Review

Need for research to support consumer confidence in the growing organic food market

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This paper investigates the state-of-the-art of organic food with respect to the law (certification, inspection, and labelling), the market, the customer, and organic food itself.

In spite of research work carried out on different aspects of organic food, there is not yet a method/methods for routine use in authentication of organic food products. The issues of organic food safety and potential nutritional benefits are also under study as controversial claims.

Research work to support and meet the needs of farmers and markets concerning