one omega-3 enriched egg elevated the serum levels of linolenic acid and triglycerides in humans. Particularly, omega-3 fatty acids mainly found in phospholipids, are considered to be an essential nutrient for brain function and visual acuity in humans (Maki et al., 2003).

Poupoulis et al. (2009) determined the FA composition of egg yolks from farms using conventional, organic, free-range and omega-3 supplemented feeding. Results showed that the farming system significantly influenced the polyunsaturated fatty acid content, total omega-3 and omega-6 fatty acids as well as the ratios of PUFA:SFA (polyunsaturated fatty acids:saturated fatty acids) and omega-6:omega-3 fatty acids. These researchers concluded that eggs produced with omega-3 supplemented feed had the best FA profile, followed by organic farms.

Results on this issue are not, however, completely consistent. Fatty acid composition of commercially available conventional, organic and omega-3 eggs was compared by Samman et al. (2009). Organic egg yolk contained a higher percentage of palmitic and stearic acids (SFA) than did conventional yolk. No differences were observed in MUFA and PUFA compositions between organic and conventional systems. Compared with organic and conventional eggs, omega-3 egg yolk contained lower percentages of myristic and palmitic acids and higher omega-3 fatty acids. The researchers concluded that the small differences in SFAs observed in the study were unlikely to have any significant health effects on the consumer.

Hidalgo et al. (2008), however, saw no differences in fatty acid composition among conventional caged, free range, barn or eggs produced organically. Similarly, no significant differences in the content of fatty acids were found by Estonian (Matt et al., 2009) and Italian (Rizzi et al., 2006) researchers on the impact of production system (organic and conventional) on the quality of chicken eggs.

The content and ratio of fatty acids depend on the composition of the feed (Seuss-Baum, 2007). It is unclear whether the rearing system affects the fatty acid composition in eggs, but it is evident that enrichment of the diet with fatty acids, increases the content of fatty acids in eggs.

Carotenoids

Carotenoids are the natural pigments of hen egg yolk. They confer its yellow color, which can go from a very pale yellow to a dark brilliant orange. Carotenoids represent less than 1% of yolk lipids. They are mainly carotene and xanthophylls (lutein, cryptoxanthin, and zeaxanthin). Carotene is the main carotenoid found in common hen feeds such as corn and alfalfa (Anton, 2007). Economically the color is important because it represents a quality criterion. Conventional egg producers make an effort to produce eggs whose yolk have rich yellow colour and therefore use feed supplementation (for example using synthetic xanthophylls).

Organic feed differs from conventional feed. Furthermore, inherent to the production system, free range and organic hens have the opportunity to forage in soils, picking up grubs, beetles, worms, grasses, and seeds as well as their commercial ration in mash or pellet form. Enhancement of feed with particular carotenoids in certain production systems may also affect egg composition.

In a recent study by Ruth et al. (2011) the carotenoid profiling in organic and conventional eggs was compared. Statistical tests revealed insufficient variation in concentration of carotenoids to separate the organic, free range, and barn eggs into three groups. Organic eggs differed significantly from the other two for a number of carotenoids. Significantly higher concentrations of lutein, zeaxanthin, and significant lower relative concentrations of canthaxanthin were determined in organic eggs in comparison with non-organic eggs. The results are in agreement with the study of Schlatterer and Breithaupt (2006) which revealed increased lutein concentrations in organic eggs compared to conventional eggs. When comparing free range and barn only, without considering the organic eggs, these two types of eggs showed significant differences for b-cryptoxanthin and citranaxanthin.

A very clear effect of the housing system on yolk colour was found by Van den Brand et al. (2004) and Dvorak et al. (2010) in their study. A darker yolk colour in the free range system compared with the cage system was determined, because of the possibility of consuming carotenoids rich grass or herbs. Castellini et al. (2006) and Rizzi et al. (2006) reported similar results. Egg yolk colour was darker in the organic free range system compared with the eggs of conventional cage birds. Mugnai et al. (2009) and Karadas et al. (2005) found statistically higher content of carotenoids and hence darker yolk colour in organically produced and free range eggs than in eggs from caged hens. The more outdoor spaces hens had, the better the results were.

To the contrary, Hidalgo et al. (2008) observed the tendency for lower value of egg yolk colour and the content of beta-carotene in organic eggs than in cage, barn and free range hen eggs. The same concluded Minelli et al. (2007) when they found that organic yolks are paler and conventional ones had more redness.

Statistically no difference or slightly more intensive egg yolk colour was found in eggs produced in the cage system than in free range systems (Dukic-Stojcic et al., 2009).

Dietary factors affect yolk pigmentation considerably. Dose and type of product applied are important. Most of the studies show that eggs from organically-fed (and free-range) have more carotenoids in the yolk. This is because of access to grass and other substances rich in carotenoid pigments.

Cholesterol

Cholesterol is a naturally occurring sterol and is considered to be one of the most important sterols in the body (Akoh and Min, 1998). Cholesterol in eggs plays an important role in the development of the embryo. It is a structural component of cell membranes and precursor for hormones, vitamin D, and bile acids (Anton, 2007). The amount of cholesterol in eggs and its contribution to the total human uptake of cholesterol is still a matter of contention among nutritionists. Recent studies, however, indicate that cholesterol from eggs does not have a negative effect on serum cholesterol levels (Hu et al., 1999, 2001) and that there is no significant relationship between dietary cholesterol intake from eggs and coronary heart disease incidence. McNamara (2000) reached the conclusion that the increased risk associated with an extremely high dietary cholesterol intake, as determined by epidemiological observations, may not be due to the dietary cholesterol but rather to the absence of multiple nutrients (e.g., fiber, antioxidant vitamins, and polyunsaturated fatty acids) in diets high in animal products.

The mean content of cholesterol was 30% greater in organic eggs compared with conventional eggs (Matt et al., 2009). This result was in agreement with Minelli et al. (2007) study where cholesterol content was significantly higher in organic eggs.

Rizzi et al. (2006) compared outdoor, cage and organic systems and found no differences in cholesterol content of egg yolks. Similar results were indicated by Milinsk et al. (2003).

The cholesterol concentration in eggs depends on the breed and age of layers, on management and on nutrition (Föster and Flock, 1997) and partly on synthesis in the liver during the synthesis of lipoproteins. Duo to the lack of information and different results of studies, it is difficult to conclude that the content of cholesterol in eggs is affected considerably by the production system.

Proteins

The high content of highly bioavailable protein in eggs is of great benefit to human nutrition (Anton, 2007). Hidalgo et al. (2008) reported the higher concentration of proteins in organic, free range and barn eggs compared with the cage system. Minelli et al. (2007) compared organic and cage rearing systems and found similarly to Hidalgo et al. (2008) significantly higher content on protein in organic eggs. By contrast, Matt et al. (2009) showed lower protein concentration in organically produced eggs.

Vitamins

Eggs are recognized as a major source of vitamins in the diet. The fat-soluble vitamins are found almost exclusively in the egg yolk and most of the water soluble vitamins as well. The concentration of vitamins is influenced by genetics, rate of egg production and, as is the case with fatty acids, with the composition of the hen's diet (Naber, 1993; Leeson and Caston, 2003). As the concentration of fat-soluble vitamins in the feed increases, so does the content of vitamins in the egg yolk (Sirri and Barroeta, 2007). Numerous publications have shown successful ways of manipulating the concentration of these substances in eggs, e.g., of vitamin E (Flachowsky et al., 2000; Galobart et al., 2002; Jeroch et al., 2002) and of vitamin D (Mattila et al., 2003). Egg yolk is one of the few foods that naturally contains vitamin D (Holick, 2002). According to several studies by Mattila et al. (1999, 2003, 2004) the vitamin D_3 content of eggs is proportional to the level of added vitamin D_3 in hen feed. However, for some vitamins, such as vitamin A, the liver acts as a reservoir so that the concentration in the yolk is buffered against large changes in the diet (Naber, 1979).

Tocopherols are bioactive compounds that have a relevant effect on human health (Mugnai et al., 2008). Lopez-Bote et al. (1998) reported that eggs from free-range hens have a higher alpha-tocopherol content than eggs from hens fed a commercial mixed diet. Mugnai et al. (2008) found higher alpha-tocopherol content in organically (with extra outdoor space) produced and cage eggs than in normal organic eggs. This was due to the large intake of grass rich in alpha-tocopherol (Lopez-Bote et al., 1998) in organic-extra space system and in the cage system due to the dietary supplementation of D-L-alpha-tocopheryl acetate (Meluzzi et al, 2000). Hens have the capacity to transfer alpha-tocopherol from feed to the egg which has a strong antioxidant effect (Cherian et al., 1996ab).

In the Matt et al. (2009) study the vitamin content of egg yolk showed significant differences between housing systems. Compared with organic, the concentration of retinol (vitamin A) was higher in conventional egg yolk. The contents of alpha-tocopherol, gamma-tocopherol and vitamin D_3 in the yolk were significantly greater in conventional than in organic eggs. A significantly higher level of beta-tocopherol was found in the organic system eggs. No differences between farming systems were found in the content of delta-tocopherol.

Several studies have found that egg content significantly depends on layers' nutrition. Also, fodder ingredients are a very important reason why the chemical composition of eggs may vary. Therefore, because the organic and conventional farming systems are grounded on different feeding systems, it can be concluded that chemical composition of hen eggs might be affected by the housing system.

Overall, there is no general consensus demonstrating the clear superiority of organic rearing system over another systems regarding egg quality.

Conclusions

Egg composition is strongly dependent on the hens' feeding but also on the housing system (free-range or indoors). There are indications of different carotenoids' profile in the organic eggs compared to the conventional ones; the result is that organic yolk is much darker. The profile of the fatty acids, also the vitamins and cholesterol contents have a tendency to differ in the organic vs. conventional eggs, however the results are inconsistent. Further studies are necessary in order to clarify which factors have the strongest impact on egg quality and whether organic eggs have the superior quality compared to the conventional ones.

5. ANIMAL EXPERIMENTS

Research on the impact of a compound feed on animal health is usually based on experiments that investigate the effects of a single component of the feed whereas feeding evaluation of organically produced crops investigates the influence of several factors connected with the farming system. Therefore, results can be diverse and hard to predict. Animal experiments use laboratory organisms as models for humans. Because research on humans is expensive and even more difficult to perform, animal experiments are the most appropriate way to compare the impact of different types of agricultural production on the animal organism. Laboratory tests provide a high level of control, as well as greater ease in choosing a homogenous population of the test organism. The life cycle of a laboratory animal is short, enabling the study of impact to be continued to subsequent generations. Although direct indications of impact on human health cannot be concluded from experiments, they can be useful for the formulation of valuable hypotheses.

This kind of research should be based on precisely controlled conditions. The feed has to be the only factor differing between experimental groups. The crops used should originate from strictly defined farming systems, with similar climatic and soil conditions. Only carefully planned comparative studies will enable sound conclusions to be drawn.

Several parameters and indicators should be measured when comparing the results of animal experiments. The most frequent ones are fertility and reproduction rates (number of pregnant females, condition of female reproductive organs, etc.), as well as condition of the newborn (birth mortality, body weight gain, survival rate) and physiological parameters (biomarkers analysis in blood and tissues). Comparative studies are usually performed on rats, rabbits, mice and chickens.

Relation between feed and fertility rates

Many animal traits result from their genetic background, whereas others are connected with environmental factors. Animal fertility belongs to the latter group of parameters.

A few studies conducted so far have shown an impact of pesticide residues in plant foods on animal fertility – Bhunya and Pati (1988) confirmed a genotoxic activity of pyrethroid consumed by mice, while Elbetieha et al. (2001) showed negative effects of cypermethrin consumed by rats on their fertility parameters.

However, these studies were based on a much higher dose of chemical substances than permissible. Products from organically grown plants, without the use of pesticides, exhibit a much lower exposure to chemical active substances.

The first investigations on the ability of mice to become pregnant confirmed a significantly higher number of pregnant females when reared on organic feed (Scott et al., 1960); moreover, they exhibited less degenerative changes in their ovaries. The same parameters were analysed by McSheehy (1977), but no differences between animals fed differently were observed. However, both studies involved only one generation of mice and feed was not analysed from a chemical point of view.

The relationship between feed origin and fertility of rabbits has been investigated in a few comparative studies. Aehnelt et al. (1973) and Staiger (1986) confirmed enhanced fertility rates as a result of organic crop consumption (positive changes on the reproductive organs were observed). However, Alter (1978) and Meinecke (1982) performed similar research, which showed no significant differences in fertility or state of generative organs between analysed groups of rabbits. Among the four studies mentioned above only that conducted by Staiger (1986) involved more than one generation of animals. This research confirmed decreasing fertility in rabbits fed conventionally, whereas no changes in the organic group were observed.

Velimirov et al. (1992) investigated reproduction and the condition of newborn rats fed differently. No impact of feed on the ability to become pregnant was observed but more young were born alive when rats were fed organically. Moreover, during and after lactation, females fed organically exhibited an increased body weight gain compared to ones fed conventionally. Similar results were obtained by Gottschewski (1975) – a significantly lower number of perinatally dead rabbits and more weaned pups in the case of animals fed organically than conventionally (figure 13).

Another experiment concerning fertility of rats has been conducted by

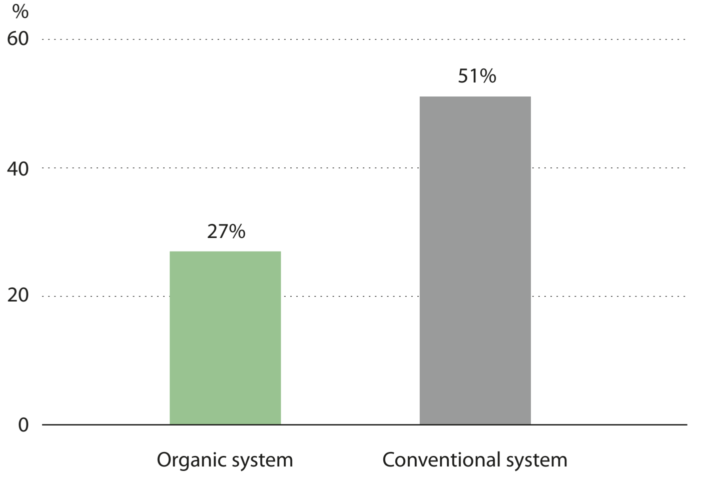

Figure 13. Mortality of the young rabbits (Gottschewski, 1975).

Jensen (2004). This Danish comparative study included analyses of the epididymis (part of the male reproductive system) weight, sperm density and testicle (male organ for producing sperm) histopathology. The results showed no differences between parameters of rats fed organically and conventionally (Jensen, 2004).

Italian research conducted by Paci et al. (2003) regarded the reproductive performance of local rabbit breeds from conventional and organic husbandry. They reported that the rearing system significantly affected birth mortality and the length of gestation. The does reared organically with access to open air exhibited a shorter gestation length than those housed in a conventional system. The organic system reduced prolificacy as well. The does reared under organic conditions produced fewer per litter than females from conventional farms. Moreover, the rearing system and delivery-season (and probably the interaction between these two factors) influenced birth mortality. Litters of females reared organically in the open air exhibited less mortality than those housed in a rabbitry (figure 14).

As far as chickens are concerned, Plochberger (1989) confirmed lower mortality of chickens fed on organic fodder. Furthermore, the eggs derived from organic birds exhibited a greater weight (and higher yolk weight) comparing to ones derived from conventionally fed chickens (Plochberger, 1989).

Impact of feed on the immune system parameters

Finamore et al. (2004) investigated the relation between the origin of feed given to rats and selected immunological rates. When animals were fed ad libitum, no significant differences in proliferation of lymphocytes were observed. This process was stimulated both in the blood of rats fed on conventional and organic feed. The differences occurred when the protein content in feed was reduced. Protein shortage resulted in enhanced proliferation of lymphocytes in the case of rats fed organically. The study included acute-phase reaction proteins, but no differences between analysed groups of animals were observed.

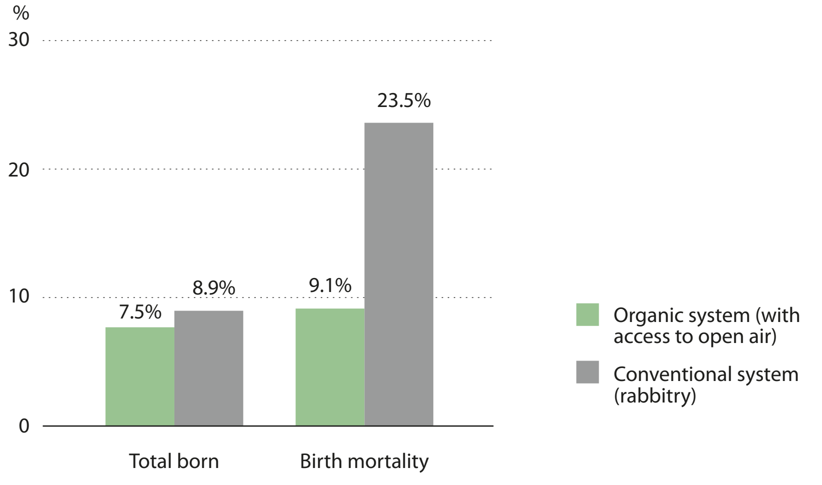

Figure 14. Effect of rearing system on rabbit reproductive performance (Paci et al., 2003).

Research carried out in Denmark by Lauridsen et al. (2005) gave more precise conclusions. They found that organic feed stimulates the immunological reactivity caused by an antigen as the secondary immune response. Rats fed organically had an elevated level of Immunoglobulins G and alpha-tocopherol in their blood serum. Furthermore, they had decreased total body fat content and much more relaxed behavior. On the other hand, Millet et al. (2005) concluded from their study with pigs that the immune responses following either a conventional or an organic diet were comparable, whereas organic housing can increase stress resistance at slaughter compared to conventional housing.

Similar research regarding the immune system of rats has been conducted by Barańska et al. (2007) within the European Union project named Quality Low Input Food (QLIF). The study included four types of feed: organic (organic fertilization and no herbicides), conventional (mineral fertilization and use of herbicides), and two 'low-input' diets – organic fertilization with use of herbicides and mineral fertilization without the use of herbicides. A pilot study showed an increased proliferation of splenocytes in males, but lower in females fed organically than in those fed other diets. This process, being a sensitive biomarker of immunological status, appeared to be suppressed by mineral fertilizers. Rats fed on feed made without the use of herbicides exhibited significantly higher antioxidative properties of their blood plasma. These preliminary results suggested that feed based on organically fertilized crops contributes to the better health status of animals, because they are better prepared to overcome infections.

Research regarding the immune status of chickens was conducted by Huber et al. (2009). The study involved two generations of animals fed on identically composed fodder from organic and conventional sources. The chickens fed organically exhibited an increased immune responsivity, as well as a stronger 'catch-up growth' after a challenge. However, chickens fed on conventional feed showed a higher weight gain compared to another group.

It is hard to assess the long term effect of pesticide residues abundant in conventional vegetables and fruits. So far, little information about these consequences is available. Lim et al., (2009) have shown in their study that long-term feeding with low concentrations of the herbicide atrazine affected insulin signaling, induced insulin resistance and weight gain in laboratory rats. It is important to bear in mind the fact, that even a small amount of such substances can contribute to distraction of body balance and negative health responses (Howard, 2005). Table 10 summarises the studies comparing parameters of animals fed organically and conventionally.

Food preference tests

So far, most food preference experiments have been performed on rats, mice, rabbits and hens. Several have shown that animals are able to discriminate between organic and conventional produce.

In 1969, Pfeiffer showed that laboratory mice prefer organically grown crops. Plochberger (1989) and Plochberger et al. (1992) showed that rats and chickens were able to distinguish between differently produced food and significantly preferred organic feed. They ate organic cereals, potatoes and common beets much more often than their conventional equivalents.

Table 10. Summary of studies comparing selected parameters of animals fed organically and conventionally

Animals	Parameter	Results	Author
Mice	Fertility	Genotoxic activity of pyrethroid	Bhunya and Pati, 1988
Mice	Fertility	More pregnant females and fewer degenerated ovaries in organic group	Scott et al., 1960
Mice	Fertility	No differences	McSheehy, 1977
Rats	Fertility	Negative effects of cypermethrin	Elbetieha et al., 2001
Rats	Reproduction	No impact on ability to get pregnant; lower percentage of perinatal deaths and greater weight gain of females in organic group	Velimirov et al., 1992
Rats	Reproduction	No differences	Jensen, 2004
Rabbits	Fertility	Enhanced fertility rates in organic group (positive changes in reproductive organs)	Aehnelt et al., 1973
Rabbits	Fertility	More pups born in organic group; greater weight at birth and during weaning period in organic group	Staiger, 1986
Rabbits	Mortality of the young	Lower mortality of young animals and more weaned pups in organic group	Gottschewski, 1975
Rabbits	Fertility	No differences	Alter, 1987
Rabbits	Fertility	No differences	Meinecke, 1982
Rabbits	Reproductive performance	Shorter gestation length and reduced prolificacy in organic group; lower number of born per litter and lower percentage of mortality in organic group	Paci et al., 2003
Chicken	Reproduction	Lower morbidity in organic group; higher weight of eggs in organic group	Plochberger, 1989
Rats	Immune status	Stimulated proliferation of lymphocytes in rats fed with protein shortage in organic group	Finamore et al., 2004
Rats	Immune status	Higher content of IgG and alpha-tocopherol in blood of rats in organic group	Lauridsen et al., 2005
Pigs	Immune response	No significant differences between the two feeding types	Millet et al., 2005
Rats	Immune status	Higher spontaneous splenocyte proliferation in males from organic group; lower spontaneous splenocyte proliferation in females from organic group	Barańska et al., 2007
Chicken	Immune status	Enhanced immune responsivity, stimulated catch-up growth and liver metabolism in organic group	Huber et al., 2009
Rats	Insulin resistance and weight gain	Long-term treatment with low concentrations of the herbicide atrazine induced insulin resistance and weight gain	Lim et al., 2009

An experiment carried out in Austria (Velimirov, 2005) confirmed the ability of rats to select a feed appropriate to their needs. Five harvests of organic and conventional carrots were used to estimate the food preference of male laboratory rats. In each harvest year, the rats' preference for organic carrots exceeded 50% and the differences compared to conventional carrots were statistically significant. Similar results were also observed in previous Velimirov (2001, 2002) studies and in the study of Mäder et al. (2007) in favour of organic production.

Woëse et al. (1997) reported in their review that, in five out of six studies, laboratory animals clearly preferred organically produced products over conventional ones. They concluded that animals can distinguish between the foods on offer from various agricultural systems and almost exclusively prefer organic produce.

Conclusions

It is difficult to draw precise conclusions regarding the impact of organic feed on animal health status. Few studies have been conducted so far and there is a need to undertake research of a higher and more specific level. An exhaustive research requires investigation of more than one generation of laboratory animals. Analysis of the chemical composition of feed from different production system is necessary as well. However, initial conclusions can be drawn. Studies conducted so far confirm a positive impact of organic crops on parameters such as immune status, fertility rates and the survival rate of the young. However, most of the research is based on intervention analyses, which cannot confirm the long-term effect of such food on overall health status. Food preference studies performed on animals have confirmed their preference for organically produced food.

6. THE IMPACT OF ORGANIC FOOD ON HUMAN HEALTH

During recent decades, 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.

Studies concerning the long term impact of organic food products on human health are very difficult to establish. There are several factors obstructing the conclusions. The predominant complication is bioavailability – the way a compound becomes absorbed by the human body. Moreover, every single organism reacts differently to a food product and it is impossible to predict this reaction. Thus, little information on correlation between organic diet and consumers' health status is available. However, a few efforts have been made so far.

There are several types of comparative studies conducted on humans. All of them must provide as much control as possible, in order to exclude any distorting factors. 'Intervention studies' include a group of people, where the only diversified element is the diet. The set of other factors should be stable, therefore people performing the same lifestyle under the same conditions are especially preferred (e.g. in prisons, orphanages or convents). Moreover, it should be a blind study, where a volunteer doesn't know the kind of applied diet. Besides, a 'cross-over' study is possible, when different test phases of the experiment are performed consecutively. The results are obtained by analyzing the biomarkers, showing the potential health responses. The 'observational' study includes a larger group of people reviewed with questionnaires. The volunteers report themselves, so the study is not fully controlled and diet is only one of a number of factors taken into account.

Fuchs et al. (2005) analysed the physical and mental status of two groups of nuns. They were on different diets, conventional and biodynamic (similar to organic), for one month. Nuns from the latter group showed a lower blood pressure and performed better immune parameters than those on the conventional diet. Moreover, they assessed their overall well-being, physical fitness and mental activity as being significantly better during the experiment. Nuns eating organic food suffered from headaches less often than before and performed an increased ability to cope under stress. However, all the nuns were aware of the kind of diet they were on so the results cannot be certain because of the potential 'placebo' effect.

Another two intervention comparative studies concerning the health effect of consumed food regarded the reactions of biomarkers for redox-processes after consumption of apples and red-wine from different production systems (Akcay et al., 2004; Briviba et al., 2007). No significant differences were observed.

The experiments mentioned above were single meal studies. A more developed comparative research study conducted by Stracke et al. (2008) included the addition of organic and conventional carrots to the usual diet of two groups of volunteers for a period of 2–3 weeks. The measured parameters were vitamin C and E levels in plasma, basic haematological rates, LDL oxidation, as well as antioxidative activity of blood plasma. In terms of the above-mentioned parameters no significant differences were observed, but plasma lutein level was much higher in the blood of people eating organic carrots.

Caris-Veyrat et al. (2004) carried out similar research on people consuming organically and conventionally produced tomato puree for 3 weeks. The study showed no significant differences in bioavailability of vitamin C, beta-carotene and lycopene between analysed groups.

The described experiments were not fully controlled dietary studies because the organic and conventional food products were only an addition to the usual diet. Therefore, the final effect should not be considered as authoritative. Only a couple of studies were conducted with effort made to avoid such distortion.

Research performed in Italy involved 10 healthy men consuming either organic or conventional products for a period of 2 weeks (Di Renzo et al., 2007). After the organic diet, an increased plasma antioxidative activity was observed. However, statistical analysis was incomplete and no conclusion on significant differences could be made. Moreover, the second phase of experiment was based on more mature crops, because they were harvested later. Nonetheless, the analysis of antioxidative properties of vegetables, fruits, wine and milk used confirmed the better nutritional quality of organic samples (Di Renzo et al., 2007).

Another study included a controlled cross-over dietary intervention on a group of 16 people fed organically and conventionally in a design for 2 × 3 weeks (Grinder-Pedersen et al., 2003). The measured parameters were excreted flavonoid levels, as well as a content of selected oxidative defence markers in blood plasma. Significant differences occurred in urinary excretion of kaempherol and quercetin; they were much higher after a period on the organic diet. The content of analysed markers in plasma was similar during the whole experiment – nonetheless, protein oxidation and plasma antioxidant capacity were higher after organic food consumption. The vegetables and fruits used in both types of diet were from similar geographical regions, but there were variations in some of the plant products given during the different periods. Therefore, it is not clear, whether the final result was an effect of different production methods or different varieties of plant foods (Grinder-Pedersen et al., 2003).

A study named PARSIFAL involved about 14,000 children from 5 European countries. The experiment compared the health status of a group of children eating either biodynamic or organic food (according to their antroposophic lifestyle) and a group consuming mass-produced food, commonly available on the conventional food market (Alfven et al., 2006). Children from the antroposophic group exhibited fewer allergies and lower body weight than those from the other group.

A study conducted in the Netherlands (KOALA Birth Cohort Study) involved 2,700 newborns and their mothers. As a result of the intake of organic dairy products there was a diminished eczema risk in children (Kummeling et al., 2008). According to Rist et al. (2007), consumption of such products was also associated with an elevated CLA content in the breast milk of mothers.

People eating organic food usually have a different lifestyle to conventional consumers. Factors such as living conditions, nutritional pattern, eating habits and sport are as important for human health as the quality of consumed food products. Therefore, true comparative assessment of the condition of people eating food from different production systems is very difficult to conduct. There are several observational studies showing that people on an organic diet evaluate their health status better than others (Rembiałkowska et al., 2008), but this result cannot be separated from the above-mentioned aspects of lifestyle.

Similarly, as was the case with laboratory animals, consumption of organic vegetables and fruits can diminish exposure to pesticide residues. Various chemical substances, commonly used by farmers to protect their crops from pests and diseases, are considered dangerous to human health due to genotoxic, carcinogenic, mutagenic and teratogenic activity. Curl et al. (2003) and Lu et al. (2006) showed that children eating organic raw materials consume significantly less organophosporus pesticides than others. The conclusion was based on the content of pesticide metabolites in their urine. Therefore, not only is nutritional value an advantage of organic foodstuffs, but food safety as well.

Conclusions

The effects of organic foods on human health are still not well known. Apart from the diet, there are too many factors affecting health status and it is probably impossible to separate them from each other. Based on research conducted so far, it is possible to build a hypothesis that organic food can have a beneficial impact on human health, but the data is insufficient for formulating clear conclusions. It is proved that regular consumption of organic milk and milk products by mothers decreases the frequency of skin allergy in the breast-fed infants and small babies. 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. Analysing the results of the studies discussed above, more effort needs to be exerted to evaluate the relationship between the nutritional quality and safety of organic food products and the health status of their consumers. The first experiments investigating the health impact of organic foods on humans brought contradictory results; they are still insufficient to formulate clear conclusions. Therefore, more comparative studies are needed, in order to provide unequivocal conclusions.

SUMMARY

Results of the studies analysed in this report indicate certain advantages in nutritional quality of organic food compared with conventional. It can be stated that organic plant products contain generally more phenolic compounds and vitamin C. However, the level of carotenoids is often higher in conventional plant products. Studies show higher content of dry matter, total sugars and mineral components, but due to the limited number and variable results of the studies it is difficult to make general conclusions. An elevated content of bioactive substances, desirable from a health point of view, in organic raw materials allows the conclusion that such food can contribute to better health. There are several studies confirming this thesis, based on analyses performed on animals. In the case of cereals, it can be concluded that organic grains contain less but a higher quality of protein than conventional grains.

The superiority of organic food is more probable if the producing and processing are in accordance with regulations. There is a common understanding that all fertilizers and pesticides are forbidden in producing organic products. The fact is that in organic food production it is necessary to keep the soil fertile and to feed the plants as well, only by the use of natural fertilizers. There are biopesticides allowed to use for plant protection in organic agriculture. They are environmentally friendly, they do not leave harmful residues in plants and their long-term use can be as effective as chemical pesticides. It is important for farmers to be informed about novel methods and products allowed in organic agriculture to reduce food producing and processing costs.

Organic milk, in comparison with conventional milk, has a higher content of CLA and omega-3 acid, a better ratio of omega-6:omega-3 acids, high levels of vitamins (vitamin E) and antioxidants, acting as an important part of human health prophylaxis. Due to the ban of the high supplementation of mineral fertilizers, organic milk may have the deficiency of specific micro- and macronutrients. Also, it has been assessed with lower points in sensory evaluation by consumers compared with conventional milk. Meat from organic production is characterised as with higher intramuscular fat content, favourable profile of fatty acids – higher content of omega-3 and lower content of saturated fatty acids. Organic eggs tend to have a higher amount of carotenoids in their yolk due to the birds having outdoor access and consuming fresh grass.

The presence of pesticide residues in conventional food is the main difference between organic and conventional food. Many monitorings and studies

have demonstrated that due to use of synthetic pesticides, conventional food may contain pesticide residues, even of several substances together and over the permitted level (over MRL). Even small amounts of chemical residues may be hazardous to human health and how the multiple compounds might interact is not clear. Pesticide intake with food have been linked to causes many disturbances, malformations and diseases (including cancers) in humans. There are evidences that conversion into organic food decreases significantly a level of pesticide residues in human breast milk and children urine. It is well proven that the content of nitrates is lower in organic crops compared with conventional. Excessive intake of nitrates is dangerous to human health – it may cause methemoglobinaemia in small babies and cancers in adults. The content of mycotoxins is an important indicator of food quality. They can contaminate both organic and conventional food, and their concentration in crops depends not only on the production system (organic vs. conventional), but also on the field production and storage conditions.

In conventional food processing several hundreds of different synthetic additives are permitted for use, while in organic food processing only around 40 natural substances are allowed. Several artificial additives used in conventional food processing have been linked to many adverse health outcomes (incl. obesity, allergies, headaches, cancers etc.); however, their hazardousness is not yet sufficiently proven to ban them.

It is difficult to draw precise conclusions regarding the impact of organic food on animal and human health status. Few studies have been conducted so far and there is a need to undertake research of a higher and more specific level. However, initial conclusions can be drawn. Studies on animals conducted so far confirm a positive impact of organic crops on parameters such as immune status, fertility rates and the survival rate of young. Food preference studies performed on animals have confirmed their preference for organically produced food. Based on human studies conducted so far, it is possible to build a hypothesis that organic food can have a beneficial impact on human health. It is proved that regular consumption of organic milk and milk products by mothers decreases the frequency of skin allergy in the breast-fed infants and small babies. Other experiments investigating the health impact of organic foods on humans have brought contradictory results. The data is still insufficient to formulate clear conclusions.

Health condition depends essentially on food and its quality. Therefore, organic methods in farming and processing can significantly improve the quality of agricultural products compared with conventional methods, which are based on the intensification and use of chemicals. Planning a healthy diet or development of healthy/functional food must consider the use of organic raw materials because they contain more bioactive substances that are important for strengthening the human immune system and metabolism. Consuming organic food may also prevent health problems caused by poor nutrition or low-quality of food (occurrence of chemical residues and artificial additives).

RECOMMENDATIONS

Researchers

Longterm comparative high-quality studies are needed both on farms and plots in order to investigate the plant and animal raw materials' composition and the factors shaping this composition. There is also a need to plan more integral comparative studies with well-advised methodology and methods, and to publish high-quality papers of conducted comparative studies.

It is necessary to conduct more studies in many fields:

- novel and holistic methods of food quality evaluation;
- looking for the relevant health & well-being indicators for plants, animals and humans;
- impact of the management and feed composition on the farm and lab animals' health & well-being;
- in vitro studies on the impact of the organic vs. conventional plant and animal extracts at the molecular level;
- intervention and cohort studies on the impact of the organic vs. conventional food consumption on human health.

Teachers

- At kindergartens, elementary and primary schools: to establish small-scale school-gardens in order to introduce healthy food production;
- To prepare relevant teaching programs, to introduce the relevant study programs materials on the healthy lifestyle, healthy food, differences between organic and conventional food and farming at schools;
- To cooperate with competent researchers to create suitable teaching materials;
- To cooperate with medical schools to create common teaching programs;
- To participate in seminars and workshops organized for educationalists by medical schools and scientists;
- To organize educational meetings with parents to present matters connected with a healthy lifestyle for children and to increase awareness of organic food;
- To encourage school managers to establish school canteens serving organic food.

Medical doctors

- To keep informed about new scientific results regarding food quality and health aspects;
- To cooperate with higher and secondary schools in teaching about a healthy lifestyle and the impact of food on health;
- To inform patients about the importance of healthy and organic food as a part of the healthy diet to avoid health problems;
- To inform patients about possible adverse impacts of synthetic chemicals used in food producing and processing;
- To encourage patients to consume more healthy food and thereby to diminish the need for synthetic medicines and food supplements;
- To include an organic/well constructed diet to hospitals´ canteens and thereby avoid the side effects of chemicals used in food producing and processing.

Enterprises (food producers, processors, caterers, traders)

- To cooperate with researchers in order to produce high-quality food with a well-designed production system and with considerable and reasonable yields;
- To be informed about high-quality/organic food production and processing novel methods;
- To cooperate with researchers and other experts to develop novel healthy foods;
- To use local and organic raw materials in dishes of restaurants and cafes thereby creating alternative choices for customers;
- To label organic food with an organic label in menus (in cooperation with policy makers);
- To be flexible in establishing requirements for small and local food producers;
- To establish (in the cooperation with the policy makers) new enterprises – retail shops, wholesale stores, processing manufactures, local small restaurants, canteens at schools and institutions, educational tracks with the organic farms, etc;
- To invest more in the organic sector;
- To invest in the research activities in the organic sector.

Policy makers

- To support and create regional common platforms for different stakeholders in the organic sector (farmers, processors, traders, advisors, teachers, medical doctors, researchers) and to cooperate with them for policy making;
- To support new initiatives in the organic sector (in cooperation with enterprises) – retail shops, wholesale stores, processing small manufactures and bigger works, local small restaurants, canteens at schools and institutions, educational tracks on organic farms, etc;
- To create a "green light" for people starting new businesses in the organic sector, especially young people;
- To facilitate the development of the organic sector in the regions.

REFERENCES

Abdel Rasoul GM, Abou Salem ME, Mechael AA, Hendy OM, Rohlman DS and Ismail AA. 2008. Effects of occupational pesticide exposure on children applying pesticides. Neurotoxicology, 29 (5), 833–8.

Abele U. 1987. Produkqualität und Düngung – mineralisch, organisch, biologisch-dynamisch. Angewendte Wissenschaft (Schriftenreihe des Bundesministers für Ernährung, Landwirtschaft und Forsten), Heft 345.

Abrahamsen RK, Borge GI, Harstad OM, Haug A and Wetlesen A. 2008. Milk quality – a future approach from a researcher's point of view. J of Animal and Feed Sci, 16, Suppl. 1, 2007, 209–226.

Aehnelt E and Hahn J. 1973. Fertility of animals – a means to test organic food and feed stuff? Tierarztliche Umschau, 28, 155–160.

AFSCA-FAVV. 2001. Chemical safety of organically produced foodstuffs. Report from the scientific committee of the Belgian federal agency for the safety of the food chain, Brussels.

Agra Europe. 2007. 2264, M/4.

Akcay YD, Yildirim HK, Guvenc U and Sozmen EY. 2004. The effects of consumption of organic and nonorganic red wine on low-density lipoprotein oxidation and antioxidant capacity in humans, Nutr Res 24, 541–554.

Akoh C and Min D. 1998. Food Lipids: Chemistry, Nutrition and Biotechnology. Marcel Dekker, New York.

Alföldi T, Mäder P, Niggli U, Spiess E, Dubois D and Besson JM. 1996. Quality investigations in the long-term DOC trial. In Quality of Plant Products Grown with Manure Fertilisation. Proceedings of the Fourth meeting in Juva (Finland).

Alfven T, Braun-Fahrlander C, Brunekreef B, von Mutius E, Riedler J, Scheynius A, van Hage M, Wickman M, Benz MR, Budde J, Michels KB, Schram D, Ublagger E, Waser M and Pershagen G. 2006. Allergic diseases and atopic sensitization in children related to farming and anthroposophic lifestyle – the PARSIFAL study. Allergy. 61(4), 414–21.

Alter G. 1978. Über den Einfluß von Fütterungsfaktoren auf das Fruchtbarkeitsgeschehen. Den Ascorbinsäuregehalt und den histologischen Aufbau der Ovarien von weiblichen Kaninchen. Inaugural dissertation, Tierärztliche Hochschule Hannover.

Amin KA, Abdel Hameid H 2nd and Abd Elsttar AH. 2010. Effect of food azo dyes tatrazine and carmoisine on biochemical parameters related to renal, hepatic function and oxidative stress biomarkers in young male rats. Food Chem Toxicol. 48(10): 2994–9.

Andersen HJ. 2000. What is pork quality? EAAP Publ. 100, 15–26.

Angood KM, Wood JD, Nute GR, Whittington FM, Hughes SI and Sheard PR. 2008. A comparison of organic and conventionally-produced lamb purchased from three major UK supermarkets: Price, eating quality and fatty acid composition. Meat Sci 78, 176–184.

Ansar Ahmed S. 2000. The immune system as a potential target for environmental estrogens (endocrine disrupters): a new emerging field. Toxicology 156, 191–206.

Anton M. 2007. Composition and Structure of Hen Egg Yolk, chapter 1. In Huopalahti, R., López-F, R., Anton, M. & Schade, R. (eds): Bioactive egg compounds. Springer-Verlag, Heidelberg, pp 3.

Anttonen MJ, Hoppula KI, Nestby R, Verheul MJ and Karjalainen RO. 2006. Influence of fertilization, mulch color, early forcing, fruit order, planting date, shading, growing environment, and genotype on the contents of selected phenolics in strawberry (Fragaria × ananassa Duch.) fruits. J Agric Food Chem, 54, 2614–2620.

Aruaz-Contreras J and Feria-Velasco A. 1984. Monosodium 1-glutamate induced convulsions I. Differences in seizure pattern and duration of effects as a function of age in rats. Gen. Pharmacol., 15 (1984), pp. 391–395.

Asami DK, Hong Y-J, Barrett DM and Mitchell AE. 2003. Comparison of the total phenolic and ascorbic acid content of freeze-dried and air-dried marionberry, strawberry, and corn grown using conventional, organic, and sustainable agricultural practices. J. Agric. Food Chem., 51, 1237–1241.

Aubert C. 1987. Pollution du lait maternel, une enquete de Terre vivante. Les Quatre Saisons du Jardinage 42, 33–39.

Augustsson K, Michaud DS, Rimm EB, Leitzmann MF, Stampfer MJ, Willett WC and Giovannucci E. 2003. A prospective study of intake of fish and marine fatty acids and prostate cancer. Cancer Epid. Biomark. Prev. 12, 64–67.

Baert k, De Meulenaer B, Kasase C, Huyghebaert A, Ooghe W and Devlieghere F. 2005. Free and bound patulin in cloudy apple juice. Food Chemistry, 100(3), pp. 1278–1282.

Baker BP, Benbrook CM, Groth E and Benbrook KL. 2002. Pesticide residues in conventional, integrated pest management (IPM)-grown and organic foods: insights from three US data sets. Food Additives and Contaminants, 19, 427–446.

Balzer-Graf U and Balzer FM. 1991. Steigbild und Kupferchloridkristallisation – Spiegel der Vitalqualitaet von Lebensmitteln. In: Meier-Ploeger A, Vogtmann H, Lebensmittelqualitaet – ganzheitliche Methoden und Konzepte. Mueller, Karlsruhe.

Barańska A, Skwarło-Sońta L, Rembiałkowska E, Brandt K, Lueck L and Leifert C. 2007. The effect of short term feeding with organic and conventional diets on selected immune parameters in rat. In: Improving Sustainability in Organic and Low Input Food Production Systems: Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF), University of Hohenheim, Germany, 20–23 March, 108–111.

Barrett DM, Weakley C, Diaz JV and Watnik M. 2007. Qualitative and nutritional differences in processing tomatoes grown under commercially organic and conventional production systems. J. Food Sci. 72, 441–450.

Bateman B, Warner JO, Hutchinson E, Dean T, Rowlandson P, Gant C, Grundy J, Fitzgerald C and Stevenson J. 2004. The effects of a double blind, placebo controlled, artificial food colourings and benzoate preservative challenge on hyperactivity in a general population sample of preschool children. Archives of Disease in Childhood 89 506–511.

Beck A, Kretzschmar U and Schmid O et al. 2006. Organic Food Processing – Principles, Concepts and Recommendations for the Future. Results of a European research project on the quality of low input foods (QLIF). Published by FiBL.

Bee G, Guex G and Herzog W. 2004. Free-range rearing of pigs during the winter: Adaptations in muscle fiber characteristics and effects on adipose tissue composition and meat quality traits. J. Anim. Sci. 82, 1206–1218.

Bellisle F, Monneuse MO, Chabert M, Larue-Achagiotis C, Lanteaume MT and Louis-Sylvestre J. 1991. Monosodium glutamate as a palatability enhancer in the European diet. Physiol Behav. 49(5): 869–73.

Bellisleb F. 2006. Effects of Monosodium Glutamate on Human Food Palatability†. Dr. Bellisle's experimental work was supported by the International Glutamate Technical Committee, the Comité Francais des Fabricants d'Acide Glutamique and the Umami Manufacturers Association of Japan. Ann NY Acad Sci 1998, 30; 855: 438–41. Article first published online 2006.

Benbrook CM, Zhao X, Yanez J, Davies N and Andrews P. 2008. New evidence confirms the nutritional superiority of plant-based organic foods. State of science review. http://www.organic-center.org/science.nutri.php?action=view&report_id=126

Benbrook CM. 2005. Breaking the mold – impacts of organic and conventional farming systems on mycotoxins in food and livestock feed. http://www.organic-center.org/science.safety.php?action=view&report_id=2

Benbrook CM. 2006. FAQS on pesticides in milk. Organic Center. Calculated from USDA's Pesticide Data Program.
http://www.organic-center.org/science.pest.php?action=view&report_id=79

Bender I, Ess M, Matt D, Moor U, Tõnutare T and Luik A. 2009. Quality of organic and conventional carrots. Agronomy Research 7, 572–577.

Bennedsgaard TW, Thamborg SM., Vaarst M and Enevoldsen C. 2003. Eleven years of organic dairy production in Denmark: herd health and production related to time of conversion and compared to conventional production. Livestock Prod Sci. 80, 121.

Bergamo P, Fedele E, Iannibeli L and Marzillo G. 2003. Fat-soluble vitamins contents and fatty acid composition in organic and conventional Italian dairy products. Food Chemistry 82, 625–631.

Berrisch-Hempen D. 1995. Fettsäurezusammensetzung von Wildfleisch – Vergleich zum Fleisch schlachtbarer Haustiere. Fleischwirtschaft 75, 809–813.

Beweise für bessere Bio-Qualität. 2006. http://www.foodaktuell.ch/printeditorial.php?id=404

Bhunya SP and Pati PC. 1988. Genotoxic effects of a synthetic pyrethroid insecticide, cypermethrin, in mice in vivo. Toxicol. Lett. 41, 223–230.

Bidlack WW. 1998. Functional foods. Biochemical and processing aspects. G. Mazza, ed. Lancaster, PA: Technomic Publishing Co., Inc., pp 437.

BMA. 1992. The BMA guide to pesticides, chemicals and health. Report of science and education. British Medical Association, UK.

Bourn D and Prescott J. 2002. A comparison of the nutritional value, sensory qualities, and food safety of organically and conventionally produced foods. Critical Reviews in Food Science and Nutrition, 42, 1–34.

Brandt K and Molgaard JP. 2001. Organic agriculture: does it enhance or reduce the nutritional value of plant foods? J. Sci. Food Agric., 81, 924–931.

Briviba K, Stracke BA, Ruefer CE, Watzl B, Weibel FP and Bub A. 2007. Effect of consumption of organically and conventionally produced apples on antioxidant activity and DNA damage in humans, J. Agric. Food Chem. 55, 7716–7721.

Bucher HC, Hengstler P, Schindler C and Meier G. 2002. n-3 polyunsaturated fatty acids in coronary heart disease: a meta-analysis of randomized controlled trials. Am. J. Med. 112, 298–304.

Budak A. Mikotoksyny and Baran E (red.). 1998. Zarys mikologii lekarskiej. Volumed, Wrocław, 533–539.

Bulling W. 1987. Qualitätsvergleich von "biologisch" und "konventionell" erzeugten Feldfruchten. Regierungspräsidium, Stuttgart.

Busscher N, Kal J, Andersen J-O, Huber M, Mergardt G, Doesburg P, Paulsen M and Poeger A. 2010. Standardization of the Biocrystallization Method for Carrot Samples. Biological Agriculture and Horticulture, Great Britain, 27, 1–23.

Butchko HH, Stargel WW, Comer CP, Mayhew DA, Benninger C, Blackburn GL et al. 2002. Aspartame: review of safety. Regul Toxicol Pharmacol 35, S1–S93.

Butler G and Leifert C. 2009. Effect of organic production methods on product quality and animal health and welfare; why are there differences? Proceedings of the conference on Improvement of quality of animal products obtained in sustainable production systems with special reference to bioactive components and their benefit for human health, 14–15 May 2009, Jastrzębiec, 88–93.

Butler G, Nielsen JH, Slots T, Seal Ch, Eyre MD, Sanderson R and Leifert C. 2008. Fatty acid and fat-soluble antioxidant concentrations in milk from high- and low-input conventional and organic systems: seasonal variation. J. Sci. Food Agric. 88, 1431–1441.

Camerini M, Taddei F, Bentivenga G, Melloni S, Aureli G and Quaranta F. 2011. Agronomical and hygienic-health quality of durum wheat productions from different mediterranean environments under organic and conventional cropping. In: Pulkrabova, Jana; Tomaniova, Monika; Kahl, Johannes and Hajšlová, Jana (Eds.) Book of Abstracts. First International Conference on Organic Food Quality and Health Research, ICT Prague Press, Prague, Czech Republic, p. 38.

Cameron DP, Poon TK and Smith GC. 1976. Effects of monosodium glutamate administration in the neonatal periood on the diabetic syndrome in KK mice. Diabetologia. 12(6): 621–6.

Carbonaro M and Mattera M. 2001. Polyphenoloxidase activity and polyphenol levels in organically and conventionally grown peach (Prunus persica L., cv. Regina bianca) and pear (Pyrus communis L., cv. Williams). Food Chemistry, 72, 419–424.

Carbonaro M, Mattera M, Nicoli S, Bergamo P and Cappelloni M. 2002. Modulation of antioxidant compounds in organic vs. conventional fruit (peach Prunus persica L., and pear Pyrus communis L.). J. Agric. Food Chem. 50(19), 9–11.

Caris-Veyrat C, Amiot MJ, Tyssandier V, Grasselly D, Buret M, Mikolajczak M, Guilland J-C, Bouteloup-Demange C and Borel P. 2004. Influence of organic versus conventional agricultural practice on the antioxidant microconstituent content of tomato and derived purees, consequence on antioxidant plasma status in humans. J. Agric. Food Chem. 52, 6503–6509.

Carlson JR, Bauer BA, Vincent A, Limburg PJ and Wilson T. 2007. Reading the tea leaves: anticarcinogenic properties of (-)-epigallocatechin-3-gallate. Mayo Clin. Proc. 82, 725–732.

Castellini C, Mugnai C and Dal Bosco A. 2002. Effect of organic production system on broiler carcass and meat quality. Meat Sci. 60, 219–225.

Castellini C, Perella F, Mugnai C and Dal Bosco A. 2006. Welfare, productivity and qualitative traits of egg in laying hens reared under different rearing systems. Poster At: Xii European Poultry Conference, Verona, 10–14 September.

Chassy AW, Bui L, Renaud ENC, Van Horn M and Mitchell AE. 2006. Three-Year Comparison of the Content of Antioxidant Microconstituents and Several Quality Characteristics in Organic and Conventionally Managed Tomatoes and Bell Peppers. J. Agric. Food Chem. 54, 8244–8252.

Chełkowski J. 1985. Mikotoksyny, wytwarzające je grzyby and mikotoksykozy. Wyd. SGGW, Warszawa.

Chełkowski J. 1994. Significance of Fusarium metabolites in interaction between a cereal plant and a pathogen. Genet. Pol. (35B): 137–142.

Chen S, Bobe G, Zimmerman S, Hammond EG, Luhman CM, Boylston TD et al. 2004. Physical and sensory properties of dairy products from cows with various milk fatty acid compositions. J Agric Food Chem 52: 3422–3428.

Chevassus H, Renard E, Bertrand G, Mourand I, Puech R, Molinier N, Bockaert J, Petit P, Bringer J. 2002. Effects of oral monosodium (L)-glutamate on insulin secretion and glucose tolerance in healthy volunteers. Br J Clin Pharmacol. 53(6): 641–3.

Chin SF, Liu W, Storkson JM, Ha YL and Pariza MW. 1992. Dietary sources of conjugated dienoic isomers of linoleic acid, a newly recognized class of anticarcinogens. J of Food Composition and Analysis, 5, 185–197.

Cieślik E. 1995a. Czynniki kształtujące zawartość azotanów and azotynów w ziemniakach. Post. Nauk Roln., 6, 67–73.

Cieślik E. 1995b. The effect of weather conditions on the level of nitrates in tubers of some potato varieties. Pol. J. Nutr. Sci. 4/45: 11–19.

Collomb M, Bisig W, Bütikofer U, Sieber R., Bregy M and Etter L. 2008. Fatty acid composition of mountain milk from Switzerland: Comparison of organic and integrated farming sustems. International Dairy J 18, 976–982.

Combes S and Dalle Zotte A. 2005. La viande de lapin: valeur nutritionnelle et particularités technologiques. In Proc. 11èmes Journées Recherche Cunicole, 2005 November, Paris, France, 167–180.

Combes S, Lebas F, Juin H, Lebreton L, Martin T, Jehl N, Cauquil L, Darche B and Corboeuf MA. 2003b. Comparaison lapin « Bio »/ lapin standard: Analyses sensorielles et tendrete mecanique de la viande. 10èmes Journées de la Recherche Cunicole, Paris, 137–140.

Combes S. 2004. Valeur nutritionnelle de la viande de lapin. INRA Productions Animales, 17, 373–383.

Combes S., Lebas F., Lebreton L., Martin T., Jehl N., Cauquil L., Darche B and Corboeuf M.A., 2003a. Comparison lapin « Bio »/ lapin standard: Caractéristique des carcasses et composition chimique de 6 muscles de la cuisse. Proc. 10èmes Journées de la Recherche Cunicole, Paris, 133–136.

Commision Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products with regard to organic production, labeing of organic products and control.

Commission of the European communities. 2008. Monitoring of Pesticide Residues in Products of plant Origin in the EU, Norway, Iceland and Liechtenstein, 2006. Brussels.

Connolly A, Hearty A, Nugent A, McKevitt A, Boylan E, Flynn A and Gibney MJ. 2010. Pattern of intake of food additives associated with hyperactivity in Irish children and teenagers. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2010 Apr; 27(4): 447–56.

Coonan C, Freestone-Smith C, Allen J and Wilde D. 2002. Determination of the major mineral and trace element balance of dairy cows in organic production systems. In: Kyriazakis, Zervas (Eds.), Proceeding of Organic Meat and Milk from Ruminants, Athens, October 4–6, 2002, EAAP Publication, vol. 106, 181–183.

Cooper J, Niggli U and Leifert C. 2007. Handbook of Organic Food Safety and Quality. Woodhead Publishing Limited, Cambridge, England.

Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91.

Curl CL, Fenske RA and Elgethun K. 2003. Organophosphorus pesticide exposure of urban and suburban preschool children with organic and conventional diets. Environ. Health Perspect. 111(3), 377–382.

Czerwiecki L, Czajkowski D and Witkowska-Gwiazdowska A. 2002b. On ochratoxin A and fungal flora in Polish cereals from conventional and ecological farms. Art 2: Occurrence of ochratoxin A and fungi in cereals in 1998. Food Additives and Contaminants, Vol. 19, No. 11: 1051–1057.

Czerwiecki L, Czajkowski D and Witkowska-Gwiazdowska A. 2002a. On ochratoxin A and fungal flora in Polish cereals from conventional and ecological farms. Part 1: Occurrence of ochratoxin A and fungi in cereals in 1997. Food Additives and Contaminants, Vol. 19, No. 5: 470–477.

Dalle Zotte A. 2004. Dietary advantages: rabbit must tame consumers. Viandes et Produits Carnés, 23, 161–167.

Dangour AD, Dodhia SK, Hayter A, Allen E, Lock K and Uauy R. 2009. Nutrional quality of organic foods: a systematic review. The Am J Clin Nutr, 90: 680–685.

Deckere De EA, 1999. Possible beneficial effect of fish and fish n-3 polyunsaturated fatty acids in breast and colorectal cancer. Europ. J. Cancer Prev. 213–221.

Delis A et al. 2003. Mycotoxin contamination of regular and organic foodstaff. Scientific plan for a sustainable development policy. Belgia.
http://www.belspo.be/belspo/home/publ/pub_ostc/CP/CP30_en.pdf

Derache R. 1986. Toxicologie et securite des aliments TEC - DOC Lavosier. APRIA, Paris.

Desjardins A. 2006. Fusarium mycotoxins. Chemistry, genetics and biology. The American Phytopathological Society.

Dewhurst RJ, Fisher WJ, Tweed JKS and Wilkins RJ. 2003. Comparison of grass and legume silages for milk production. Production responses with different levels of concentrate. J of Dairy Sci 86, 2598–2611.

Di Renzo L, Di Pierro D, Bigioni M, Sodi V, Galvano F and Cianci R. 2007. Is antioxidant plasma status in humans a consequence of the antioxidant food content influence? European review for medical and pharmacological sciences, 185–192.

Dimberg LH, Gissen C, and Nilsson J. 2005. Phenolic compounds in oat grains (Avena sativa L.) grown in conventional and organic systems. Ambio 34: 331–337.

Diniz YS, Faine LA, Galhardi CM, Rodrigues HG, Ebaid GX, Burneiko RC, Cicogna AC and Novelli EL. 2005. Monosodium glutamate in standard and high-fiber diets: metabolic syndrome and oxidative stress in rats. Nutrition. 21(6): 749–55.

Dixon RA and Paiva NL. 1995. Stress-induced phenylpropanoid metabolism. Plant Cell 7: 1085–1097.

Duchań B and Hady S. 1992. Trzy przypadki methemoglobinemii w przebiegu zatrucia azotanami. Roczn. PZH, 42, 267–270.

Đukić-Stojčić M, Perić L, Bjedov S and Milošević N. 2009. The quality of table eggs produced in different housing systems. Biotechnology in Animal Husbandry 25 (5–6), p 1103–1108.

Dvorak P, Suchy P, Strakova E and Doležalova. 2010. Variation in egg yolk colour in different systems of rearing laying hens. Acta Vet Brno. 79: S13–S19.
Eddleston M, Buckley NA, Eyer P and Dawson AH. 2008. Management of acute organophosphorus pesticide poisoning. Lancet, February 16, 371(9612), 597–607.
EFSA (European Food Safety Authority). 2010. Annual Report on Pesticide Residues 2008 according to Article 32 of Regulation (EC) No 396/2005. EFSA Journal 8(6): 1646, Parma, Italy.
Elbetieha A, Da'as SI, Khamas W and Darmani H. 2001. Evaluation of the toxic potentials of cypermethrin pesticide on some reproductive and fertility parameters in the male rats. Arch. Environ. Contamin. Toxicol. 41, 522–528.
Ellis KA, Innocent GT, Grove-White D, Cripps P, McLean WG, Howard CV and Mihm M. 2006. Comparing the fatty acid composition of organic and conventional milk. J of Dairy Sci 89, 1938–1950.
Emanuelson U and Fall N. 2007. Vitamins and selenium in bulk tank milk of organic and conventional dairy farms. EAAP 2007, Dublin, Ireland.
Enser M, Hallett KG, Hewett B, Fursey GAJ, Wood JD and Harrington G. 1998. Fatty acid content and composition of UK beef and lamb muscle in relation to production system and implications for human nutrition. Meat Sci. 49, 329–341.
Erb J. 2006. The slow poisoning of minkind. Areport on the toxic effects of the food additive monosodium glutamate. To the Joint FAO/WHO Expert Committee on Food Additives. http://www.holisticmed.com/msg/TheErbreportonMSGtotheWHO.pdf
Faller ALK and Fialho E. 2010. Polyphenol content and antioxidant capacity in organic and conventional plant foods. J Food Comp. and Analysis 23(6): 561–568.
Fennema OR. 1996. Food chemistry 3rd Ed., Marcel Dekker, New York.
Fernandez X, Monin G, Talmant A, Mourot J and Lebret B. 1999. Influence of intramuscular fat content on the quality of pig meat. Meat Sci. 53, 67–72.
Fernandez-Tresguerres Hernández JA. 2005. Effect of monosodium glutamate given orally on appetite control (a new theory for the obesity epidemic). An R Acad Nac Med (Madr). 122(2): 341–55; discussion 355–60. Spanish.
FiBL – Research Institute of Organic Agriculture. 2009: Organic Farming in Europe – A Brief Overview. Prepared for the European Organic Congress "Organic Food and Farming in times of Climate Change, Biodiversity loss and Global Food Crisis", Frick/Brussels, December 1, 2009.
http://www.fibl.org/fileadmin/documents/en/publications/fibl-2009-latest-figures.pdf
FiBL and IFOAM. 2011. The World of Organic Agriculture. Statistics and Emerging Trends 2011. FiBL-IFOAM Report. Eds.: Helga Willer and Lukas Kilcher. IFOAM, Bonn and FiBL, Frick.
Finamore A, Britti MS, Roselli M, Bellovino D, Gaetani S and Mengheri E. 2004. Novel approach for food safety evaluation. Results of a pilot experiment to evaluate organic and conventional foods. J. Agric. Food Chem. 52, 7425–7431.
Fischer A and Richter C. 1984. Influence of organic and mineral fertilizers on yield and quality of potatoes. In: Vogtmann H, Boehncke E, Fricke I, eds. The Importance of Biological Agriculture in a World of Diminishing Resources. Witzenhausen: Veriagsgruppe Weiland, 1984: 236–248.
Fisher AV, Enser M, Richardson RI, Wood JD, Nute GR, Kurt E, Sinclair LA and Wilkinson RG. 2000. Fatty acid composition and eating quality of lamb types derived from four diverse breed x production system. Meat Sci. 55, 141–147.
Flachowsky G, Engelmann D, Sünder A, Halle I and Sallmann HP. 2000. Eggs and poultry meat as tocopherol sources in dependence on tocopherol supplementation of poultry diets. Proceedings of 5th Karlsruhe nutrition congress, session 3P, pp. 102.
Förster A and Flock DK. 1997. Egg quality criteria for table eggs and egg product. In: Proceedings of the VII European Symposium on the Quality of Eggs and Egg Products, Poznan, pp. 28–38.
Frei B and Higdon JV. 2003. Antioxidant activity of tea polyphenols in vivo: evidence from animal studies. J. Nutr. 133, 3275.
Fresco P, Borges F, Diniz C and Marques MPM. 2006. New insights on the anticancer properties of dietary polyphenols. Med. Res. Rev. 26, 747.

Frydecka - Mazurczyk A and Zgórska K. 1990. Zawartość azotanów w bulwach kilku odmian ziemniaka uprawianych w Jadwisinie w 1988 r. Biul. Inst. Ziemniaka, 40, 17–22.

Fuchs N, Huber K, Hennig J and Dlugosch G. 2005. Influence of biodynamic nutrition on immunological parameters and well-being of postmenopausal women „convert-study". Proceedings of the 1st scientific FQH conference in Frick, 63–67.

Gabryszuk M, Słoniewski K and Sakowski T. 2008. Macro- and microelements in milk and hair of cows from conventional vs. organic farms. Animal Science Papers and Reports 26(3), 199–209.

Galobart J, Barroeta AC, Cortinas L, Baucells MD and Codony R. 2002. Accumulation of alphatocopherol in eggs enriched with omega-3 and omega-6 polyunsaturated fatty acids. Poult. Sci. 81(12), 1873–1876.

Geier U. 2005. Pflanzenorganbildtypen in Kupferchloridkristallisation und Steigbild. Lebendige Erde, Darmstadt, 5.

Gelin J-P. 1987. Natürliche Alterungs- und experimentell gesteuerte Abbauprozesse organischer Substanzen in Fliessbildern. Elemente der Naturwissenschaft Naturwissenschaftliche Sektion am Goetheanum, Dornach, 1/46.

Ghidini S et al. 2005. Comparison of contaminant and residue levels in organic and conventional milk and meat products from Northern Italy. Food Additives and Contaminants 22(1): 9–14.

Gilman AP, Van Oostdam JC, Hansen JC, Odland JO, Tchachtchine V, Walker J, Lagerkvist BJ, Olafsdottir K, Weber JP, Bjerregaard P and Klopov V. 1997. The AMAP International Symposium on Environmental Pollution in the Arctic. (Extended Abstracts volume1: 57–58). Tromso, Norway, June 1–5.

Gottschalk C, Barthel J, Engelhardt G, Bauer J and Meyer K. 2007. Occurrence of type A trichothecenes in conventionally and organically produced oats and oat products. Mol. Nutr. Food Res. 51: 1547–1553.

Gottschewski GHM. 1975. New toxicological methods to study pesticides and herbicides. Plant Foods Human Nutr. 25, 21–42.

Griinari JM., Corl BA., Lacy SH, Chouinard PY, Nurmela KVV and Bauman DE. 2000. Conjugated linoleic acid is synthesized endogenously in lactating dairy cows by Δ9-desaturase. J of Nutr, 130, 2285–2291.

Grinder-Pedersen L, Rasmussen SE, Bugel S, Jorgensen LV, Dragsted LO., Gundersen V and Sandstrom B. 2003. Effect of diets based on foods from conventional versus organic production on intake and excretion of flavonoids and markers of antioxidative defense in humans, J Agric Food Chem. 51, 5671–5676.

Guadagnin SG, Rath S and Reyes FGR. 2005. Evaluation of the nitrate content in leaf vegetables produced through different agricultural systems. Food Additives and Contaminants, 22 (12): 1203–1208.

Guillette EA, Meza MM, Aquilar MG, Soto AD and Garcia IE. 1998: An anthropological approach to the evaluation of preschool children exposed to pesticides in Mexico. Environmental Health Perspectives – Volume 106, Number 6, 347–353.

Guinot-Thomas P, Jondreville C and Laurent F. 1991. Comparison of milk from farms with biological, conventional and transitional feeding. Milchwissenschaft 46, 779–782.

Gurney JG, Pogoda JM, Holly EA, et al. 1997. Aspartame consumption in relation to childhood brain tumor risk: results from a case-control study. J Natl Cancer Inst. 89: 1072–4.

Guy JH and Edwards SA. 2002. Consequences for meat quality of producing pork under organic standards. Pigs News Inf. 23, 75–80.

Ha YL, Grimm NK and Pariza MW. 1989. Newly recognized anticarcinogenic fatty acids: identification and quantification in natural and processed cheese. J of Agricultural and Food Chemistry, 37, 75–81.

Haas G, Wetterich F and Köpke U. 2000. Life cycle assessment of intensive, extensified and organic grassland farms in southern Germany. Proceedings 13th International IFOAM Scientific Conference, 28–31 Sept. 2000, Basel, Switzerland, 157.

Hajslova J, Schulzova V, Slanina P, Janne K, Hellena KE and Anderssonet CH. 2005. Quality of organically and conventionally grown potatoes: four-year study of micronutrients, metals, secondary metabolites, enzymic browning and organoleptic properties. Food additives and contaminants, 22, 514–534.

Häkkinen SA and Törrönen AR. 2000. Content of flavonols and selected phenolic acids in strawberries and Vaccinium species: influence of cultivar, cultivation site and technique. Food Research International 33, 517–524.

Hale M. 2006. Dairy Resource list: Organic and pasture based. A publication of ATTRA-National Sustainable Agriculture Information Service www.attra.ncat.org

Hallmann E and Rembiałkowska E. 2006. Zawartość związków antyoksydacyjnych w wybranych odmianach cebuli z produkcji ekologicznej and konwencjonalnej. J of Research and Applications in Agricultural Engineering 51 (2), 42–46.

Hallmann E and Rembiałkowska E. 2007a. Zawartość związków bioaktywnych w owocach papryki z uprawy ekologicznej and konwencjonalnej. Żywienie Człowieka and Metabolizm, XXXIV, 538–543.

Hallmann E and Rembiałkowska E. 2007b. Comparison of the nutritive quality of tomato fruits from organic and conventional production in Poland. Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF) (U. Niggli et al., eds), University of Hohenheim, Germany, March 20–23: 131–135.

Hallmann E and Rembiałkowska E. 2008a. Ocena wartości odżywczej and sensorycznej pomidorów oraz soku pomidorowego z produkcji ekologicznej and konwencjonalnej. J of Research and Applications in Agricultural Engineering, Vol. 53/ 3, 88–95.

Hallmann E and Rembiałkowska E. 2008b. The content of selected antioxidant compounds in bell pepper varieties from organic and conventional cultivation before and after freezing process. Proceedings of the Second Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR) (D. Neuhoff et al. eds.). Modena, 18–20 June, vol. 2: 802–805.

Hallmann E, Rembiałkowska E and Kaproń L. 2005. Zawartość związków bioaktywnych w pomidorach and papryce z uprawy ekologicznej and konwencjonalnej. Wybrane zagadnienia ekologiczne we współczesnym rolnictwie. Monografia, PIMR, Poznań, tom 2: 258–263.

Hallmann E, Rembiałkowska E, Szafirowska A and Grudzień K. 2007. Znaczenie surowców z produkcji ekologicznej w profilaktyce zdrowotnej na przykładzie papryki z uprawy ekologicznej. Roczniki PZH 2007, 58/1, 77–82.

Hallmann E, Sikora M and Rembiałkowska E. 2008. Porównanie zawartości związków przeciwutleniających w owocach papryki świeżej and mrożonej pochodzącej z uprawy ekologicznej and konwencjonalnej. Postępy Techniki Przetwórstwa Spożywczego , 18/1, 30–33.

Hamm U and Gronefeld F. 2004. The European Market for Organic Food: Revised and updated analysis, organic marketing initiatives and rural development. The University of Wales, Aberystwyth.

Hansen LL, Bejerholm C, Claudi MC and Andersen HJ. 2000. Effects of organic feeding including roughage on pig performance, technological meat quality and the eating of the pork. Proc. 13-th IFOAM Sci. Conf., Basel, s. 288.

Hansen LL, Cludi-Magnussen C, Jensen SK and Andersen HJ. 2006. Effect of organic production system on performance and meat quality. Meat Sci. 74, 605–615.

Hansson J, Hamilton C, Ekman T and Forslund K. 2000. Carcass quality in certified organic production compered with conventional livestock production. J. Vet. Med. 47, 111–120.

Hardeng F and Edge VL. 2001. Mastitis, ketosis and milk fever in 31 organic and 93 conventional Norwegian dairy herds. J. Dairy Sci. 84, 2673.

Haug A, Hostmark AT and Harstad OM. 2007. Bovine milk in human nutrition-a review. Lipids in Health and Disease 6, 25 (www.lipidworld.com/content/6/I/25).

Haug A, Taugbol O, Olsen ES, Biong AS and Harstad OM. 2004. Milk fat in human nutrition. Studies in dairy cows with special reference to CLA. Animal Science Papers and Reports, Vol. 22, No 3, 381–390.

He K, Zhao L, Daviglus ML, Dyer AR, Van Horn L, Garside D, Zhu L, Guo D, Wu Y, Zhou B, Stamler J. 2008. Association of monosodium glutamate intake with overweight in Chinese adults: the INTERMAP Study. INTERMAP Cooperative Research Group. Obesity (Silver Spring). 16(8): 1875–80.

Heaton S. 2001. Organic farming, food quality and human health. Soil Association report, Bristol, UK, 87.

Hermansen JE, Badsbegr JH, Kristensen T and Gundersen V. 2005. Major and trace elements in organically or conventionally produced milk. J of Dairy Research 72, 362–368.

Hermanussen M, Garcia AP, Sunder M, Voigt M, Salazar V and Tresguerres JA. 2006. Obesity, voracity, and short stature: the impact of glutamate on the regulation of appetite. Eur J Clin Nutr. 60(1): 25–31.

Hernández P and Gondret F. 2006. Rabbit meat quality. In: Maertens L., Coudert P. (Eds.). Recent Advances in Rabbit Sciences. ILVO, Merelbeke, Belgium, 269–290.

Hidalgo A, Rossi M, Clerici F and Ratti S. 2008. A market study on the quality characteristics of eggs from different production systems. Food Chem 106, 1031–1038.

Hill MJ, Drasar V, Aries JS, Crowther S, Hawksworth G and Williams REO. 1971. Bacteria and aetiology of cancer of large bowel. Lancet 1: 95–100.

Hoffman M. 1991. Elektro-chemische Merkmale zur Differenzierung von Lebensmitteln. In: Meier-Ploeger A., Vogtmann H. (Hrsg.), Lebensmittelqualitaet – ganzheitliche Methoden und Konzepte. Mueller, Karlsruhe.

Holick MF. 2002. Vitamin D. Vitamin D, Skin, and Bone Research Laboratory, Section of Endocrinology, Diabetes and Nutrition. Department of Medicine. Boston University School of Medicine, Boston, MA.

Hord NG, Tang Y and Bryan NS. 2009. Food sources of nitrates and nitrites: the physiologic context for potential health benefits. Am J Clin Nutr. 90(1): 1–10.

Horoszkiewicz JJ, Korbas M, Jajor E and Krawczyk R. 2004. Mycotoxins content and colonization level in winter wheat grain cultivated in transition period following to ecological system. J Research and Appl in Agric Eng Vol. 55(3).

Horrobin DF. 1993. Fatty acid metabolism in health and disease: the role of delta-6-desaturase. Am J Clin Nutr. 57, 732S–736S.

Howard V. 2005. Pesticides and health. QLIF Congress, Newcastle upon Tyne, oral presentation.

Howard V. 2005. Pesticides and Health: International Congress: Organic Farming, Food Quality and Human Heath, Newcastle, UK.

Hu FB, Stampfer MJ, Manson JE, Rimm EB, Wolk A, Colditz GA, Hennekens CH and Willett WC. 1999. Dietary intake of (alpha)-linolenic acid and risk of fatal ischemic heart disease among women. Am J Clin Nutr. 69(5), 890–897.

Hu L, Fernstrom JD and Goldsmith PC. 1998. Exogenous glutamate enhances glutamate receptor subunit expression during selective neuronal injury in the ventral arcuate nucleus of postnatal mice. Neuroendocrinology. 68(2): 77–88

Huber M, Andersen J-O, Kahl J, Busscher N, Doesburg P, Mergardt G, Kretschmer S, Załęcka A, Meelursarn A, Ploeger A, Nierop D, van de Vijver L and Baars E. 2010. Standardization and Validation of the Visual Evaluation of Biocrystallizations. Biological Agriculture and Horticulture, Great Britain, 27: 25–40.

Huber M, van de Vijver L, Parmentier H, Savelkoul H, Coulier L, Wopereis S, Verheij E, van der Greef J, Nierop D and Hoogenboom RAP. 2009. Effects of organically and conventionally produced feed on biomarkers of health in a chicken model. Br J Nutr, 1–14.

Hughner RS, McDonagh P, Prothero A, Schultz CJ and Stanton J. 2007. Who are organic food consumers? A compilation and review of why peaple purchase organic food. J of Consumer Behaviour, 6: 94–110.

Huopalahti R, López-F R., Anton M and Schade R (eds). 2007. Bioactive Egg Compounds. Springer-Verlag, Heidelberg, pp. 298.

Ingver A, Koppel R, Tamm I and Tamm Ü. 2009. Comparison of baking quality of spring wheat cultivated in organic and conventional conditions (In Estonian). Agronomy 2009, Saku.

Ip C. 1997. Review of the effects of trans fatty acids, oleic acid, n-3 polyunsaturated fatty acids, and conjugated linoleic acid on mammary carcinogenesis in animals. Am Jo Clin Nutr, 66, 1523S–1529S.

ISO 17025. 2000. General requirements for the competence of testing and calibration laboratories. ISO, Geneva.

Iwata T, Incefy GS, Tanaka T, Fernandes G, Menendez-Botet CJ, Pih K and Good RA.1979. Circulating t hymic hormone levels in zinc defiency. Cell Immunol. 15;47(1): 100–5.

Jacobs DRJ, Slavin J and Marquart L. 1995. Whole grain intake and cancer: a review of the literature. Review. Nutrition & Cancer, 24(3), 221–9.

Jahreis G, Fritsche J and Steinhart H. 1997. Conjugated linoleic acid in milk fat: high variation depending on production system. Nutr Research. 17, 1479–1484.

Janicki K. 1991. Woda pitna na wsi jako czynnik zdrowia lub choroby. Materiały z and Ogólnopolskiego Forum Ekologii Wsi, Solina 31.V–2.VI. 1991: 27–43.

Jeffrey AM and Williams GM. 2000. Lack of DNA-damaging activity of five nonnutritive sweeteners in the rat hepatocyte/DNA repair assay. Food Chem. Toxicol. 38(4): 335–338.

Jensen MN. 2004. Organic diet and fertility – possible effects of diet on male reproductive parameters. M.Sc. Thesis, University of Southern Denmark, 34–47.

Jeroch H, Eder K, Schöne F, Hirche F, Böttcher W, Sesekeviciene J and Kluge H. 2002. Amounts of essentiall fatty acids, a-tocopherol, folic acid, selenium and iodine in designer eggs. International symposium on physiology of livestock, Lithuanian Veterinary Academy, pp. 31–32.

Jestoi M, Somma MC, Kouva M, Veijalainen P, Rizzo A, Ritieni A and Peltonen K. 2004. Levels of mycotoxins and sample cytotoxicity of selected organic and conventional grain-based products purchased from Finnish and Italian markets. Mol. Nutr. Food Res. 48: 299–307.

Joergensen V and Edlefsen O. 1987. Vanding af kartoffler, Kartoffel – nyt, 40,6, 22.

Johannessen GS, Bengtsson GB, Heier BT, Bredholt S, Wasteson Y and Rorvik LM. 2005. Potential uptake of Escherichia coli O157:H7 from organic manure into crisphead lettuce. Appl Environ Microbiol 71: 2221–5.

Juroszek P, Lumpkin HM, Yang R.-Y, Ledesma DR and Ma C-H. 2009. Fruit quality and bioactive compounds with antioxidant activity of tomatoes grown on-farm: comparison of organic and conventional management systems. J of the Agricultural and Food Chemistry, 57, 1188–1194.

Kahl J, Busscher N and Ploeger A. 2010. Questions on the validation of holistic methods of testing organic food quality. Biological Agriculture and Horticulture, 27, 81–94.

Kahl J. 2006. Entwicklung, in-house Validierung und Anwendnung des ganzheitlichen Verfahrens Biokristallisation für die Unterscheidung von Weizen-, Möhren- und Apfelproben aus unterschiedlichem Anbau und Verarbeitungsschritten. Praca habilitacyjna. Universität Kassel, Fachgebiet Ökologische Lebensmittelqualität und Ernährungskultur, Witzenhausen.

Kahu K, Jänes H, Luik A and Klaas L. 2009. Yield and fruit quality of organically cultivated blackcurrant cultivars. Acta Agriculturae Scandinavica, Section B-Plant Soil Science 59(1): 63–69.

Kahu K, Klaas L and Kikas A. 2010. Effect of cultivars and different growing tehnologies on strawberry yield and fruit quality. Agronomy Research, 8(3): 589–593.

Kalinova J and Vrchotova N. 2011. The influence of organic and conventional crop management, variety and year on the yield and flavonoid level in common buckwheat groats. In: Food Chemistry. Vol 127, pp. 602–508.

Kampa M, Nifli AP, Notas G and Castanas E. 2007. Polyphenols and cancer cell growth. Rev. Physiol. Biochem. Pharmacol. 159, 79–113.

Karadas F, Pappas AC, Surai PF and Speake BK. 2005. Embryonic development within carotenoid-enriched eggs influences the post-hatch carotenoid status of the chicken. Comp Biochem Physiol. B 141: 244–251.

Karstadt M. 2007. Testing needed for acesulfame potassium, an artificial sweetener. Correspondence. Environmental Health Perspectives. 114, 9.

Karwowska W. 1999. Ocena jakości mikrobiologicznej mleka w gospodarstwach ekologicznych and konwencjonalnych. In: Górny M. Porównanie ekologicznych and konwencjonalnych gospodarstw rolnych w Polsce. Wydawnictwo SGGW, Warszawa.

Katan MB. 2009. Nitrate in foods: harmful or healthy? Am J Clin Nutr. 90 (1): 11–12.

Kazimierczak R, Hallmann E, Rusaczonek A and Rembiałkowska E. 2008. Anioxidant content in black currants from organic and conventional cultivation. Food Sci Technol Res. 2(11), 57–61.

Kerry JP, Buckley DJ and Morrissey PA. 2000. Improvement of oxidative stability of beef and lamb with vitamin E. In: Decker E., Faustman C. and Lopez-Bote C.J. (Eds.). Antioxidants in muscle foods, nutritional strategies to improve quality. United States, Wiley, 229–261.

Kim DH, Seong PN, Cho SH, Kim JH, Lee JM, Jo C and Lim DG. 2009. Fatty acid composition and meat quality traits of organically reared Korean native black pigs. Livestock Sci 120, 96–102.

Kitts DD. 2005. Antioxidant properties of casein-phosphopeptides. Trends in Food Science & Technology, 16, 549–554.

Kobylewski S and Jacobson MF. 2010. Food dyes: A rainbow of risks. Washington, D. C.: Center for Science in the Public Interest. http://www.cspinet.org/new/pdf/food-dyes-rainbow-of-risks.pdf

Kolisko E and Kolisko L. 1923. Agriculture of Tomorrow. Printed by John Jennings, Gloucester.

Komeda K, Yokote M and Oki Y. 1980. Diabetic syndrome in the Chinese hamster induced with monosodium glutamate. Experientia. 36(2): 232–4.

Kondoh T and Torii K. 2008. MSG intake suppresses weight gain, fat deposition, and plasma leptin levels in male Sprague-Dawley rats. Physiol Behav. 95(1–2): 135–44.

Korhonen H, Marnila P and Gill HS. 2000. Milk immunoglobulins and complement factor. Br J Nutr, 84, 75–80.

Kouba M. 2003. Quality of organic animal products. Livestock Production Sci, 80, 33–40.

Kris-Etherton PM, Pearson TA, Wan Y, Hargrove RL, Moriarty K, Fishell V and Etherton TD. 1999. High-monounsaturated fatty acid diets lower both plasma cholesterol and triacylglycerol concentrations. Am J Clin Nutr. 70, 1009–15.

Kummeling I, Thijs C, Huber M, van de Vijver L.P, Snijders BE, Penders J, Stelma F, van Ree R, van den Brandt PA and Dagnelie PC. 2008. Consumption of organic foods and risk of atopic disease during the first 2 years of life in the Netherlands. Br J Nutr 99(3), 598–605.

Lairon D, Termine E, Gauthier S, Trouilloud M, Lafont H and Hauton JCh. 1984. Effects of organic and mineral fertilization on the contents of vegetables in minerals, vitamin C and nitrates, w: H, Vogtmann and in. (ed.) The Importance of Biological Agriculture in a World of Diminishing Resources. Proc. 5th IFOAM Conference, Verlagsgruppe, Witzenhausen.

Lairon D. 2009. Nutritional quality and safety of organic food. A review. Agronomy for Sustainable Development 30: 33–4.

Lamperti A and Blaha G. 1976. The effects of neonatally-administered monosodium glutamate on the reproductive system of adult hamsters. Biol Reprod 14: 362–369.

Lau KWG, McLean G, Williams DP and Howerd CV. 2006. Synergistic interactions between commonly used food additives in a developmental neurotoxicity test. Toxicol Sci 90(1): 178–187.

Lauridsen C, Jorgensen H, Halekon U, Lars-Porskjer Ch and Brandt K. 2005. Organic diet enhanced the health of rats. Newsletter from Danish Research Centre for Organic Farming 1, 2–11.

Lavin JH, French SJ and Read NW. 1997. The effect of sucrose-and aspartame-sweetened drinks on energy intake, hunger and food choice of female, moderately restrained eaters. Int J of Obestiy. 21, 37–42.

Lebas F, Lebreton L and Martin T. 2002. Statistics on organic production of rabbits on grassland. Cuniculture 164, 74–80.

Leclerc J, Miller ML, Joliet E and Rocquelin G. 1991. Vitamin and mineral contents of carrot and celeriac grown under mineral or organic fertilization, Biological Agriculture and Horticulture, 7, 339–348.

Leeson S and Caston LJ. 2003. Vitamin enrichment of eggs. J. Appl. Poult. Sci. Res. 12, 24–26.

Lim U, Subar AF, Mouw T, Hartge P, Morton LM, Stolzenberg-Solomon R, Campbell D, Hollenbeck AR and Schatzkin A. Consumption of aspartame-containing beverages and incidence of hematopoietic and brain malignancies. Cancer Epidemiol Biomarkers. 15(9): 1654–59.

Lima GPP and Vianello F. 2011. Review on the main differences between organic and conventional plant-based foods. Int J Food Sci & Techn. 46 (1), 1–13.

Lin H, Boylston TD, Chang MJ, Luedcke LO and Shultz TD. 1995. Survey of the conjugated linoleic acid contents of dairy products. J of Dairy Sci, 78, 2358–2365.

Lindmark-Månsson H and Åkesson B. 2000. Antioxidative factors in milk. Br J of Nutr 84, Suppl. 1, 103–110.

Lombardi-Boccia G, Lucarini M, Lanzi S, Aguzzi A and Cappelloni M. 2004. Nutrients and antioxidant molecules in yellow plums (Prunus domestica L.) from conventional and organic productions: A comparative study, J Agric Food Chem. 52, 90–94.

Lopez-Bote C., Diestre A and Monfort JM. 1998. Sustained utilization of the Iberian pig breed. Meat Sci. 49, 17–27.

Lu Ch, Toepel K, Irish R, Fenske RA, Barr DB and Bravo R. 2006. Organic diets significantly lower children's dietary exposure to organophosphorus pesticides. Environ. Health Perspect. 114(2), 260–263.

Lund P. 1991. Characterization of alternatively produced milk. Milchwissenschaft 46, 166–169.

Lundegardh B and Mårtensson A. 2003. Organically produced plant foods – evidence of health benefits. Acta Agric Scand B, 53, 3–15.

Luning PA, Marcelis WJ and Jongen WM. 2005. Zarządzanie jakością żywności. Ujęcie techno-logiczno-menadżerskie. Wydawnictwo Naukowo-Techniczne, Warszawa.

Luukkonen J, Kemppinen A, Karki M, Laitinen H, Maki M, Sivela S. Taimisto A-M and Ryhanen E-L. 2005. The effect of a protective culture and exclusion of nitrate on the survival of enterohemorrhagic E. coli and Listeria in Edam cheese made from Finnish organic milk. International Daily J 15, 449–457.

Macho L, Fickova M, Jezova and Zorad S. 2000. Late effects of postnatal administration of monosodium glutamate on insulin action in adult rats. Physiol Res. 49 Suppl 1: S79–85.

Mäder P, Hahn D, Dubois D, Gunst L, Alföldi T, Bergmann H, Oehme M, Amado R, Schneider H, Graf U, Velimirov A, Fließbach A and Niggli U. 2007. Wheat quality in organic and conventional farming: results of a 21 year field experiment, J Sci Food Agric. 87, 1826–1835.

Mäder P, Pfiffner L, Niggli U, Balzer U, Balzer F, Plochberger K, Velimirov A and Besson J-M. 1993. Effect of three farming systems (bio-dynamic, bio-organic, conventional) on yield and quality of beetroot (Beta vulgaris L. var. esculenta L.) in a seven year crop rotation. Acta Hor., 339, 10–31.

Magkos F, Arvaniti F and Zampelas A. 2003. Organic food: nutritious food or food for thought? A review of the evidence. Int J Food Sci Nutr. 54(5), 357–71.

Magnuson B and Williams GM. 2008. Carcinogenicity of aspartame in rats not proven. Correspondense. Environmental Health Perspectives. 116(6): 239–240.

Maki KC, Davidson MH, Ricklin MR, Ingram KA, Cyrowski M, Umporowicz DM, Bell M and Elliott JG. 2003. Bioavailability of Eicosapentaenoic and Docosahexaenoic n-3 Polyunsaturated Fatty Acids in Salmon Patties Compared with Capsules. J. Food Sci: 68(3): 761–764.

Marmer WN, Maxwell RJ and Williams JE. 1984. Effects of dietary regimen and tissue site on bovine fatty acid profiles. J Animal Sci. 59, 109–121.

Matt D, Veromann E and Luik A. 2009. Effect of housing system on biochemical composition of checken eggs. Agronomy Research, 7(2), 662–667.

Matthes HD and Pastushenko V. 1999. Einfluß der landwirtschaftlichen Produktionsweise auf den Fettsäurengehalt des Fleisches. Ernährungs-Umschau 46, 335–338.

Mattila P, Lehikoinen K, Kiiskinen T and Piironen V. 1999. Cholecalciferol and 25- hydroxycholecalciferol content of chicken egg yolk as affected by the cholecalciferol content of feed. J Agric Food Chem. 47, 4089–4092.

Mattila P, Rokka T, Konko K, Valaja J, Rossow L and Ryhanen EL. 2003. Effect of cholecalciferol-enriched hen feed on egg quality. J Agric Food Chem. 51, 283–287.

Mattila P, Valaja J, Rossow L, Venalainen E and Tupasela T. 2004. Effect of vitamin D-2- and D-3-enriched diets on egg vitamin D content, production, and bird condition during an entire production period. Poult Sci 83, 433–440.

Mazzoncini M, Belloni P, Risaliti R and Antichi D. 2007. Organic vs conventional winter wheat quality and organoleptic bread test. Proceedings of the 3rd International Congress of the European Integrated Project „Quality Low Input Food" (QLIF), March 20–23, 2007, University of Hohenheim, Germany: 135–138.

McCann D, Barrett A, et al. 2007. Food additives and hyperactive behaviour in 3-year old and 8/9-year old children in the community: a randomised, double-blinded, placebo-controlled trial." Lancet 370: 1560–1567.

McDowell LR. 2003. Minerals in animal and human nutrition. Elsevier.

McNamara DJ and Thesmar HS. 2005. Eggs. Encyclopedia of human nutrition. Allen L., Prentice A (eds). Elsvier, 86–92.

McNamara DJ. 2000. The impact of egg limitations on coronary heart disease risk: Do the numbers add up? J Am Coll Nutr. 19 (5 Suppl): 540S–548S.

McSheehy TW. 1977. Nutritive value of wheat grown under organic and chemical systems of farming. Qualitas Planitarum 27, 113–123.

Meelursarn A. 2006. Statistical evaluation of texture analysis from the biocrystallization method: Effect of image parameters to differentiate samples from different farming systems. Dissertation. University of Kassel, Witzenhausen.

Meinecke B. 1982. Effect of conventionally and organically produced feed stuff on the fertility of rabbits. Zentrablatt für Veterinarmedizin 29, 5–15.

Meluzzi A, Tallarico N, Manfreda G, Sirri F and Franchini A. 2000. Effect of dietary vitamin E on the quality of table eggs enriched with n-3 long chain fatty acids. Poultry Sci. 79, 539–545.

Mensink RP, Zock PL, Kester AD and Katan MB. 2003. Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. Am J Clin Nutr. 77, 1146–55.

Meydani M. 2000. Vitamin E and prevention of heart disease in high-risk patients. Nutrition Reviews, 8, 278–281.

Meyer KA, Kushi LH, Jacobs DRJr, Slavin J, Sellers TA and Folsom AR. 2000. Carbohydrates, dietary fiber, and incident type 2 diabetes in older women. Am J Clin Nutr, 71(4), 921–30.

Michalski M-C. 2007. On the supposed influence of milk homogenization on the risk of CVD, diabetes and allergy. Review Article. Br J Nutr. 97(4), 598–610.

Mikkonen TP, Maata KR, Hukkanen AT, Kokko HJ, Törrönen AR, Karmenlampi SO and Karjalainen RO. 2001. Flavonols content varies among blackcurrant cultivars. J Agric Food Chem. 49, 3274–3277.

Milinsk MC, Murakami AEM, Gomes STM, Matsushita M and de Souza NE. 2003. Fatty acid profile of egg yolk lipids from hens fed diets rich in n-3 fatty acids. Food Chemistry 3, 287–292.

Millet S, Cox E, Buyse J, Goddeeris BM and Janssens GPJ. 2005. Immunocompetence of fattening pigs fed organic versus conventional diets in organic versus conventional housing. Veterinary journal (London, England: 1997). 169(2): 293–9.

Millet S, Hesta M, Seynaeve M, Ongenae E, De Smet S, Debraekeleer J and Janssens GPJ. 2004. Performance, meat and carcass traits of fattening pigs with organic versus conventional hausing and nutrition. Livest Prod Sci 87, 109–119.

Minelli G, Sirri F, Folegatti E, Meluzzi A and Franchini A. 2007. Egg quality traits of laying hens reared in organic and conventional systems. Ital. J Anim Sci. 6(1), 728–730.

Mirvish SS. 1993. Vitamin C inhibition of N-nitroso compounds formation. Am J Clin Nutr. 57, 598–599.

Mitchell AE, Hong YJ, Koh E, Barrett DM, Bryant DE, Denison RF and Kaffka S. 2007. Ten-year comparison of the influence of organic and conventional crop management practices on the content of flavonoids in tomatoes. J Agric Food Chem. 55, 6154–6159.

Moore J, Hao Z, Zhou K, Luther M, Costa J and Yu L. 2005. Carotenoid, tocopherol, phenolic acid and antioxidant properties of Maryland-grown soft wheat. J Agric Food Chem. 53: 6649–6657.

Moreira MR, Roura SI and Valle CE Del. 2003. Quality of Swiss chard produced by conventional and organic methods. Lebensm.-Wiss. U.-Technol., 36, 135–141.

Mugnai C, Dal Bosco A and Castellini C. 2009. Effect of rearing system and season on the performance and egg characteristics of Ancona laying hens. Ital J Anim Sci, 8, 175–188.

Mukherjee A, Speh D, Dyck E and Diez-Gonzalez F. 2004. Preharvest evaluation of coliforms, Escherichia coli, Salmonella, and Escherichia coli O157:H7 in organic and conventional produce grown by Minnesota farmers. J Food Prot 67: 894–900.

Nabe EC. 1979. The effect of nutrition on the composition of eggs. Poultry Sci. 58, 518–528.

Naber EC. 1993. Modifying vitamin composition of eggs: a review. J Appl Poultry Res. 2, 385–393.

Nagata M, Suzuki W, Iizuka S, Tabuchi M, Maruyama H, Takeda SAburada M and Miyamoto K. 2006. Type 2 diabetes mellitus in obese mouse model induced by monosodium glutamate. Exp Anim. 55(2): 109–15.

Napolitano F, Girolami A and Braghieri A. 2009. Organic meat: market development and consumer willingness to pay. In: Organic Farming: Methods, Economics and Structure (Ed-s: Nelson M and Artamova I). Nova Science Publishers, Inc.

National Toxicology Program USDoHaHS. 2003. Toxicity studies of aspartame (CAS No. 22839-47-0) in FVB/N-TgN (v-Ha-ras) Led(Tg.AC) hemizygous mice and carcinogenicity studies of aspartame in B6.129-Trp53tm1Brd (N5) haploinsufficient mice. NTP Technical Report (NIH Publication No. 03-4459).

Nauta WJ, Baars T and Bovenhuis H. 2006. Converting to organic dairy farming: Consequences for production, somatic cell scores and calving interval of first parity Holstein cows. Livestock Sci 99, 185–195.

Nemeroff CB. 1981. Monosodium glutamate-induced neurotoxicity: review of the literature and call for further research. In: Miller SA, ed. Nutrition & Behavior. Philadelphia: The Franklin Institute Press.

Ng-Kwai-Hang KF, Hayes JF, Moxley JE and Monardes HG. 1984. Association of genetic variants of casein and milk serum proteins with milk, fat, and protein production by dairy cattle. J Dairy Sci. 67: 835–840.

Nielsen JH, Lund-Nielsen T and Skibsted L. 2004. Higher antioxidant content in organic milk than in conventional milk due to feeding strategy. DARCOF enews, Newsletter from Danish Research Centre for Organic Farming, 3.

Niijima A, Togiyama T and Adachi A. 1990. Cephalic-phase insulin release induced by taste stimulus of monosodium glutamate (umami taste). Physiol Behav. 48(6): 905–8.

Nilzen V, Babol J, Dutta PC, Lundeheim N, Enfält AC and Lundstrom K. 2001. Free range rearing of pigs with access to pasture grazing – effect on fatty acid composition and lipid oxidation products. Meat Sci. 58, 267–275.

Odum J, Lefevre PA, Tittensor S, Paton D, Routledge EJ, Beresford NA, Sumpter JP and Ashby J. 1997. The rodent uterotrophic assay: critical protocol features, studies with nonyl phenols, and comparison with a yeast estrogenicity assay. Reg Toxicol Pharmacol 25, 176–188.

Ohguro H, Katsushima H, Maruyama I, Maeda T, Yanagihashi S, Metoki T and Nakazawa M. 2002. A high dietary intake of sodium glutamate as flavoring (ajinomoto) causes gross changes in retinal morphology and function. Exp Eye Res. 75(3): 307–15.

Oliveira M, Usall J, Viñas I, Anguera M, Gatius F and Abadias M. 2010. Microbiological quality of fresh lettuce from organic and conventional production. Food of Microbiology 27 (5): 679–684.

Olney JW. 1969. Brain lesions, obesity and other disturbances in mice treated with monosodium glutamate. Science 164: 719–721.

Olsson V, Andersson K, Hansson I and Lundström K., 2003. Differences in meat quality between organically and conventionally produced pigs. Meat Sci. 64 (3), 287–297.

Orton F, Rosivatz E, Scholze M, Kortenkamp A. 2011. Widely used pesticides with previously unknown endocrine activity revealed as in vitro anti-androgens. Environ Health Perspectives.

Ortuno A, Benavente-Garcia O, Castillo J, Alcaraz M, Vicente V and Del Rio J.A. 2007. Beneficial action of citrus flavonoids on multiple cancerrelated biological pathways. Curr Cancer Drug Targets. 7, 795–809.

Overmeyer S and Taylor E. 1999. Annotation: Principles of treatment for hyperkinetic disorder: Practice Approaches for the U.K.Journal of Child Psychology and Psychiatry, 40: 1147–1157.

Paci G, Lisi E, Maritan A and Baglacca M. 2003. Reproductive performance in a local rabbit population reared under organic and conventional system. Annali della Facolta di Medicina Veterinaria, LVI/20, 115–126.

Padel S. 2005. Exploring the gap between attitudes and behaviour. Br Food J, 107 (8), 606–625.

Palmquist DL, Stelwagen K and Robinson PH. 2006. Modifying milk composition to increase use of dairy products in healthy diets. Animal Feed Sci and Techn. 131(3–4), Special Issue: Modifying Milk Composition, 149–153.

Parodi PW. 1977. Conjugated octadecadienoic acids of milk fat. J Dairy Sci, 60, 1550–1553.

Parodi PW. 1999. Conjugated linoleic acid and other anticarcinogenic agents of bovine milk fat. J Dairy Sci, 82, 1339–1349.

Parodi PW. 2007. A role for milk proteins and their peptides in cancer prevention. Current Pharmaceutical Design, 13(8), 813–828.

Pastuschenko V, Matthes H-D, Hein T and Holzer Z. 2000. Impact of cattle grazing on meat fatty acid composition in relation to human nutrition. Proceedings of the 13th International IFOAM Scientific Conference (ed. T. Alföldi, W. Lockeretz, U. Niggli), Basel, Switzerland. 293–296.

Pennycook FR, Diamand EM, Watterson A and Howard W. 2004. Modeling the dietary pesticide exposures of young children. Int J Occupational and Environmental Health, 10 (3), 304–309.

Perez-Lopez AJ, Fortea MI, Amor FM del, Serrano-Martinez A and Nunez-Delicado E. 2007. Influence of agricultural practices on the quality of sweet pepper fruits as affected by the maturity stage. J Sci Food and Agric, 87, 2075–2080.

Pestana S, Moreira M and Olej B. 2010. Safety of ingestion of yellow tartrazine by double-blind placebo-controlled challenge in 26 atopic adults. Allergologia et Immunopathologia (Madr), 38, 142–146.

Petterson BD. 1978. A comparison between the conventional and biodynamic farming systems as indicated by yields and quality. In: International IFOAM Conference – Towards a Sustainable Agriculture – Sissach.

Pfeiffer E. 1969. Die Fruchtbarkeit der Erde (5th edn). Rudolf Geering, Dornach.

Pfeiffer E. 1984. Chromatography applied to quality testing. Bio-Dynamic Literature, Wyoming, Rhode Island.

Pfeuffer M and Schrezenmeir J. 2000. Bioactive substances in milk with properties decreasing risk of cardiovascular disease. Br J Nutr. 84 (1), 155–159.

Pihlanto A. 2006. Antioxidative peptides derived from milk proteins. Int Dairy J 16, 1306–1314.

Pla M, Hernandez P, Arino B, Ramirez JA and Diaz I. 2007. Prediction of fatty acid kontent in Rabbit meat and discrimination between conventional and organic production systems by NIRS methodology. Food Chem. 100, 165–170.

Pla M. 2008. A comparison of the carcass traits and meat quality of conventionally and organically produced rabbits. Livestock Sci 115, 1–12.

Plochberger K, Velmirov A, Huspeka U and Schott W. 1992. The influence of biologically and conventionally cultivated food on the fertility of rats. Biological Agriculture and Horticulture. 8. pp. 325–337.

Plochberger K. 1989. Feeding experiments. a criterion for quality estimation of biologically and conventionally produced foods. Agric Ecosyst Environ 27, 419–428.

Pogorzelska E, Dzieniszewski J, Reguła A and Kafel S. 1990. Azotany and azotyny w racjach pokarmowych dzieci przedszkolnych. Rocz. PZH, 41,1–2: 58–62.

Popp FA. 1991. Biophotonen – Analyse der Lebensmittelqualitaet In: Meier-Ploeger A., Vogtmann H., Lebensmittelqualitaet – ganzheitliche Methoden und Konzepte. Mueller, Karlsruhe.

Poupoulis C, Salepi M, Skapetas B and Touska M. 2009. Fatty acid composition of hens' egg yolk from conventional, organic, omega-3 and free range farming types. Epitheōrēsē Zōotehnikēs Epistēmēs 40, 73–84.

Pradhan SN and Lynch JFJr. 1972. Behavioral changes in adult rats treated with monosodium glutamate in the neonatal state. Arch Int Pharmacodyn Ther 197: 301–304.

Prandini A, Geromin D, Conti F, Masoero F, Piva A and Piva G. 2001. Survey on the level of conjugated linoleic acid in dairy products. It J Food Sci, 13, 243–253.

Pussemier L, Larondelle Y, Peteghem C and Huyghebaert A. 2006. Chemical safety of conventionally and organically produced food stuffs: a tentative comparison under Belgian conditions. Food control, 6: 14–21.

QLIF (Quality Low Input Food). 2008. www.qlif.org

Quist MA, Blanc SJ, Hand KJ, Lazenby D, Miglior F and Kelton DF .2008. Milking to milking variability for milk yield, fat and protein percentage, and somatic cell count. J Dairy Sci 91(9): 3412–3423.

Ramos S. 2007. Effects of dietary flavonoids on apoptotic pathways related to cancer chemoprevention. J Nutr Biochem 18, 427.

Rapisarda P, Calabretta ML, Romano G and Intrigliolo F. 2005. Nitrogen metabolism components as a tool to discriminate between organic and conventional citrus fruits. J Agric Food Chem. 53 (7), 2664–2669.

Rascher K and Mesters P. 1980. Reaction of the hypothalamic ventricular lining following systemic administration of MSG. Scan Electron Microsc. (3): 457–64.
Reif-Lehrer L, Bergenthal J and Hanninen L. 1975. Effects of monosodium glutamate on chick embryo retina in culture. Invest Ophthalmol. 14(2): 114–24.
Rejmer P. 1997. Podstawy ekotoksykologii. Wydawnictwo Ekoinżynieria, Lublin, 208 ss.
Rembiałkowska E and Rutkowska B. 1996. Comparison of sensory, nutritional and storage quality of potatoes from ecological and conventional farms. In: Proc. of the 5th International Conf. “Quality for European Integration” (ed. Szafran M., Kozioł J., Małecka M.), Poznań, 382 –385.
Rembiałkowska E and Srednicka D. 2009. Organic food quality and impact on human health, Agronomy Research 7 (Special issue II): 181–186.
Rembiałkowska E, Adamczyk M and Hallmann E. 2003b. Jakość sensoryczna and wybrane cechy jakości odżywczej jabłek z produkcji ekologicznej and konwencjonalnej. Bromat. Chem. Toksykol., 36, 33–40.
Rembiałkowska E, Hallmann E and Szafirowska A. 2005. Nutritive quality of tomato fruits from organic and conventional cultivation. Culinary Arts and Sciences V. Global and National Perspectives. (ed. Edwards JSA, Kowrygo B, Rejman K): 193–202.
Rembiałkowska E, Hallmann E and Wasiak-Zys G. 2003a. Jakość odżywcza and sensoryczna pomidorów z uprawy ekologicznej and konwencjonalnej. Żywienie Człowieka and Metabolizm, 30, 893–899.
Rembiałkowska E, Hallmann E, Adamczyk M, Lipowski J, Jasińska U and Owczarek L. 2006. Wpływ procesów technologicznych na zawartość polifenoli ogółem oraz potencjał przeciwutleniający przetworów (soku and kremogenu) uzyskanych z jabłek pochodzących z produkcji ekologicznej and konwencjonalnej. Żywność, Technologia Jakość, 1(46), Suplement, 121–126.
Rembiałkowska E, Kazimierczak R, Średnicka D, Bieńko K and Bielska M. 2008. Different aspects of organic and conventional food consumers lifestyle. New Medicine 1, 16–19.
Rembiałkowska E, Wasiak-Zys G and Adamczyk M. 2004. Porównanie wybranych cech jakości jabłek oraz ich przetworów z produkcji ekologicznej and konwencjonalnej. In: Wybrane zagadnienia ekologiczne we współczesnym rolnictwie. Monografia (red. Z. Zbytek). Przemysłowy Instytutu Maszyn Rolniczych, Poznań: 143–155.
Rembiałkowska E. 1998. Badania porównawcze jakości zdrowotnej and odżywczej marchwi and białej kapusty z gospodarstw ekologicznych and konwencjonalnych. Rocz. AR Pozn. CCCIV, Ogrod., 27, 257–266.
Rembiałkowska E. 2000. Zdrowotna and sensoryczna jakość ziemniaków oraz wybranych warzyw z gospodarstw ekologicznych. Rozprawa habilitacyjna. Fundacja Rozwój SGGW, Warszawa.
Rembiałkowska E. 2007. Quality of plant products from organic agriculture. J Sci Food Agric, 87: 2757–2762.
Ren H, Endo H and Hayashi T. 2001. Antioxidative and antimutagenic activities and polyphenol content of pesticide-free and organically cultivated green vegetables using water-soluble chitosan as a soil modifier and leaf surface spray. J Sci Food Agic. 81, 1426–1432.
Renwick AG and Sims J. 1982. Distension of the urinary bladder in rats fed saccharin containing diet. Cancer Let. 18(1): 63–8
Richter ED. 2002. Acute Human Pesticide Poisonings. Encyclopedia of Pest Management, Taylor & Francis, 3–6.
Rickman Pieper J and Barrett DM. 2009. Effects of organic and conventional production systems on quality and nutritional parameters of processing tomatoes. J Sci Food Agric, 89, 177–194.
Rist L, Mueller A, Barthel C, Snijders B, Jansen M, Simões-Wüst AP, Huber M, Kummeling I, von Mandach U, Steinhart H and Thijs C. 2007. Influence of organic diet on the amount of conjugated linoleic acids in breast milk of lactating women in the Netherlands. Br J Nutr. 97 (4), 735–43.
Ritieni A. 2003. Patulin in Italian commercial apple products. J Agric Food Chem. 51(20): 6086–6090.
Rizzi L, Simioli M, Martelli G, Paganelli R and Sardi L. 2006. Effects of organic farming on egg

quality and welfare of laying hens. XII European Poultry Conference, Verona , Italy , 10–14 September 2006.
Rizzi L, Simioli M, Martelli G, Paganelli R and Sardi L. 2006. Effects of organic farming on egg quality and welfare of laying hens. World's Poultry Sci J. 62, pp. 165 XII European Poultry Conference, Verona 10–14 September.
Robinzon B, Snapir N and Perek M. 1975. The relation between monosodium glutamate inducing brain damage, and body weight, food intake, semen production and endocrine criteria in the fowl. Poult Sci. 54(1): 234–41.
Roesch M, Doherr MG and Blum JW. 2005. Performance of dairy cows on swiss farms with organic and integrated production. J Dairy Sci. 88, 2462–2475.
Rosati A and Aumaitre A. 2004. Organic dairy farming in Europe. Livestock Production Sci. 90, 41–51.
Rossi F, Godani F, Bertuzzi T, Trevisan M, Ferrari F and Gatti S. 2008. Health-promoting substances and heavy metal content in tomatoes grown with different farming techniques. Eur J Nutr. 47, 266–272.
Ruth van S, Alewijn M, Rogers K, Newton-Smith E, Tena N, Bollen M and Koot A. 2011. Authentication of organic and conventional eggs by carotenoid profiling. Food Chemistry 126, 1299–1305.
Rutkowska G. 1999. Badania zawartości azotanów and azotynów w warzywach uprawianych ekologicznie and konwencjonalnie. Przem. Spoż. 6: 47–49.
Ryan MH, Derrick JW and Dann PR. 2004. Grain Mineral Concentrations and Yield of Wheat Grown under Organic and Conventional Management. J Sci Food and Agric 84, no. 3, pp. 207–216.
Samaras J. 1978. Nachernteverhalten unterschiedlich geduengter Gemusearten mit besonderer Berucksichtigung physiologischer und mikrobiologiscer Parameter. Schriftenreihe "Lebendige Erde" Darmstadt.
Samman S, Kung FP, Carter LM, Foster MJ, Ahmad ZI, Phuyal JL and Petocz P. 2009. Fatty acid composition of certified organic, conventional and omega-3 eggs. Food Chemistry 116, 911–914.
Sasaki YF, Kawaguchi S, Kamaya A, Ohshita M, Kabasawa K, Iwama K, Taniguchi K and Tsuda S. 2002. The comet assay with 8 mouse organs: results with 39 currently used food additives. Mutat. Res. 519, 103–119.
Sato K, Bartlett PC, Erskine RJ and Kaneene JB. 2005. A comparison of production and management between Wisconsin organic and conventional dairy herds. Livestock Production Sci. 93, 105–115.
Schaack D. Willer H and Padel S. 2011. The organic market in Europe. The World of Organic Agriculture. Statistics and Emerging Trends 2011. FiBL-IFOAM Report. Eds.: Helga Willer and Lukas Kilcher. IFOAM, Bonn and FiBL, Frick.
Schab DW and Trinh NH. 2004. Do artificial food colors promote hyperactivity in children with hyperactive syndromes? A meta-analysis of double-blind placebo-controlled trials". Journal of developmental and behavioral pediatrics : JDBP 25 (6): 423–34.
Schlatterer J and Breithaupt DE. 2006. Xanthophylls in commercial egg yolks: Quantification and identification by HPLC and LC–(APCI) MS using a C30 phase. J of Agric and Food Chem, 54, 2267–2273.
Schoenig GP, Goldenthal EI, Geil RG, Frith CH, Richter WR and Carlborg FW. 1985. Evaluation of the dose response and in utero exposure to saccharin in the rat. Food Chem Toxicol 23: 475–490.
Schollenberger M, Jara HT, Suchy S, Drochner W and Müller HM. 2002. Fusarium toxins in wheat flour collected in area in southwest Germany. Int J Food Microbiology, (72), 85–89.
Schuphan W. 1974. Nutritional value of crops as influenced by organic and inorganic fertilizer treatments – Qualitas Plantarum – Pl.Fds. Hum.Nutr.XIII, 4, 333–358.
Schwenk W. 1991. Trinkwasser – seine belebenden Eigenschaften und deren Darstellung mit der Tropfenbildmethode. In: Meier-Ploeger A., Vogtmann H., Lebensmittelqualitaet – ganzheitliche Methoden und Konzepte. Mueller, Karlsruhe.
Scott PP, Greaves JP and Scott MG. 1960. Reproduction in laboratory animals as a measure of the value of some natural and processed foods. J Reprod Fert. 1, 130–138.

Seuss-Baum I. 2007. Nutritional Evaluation of Egg Compounds. In Huopalahti, R., López-F, R., Anton, M., Schade, R. (eds): Bioactive egg compounds. Springer-Verlag, Heidelberg, chapter 18, pp. 132.

Severin S and Wenshui X. 2005. Milk biologically active components as nutraceuticals: Review. Critical reviews in Food Sci and Nutr 45, 645–656.

Shankar S, Ganapathy S and Srivastava RK. 2007. Green tea polyphenols: biology and therapeutic implications in cancer. Front Biosci. 12, 4881.

Sindelar CA, Scheerger SB, Plugge SL, Eskridge KM, Wander RC and Lewis NM. 2004. Serum lipids of physically active adults consuming omega-3 fatty acid-enriched eggs or conventional eggs. Nutr Res 24(9): 731–9.

Sirri F and Barroeta A. 2007. Enrichment in Vitamins. In: Huopalahti, R., López-F, R., Anton, M., Schade, R. (eds): Bioactive egg compounds. Springer-Verlag, Heidelberg, chapter 21, pp. 171.

Sisk DR, Kuwabara T. 1985. Histologic changes in the inner retina of albino rats following intravitreal injection of monosodium L-glutamate. Graefes Arch Clin Exp Ophthalmol. 223(5): 250–8.

Skvortsova Z., Henno M and Leming R. 2008. Mahe ja tavapiima rasvhappeline koostis (Fatty acid composition in organic and conventional milk. Master Thesis, Estonian University of Life Sciences.

Słoniewski K, Sakowski T, Jóźwik A and Rembiałkowska E. 2005. The influence of the grazing season on polyunsaturated fatty acids content in cow milk fat from Bieszczady Region of Poland. Proceedings of the 4th SAFO Workshop, Frick, Switzerland.

Smith B. 1993. Organic foods vs. Supermarket foods: element levels. J Appl Nutr, 45, 35–39.

Soffiritti M, Belpoggi F, Tibaldi E, Esposti DD and Lambertini L. 2007. Life-span exposure to low doses of aspartame beginning during prenatal life increases cancer effects in rats. Environmental Health Perspectives. 115(9): 1293–1297.

Soffritti M, Belpoggi F, Esposti DD and Lambertini L. 2005. Aspartame induces lymphomas and leukemias in rats. Eur J Oncol 10, 107–116.

Soffritti M, Belpoggi F, Esposti DD, Lambertini L, Tibaldi E and Rigano A. 2006. First experimental demonstration of the multipotential carcinogenic effects of aspartame administered in the feed to Spargue-Dawley rats. Environmental Health Perspectives. 114(3): 379–385.

Soffritti M. 2006. Acesulfame Potassium. Cerrespondence. Soffritti responds. Environmental Health Perspoctives. 114(9): 516–517.

Spadaro D, Ciavorella A, Frati S, Garibaldi A and Gullino ML. 2008. Occurrence and level of patulin contamination in conventional and organic apple juices marketed in Italy. Poster at: Cultivating the Future Based on Science: 2nd Conference of the International Society of Organic Agriculture Research ISOFAR, Modena, Italy, June 18–20, 2008.

Staiger D. 1986. The influence of conventional vs. organic fodder on fertility, health condition and quality of rabbit meat. M.Sc. Thesis, University of Bonn, Germany, 35–61.

Stepień M, Sokół-Leszczyńska B and Łuczak M. 2007. Mykotoksyny, produkty spożywcze a zdrowie człowieka. Post Mikrobiol. 46, 2, 167–177.

Stertz SC, Santos RMI and Sossela De Freitas RJ. 2005. Qualidade nutricional e contaminantes da batata (solanum tuberosum L., solanaceae) convencional e orgânica na regio metropolitana de curitiba – paraná. B.CEPPA, Curitiba, v. 23, n. 2, jul./dez., 383–396.

Stolarczyk A and Socha I. 1992. Azotany, azotyny and nitrozoaminy w pożywieniu niemowląt and małych dzieci w Polsce. Medycyna 2000: 41–43.

Stracke BA, Ruefer CE, Bub A, Briviba K, Seifert S, Kunz C and Watzl B. 2008. Bioavailability and nutritional effects of carotenoids from organically and conventionally produced carrots in healthy men, Br J. Nutr Forthcoming, 1–9.

Sundrum A and Acosta AY. 2003. Nutritional strategies to improve the sensory quality and food safety of pork while improving production efficiency within organic framework conditions. Report of EU-project, Improving Quality and Safety and Reduction of Costs in the European Organic and 'Low Input' Supply Chain, CT-2003 506358.

Sundrum A, Butfering L, Henning M and Hoppenbrock KH. 2000. Effects of on-farm diets for organic pig production on performance and carcass quality. J Anim Sci. 78, 1199–1205.

Szente V, Szakaly S, Bukovics ZS, Szigeti O, Polereczki ZS, Szekely O, Berke SZ, Takacs GY,

Nagyne Farkas R and Szakaly Z. 2006. The role of CLA content of organic milk in consumers' healthcare. Materiały konferencyjne Joint Organic Congress, Odense, Denmark. www.orgprints.org/7207/
Szponar L and Kierzkowska E. 1990. Azotany and azotyny w środowisku oraz ich wpływ na zdrowie człowieka. Post. Hig. Med. Dośw., 44, 327–350.
Szponar L and Traczyk J. 1995. Azotany and azotyny w żywności, racjach pokarmowych and płynach biologicznych. Żyw. Człow. Metab. 22: 66–77.
Szteke B. 1992. Wpływ skażeń chemicznych na zdrowotność surowców and przetworów owocowo- warzywnych. Przem. Ferm. Owoc. Warz. 8: 13–17.
Świątkowski A. 1980. Zatrucie azotanami and azotynami u niemowląt. Pol. Tyg. Lek. 35: 1035 –1037.
Tamm I, Tamm Ü and Ingver A. 2009. Suviteraviljade proteiinisisaldus tava- ja maheviljeluses. Agronoomia 2009 (78–81), Eds. Tamm S, Schmidt R.
Tarozzi A, Hrelia S, Angeloni C, Morroni F, Biagi P, Guardigli M, Cantelli-Forti G and Hrelia P. 2006. Antioxidant effectiveness of organically and non-organically grown red oranges in cell culture systems. Eur J Nutr. 45: 152–158.
Taylor G.C. and Zahradka P., 2004. Dietary conjugated linoleic acid and insulin sensitivity and resistance in rodent models. Am J of Clinical Nutr 79(Supl.6), 1164S–1168S.
Taylor JM, Weinberger MA and Friedman L. 1980. Chronic toxicity and carcinogenicity to the urinary bladder of sodium saccharin in the in utero-exposed rat. Toxicol. appl. Pharmacol., 54, 57–75.
TemaNord. 2002. Food additives in Europe 2000; Status of safety assessments of food additives presently permitted in the EU. TemaNord 2002: 560.
The Swedish Monitoring of Pesticide Residues in Food of Plant Origin. 2003. Livsmedelsverkets rapport nr 12/2003.
The Swedish Monitoring of Pesticide Residues in Food of Plant Origin. 2004. EC and National Report, Livsmedelsverkets rapport nr 12/2004.
Tikofsky LL, Barlow JW, Santisteban C and Schukken YH. 2003. A comparison of antimicrobial susceptibility patterns for Staphylococcus aureus in organic and conventional dairy herds. Microb Drug Resist. 9 Suppl 1, 39.
Toledo P, Andren A and Bjorck L. 2002. Composition of raw milk from sustainable production systems. Int Dairy J 12, 75–80.
Tõnutare T, Moor U, Mölder K, Põldma P. 2009. Fruit composition of organically and conventionally cultivated strawberry 'Polka'. Agronomy Research 7: 755–760.
Toome M. 2011. The results of monitorings of pesticide residues in Estonia (2008 and 2009) and in Europe (2008) – comparixon of results (Taimekaitsevahendite jääkide seire tulemused Eestis 2008 ja 2009 ning Euroopas 2008 – tulemuste võrdlus). Report, Saku, Estonia.
Toor RK, Savage GP and Heeb A. 2006. Influence of different types of fertilizers on the major antioxidant components of tomatoes. J Food Comp Anal, 19, 20–27.
Toth L, Karcsu S, Feledi J and Kreutzberg GW. 1987. Neurotoxicity of monosodium-L-glutamate in pregnant and fetal rats. Acta Neuropathol (Berl). 75(1): 16–22.
Troy DJ. 1995. Modern methods to improve and control meat quality. In: International developments in process efficiency and quality in the meat industry. Dublin Castle, Ireland, 57–72.
Tyburski J and Żakowska-Biemans S. 2007. Wprowadzenie do rolnictwa ekologicznego. Wydawnictwo Szkoły Głównej Gospodarstwa wiejskiego, Warszawa.
Vaarst M and Enevoldsen C. 1997. Patterns of clinical mastitis manifestations in Danish organic dairy herds. J Dairy Res. 64: 23.
Van den Brand H, Parmentier HK and Kemp B. 2004. Effects of housing system (outdoor vs cages) and age of laying hens on egg characteristics. Br Poultry Sci, 45, 745–752
Van den Eeden SK, Koepsell TD, Longstreth WT, van Belle G, Daling JR and McKnight B. 1994. Aspartame ingestion and headaches. Neurology. 44(10): 1787–93.
Van Poppel G. 1993. Carotenoids and cancer: an update with emphasis on human intervention studies. Eur J Cancer. 29, 1335–1344.
Velimirov A, Plochberger K, Huspeka U and Schott W. 1992. The influence of biologically and conventionally cultivated food on the fertility of rats. Biol Agric Hortic 8, 325–337.

Velimirov A. 2001. Ratten bevorzugen Biofutter. Oekologie & Landbau 117, 19–21.

Velimirov A. 2002. Integrative Qualitaetsmethoden im Zusammenhang mit der P-Wert_Bestimmung. Tagungsband 9. Internationale Tagung Elektrochemischer Qualitaetstest, 30.05.–01.06.2002, Institut fuer Gemuesebau und Blumenproduktion, Mendel-Universitaet.

Velimirov A. 2005. The consistently superior quality of carrots from one organic farm in Austria compared with conventional farms. In: Proceedings of the 15th IFOAM Organic World Congress: Researching and Shaping Sustainable Systems, ed. by Köpke U., Niggli U., Neuhoff D., Cornish P., Lockeretz W. and Willer H., Adelaide, 21–23.

Versari A, Parpinello GP and Mattioli AU. 2007. Survey of Patulin Contamination in Italian Apple Juices from Organic and Conventional Agriculture. J of Food Technology, 5 (2): 143–146.

Vogtmann 1991. In Lassen J. Paper – Food Quality and the Consumers. 1993.

Vogtmann H, Temperli AT, Kunsch U, Eichenberger M and Ott P. 1984. Accumulation of nitrates in leafy vegetables grown under contrasting agricultural systems. Biol Agric Hort, 2, 51–68.

Vogtmann H. 1985. Ökologischer Landbau – Landwirtschaft mit Zukunft. Pro Natur Verlag, Stuttgart, pp. 159.

Walshe BE, Sheehan EM, Delahunty CM, Morrissey PA and Kerry JP. 2006. Composition, sensory and shelf life stability analyses of Longissimus dorsi muscle from steers reared under organic and conventional production systems. Meat Sci 73, 319–325.

Wang SY, Chen CT, Sciarappa W, Wang CY and Camp MJ. 2008. Fruit quality, antioxidant capacity, and flavonoid content of organically and conventionally grown blueberries. J Agric Food Chem. 56, 5788–5794.

Warman PR. and Havard KA. 1997. Yield, vitamin and mineral contents of organically and conventionally grown carrots and cabbage. Agriculture, Ecosystems and Environment, 61, 155–162.

Wawrzyniak A, Hamułka J and Gołębiewska M. 2004. Ocena zawartości azotanów (V) and azotanów (III) w wybranych warzywach uprawianych konwencjonalnie and ekologicznie, Bromatologia and Chemia Toksykologiczna, 4: 341–345.

Weibel FP, Bickel R, Leuthold S and Alfoldi T. 2000. Are organically grown apples tastier and healthier? A comparative field study Rusing conventional and alternative methods to measure fruit quality. Acta. Hortic., 7, 417–427.

Weibel FP, Treutter D, Haseli A and Graf U. 2004. Sensory and healthrelated quality of organic apples: a comparative field study over three years using conventional and holistic methods to assess fruit quality. 11th International Conference on Cultivation Technique and Phytotpathological Problems in Organic Fruit Growing; LVWO: Weinsberg, Germany, 185–195.

Weihrauch MR and Diehl V. 2004. Artificial sweeteners – do they bear a carcinogenic risk? Annals of Oncology 15, 1460–1465.

Weiss D, Hilger M, Meyer HHD and Bruckmaier RM. 2002. Variable milking intervals and milk composition. Milchwissenschaft 57: 246–249.

Whigham LD, Cook ME and Atkinson RL. 2000. Conjugated linoleic acid: implications for human health. Pharmacological Research 42(6), 503–10.

WHO Technical Report Series No. 513, 1973. Safe use of pesticide: twentieth report of the WHO Expert Committee on Insecticides.

WHO. 2010. World Health Statistics 2010. WHO Statistical Information System. http://www.who.int/whosis/whostat/EN_WHS10_Full.pdf

Willer H. 2011. Organic Agriculture in Europe: Overview. The World of Organic Agriculture. Statistics and Emerging Trends 2011. FiBL-IFOAM Report. Eds.: Helga Willer and Lukas Kilcher. IFOAM, Bonn and FiBL, Frick.

Williams CM. 2002. Nutritional quality of organic food: shades of grey or shades of green? Proc Nutr Society, 61, 19–24.

Winter CK and Davis SH. 2006. Organig foods. J Food Sci 71(9): 117–124.

Woese K, Lange D, Boess C and Bögl KW. 1997. A Comparision of Organically and Conventionally Grown Foods-Results of a Review of the Relevant Literature. J Sci Food Agric. 74(3): 281–193.

Wood JD, Enser M, Fisher AV, Nute GR, Richardson RI and Shed PR. 1999. Manipulating meat quality and composition. Proc. Nutr Society. 58, 363–370.

Wood JD, Richardson RI, Nute GR, Fisher AV, Campo MM, Kasapidou E, Sheard PR. and Enser M. 2003. Effects of fatty acids on meat quality: a review. Meat Sci 66, 21–32.

Woodward BW and Fernandez MI. 1999. Comparison of conventional and organic beef production systems II. Carcass characteristics. Livestock Prod. Sci. 61, 225-231.41-147.

Worthington V. 2001. Nutritional quality of organic versus conventional fruits, vegetables, and grains. The J Alt and Compl Med, 7/2, 161–173.

Wunderlich SM, Feldman C, Kane S and Hazhin T. 2008. Nutritional quality of organic, conventional, and seasonally grown broccoli using vitamin C as a marker, Int. J. Food Sci. Nutr. 59, 34–45.

Young JE, Zhao X, Carey EE, Welti R, Yang S-S and Wang W. 2005. Phytochemical phenolics in organically grown vegetables. Mol Nutr Food Res. 49, 1136–1142.

Zadoks JC. 1989. Development of farming systems. Evaluation of the five-year period 1980–1984. Pudoc, Wageningen.

Załęcka A, Kahl J, Doesburg P, Pyskow B, Huber M, Skjerbaek K and Ploeger A. 2010. Standardization of the Steigbild Method. Biological Agriculture and Horticulture, Great Britain, 27: 41–57.

Załęcka A. 2006. Entwicklung und Validierung der Steigbildmethode zur Differenzierung von ausgewählten Lebensmitteln aus verschiedenen Anbausystemen und Verarbeitungsprozessen. Praca doktorska. Universität Kassel, Fachgebiet Ökologische Lebensmittelqualität und Ernährungskultur, Witzenhausen.

Zörb C, Langenkämper G, Betsche T, Niehaus K and Barsch A. 2006. Metabolite profiling of wheat grains (Triticum aestivum L) from organic and conventional agriculture. J Agric Food Chem. 54, 8301–8306.

Zuchowski J, Jonczyk K, Pecio L and Oleszek W. 2011. Phenolic acid concentrations in organically and conventionally cultivated spring and winter wheat. J Sci of Food Agric. 91: 1089–1095.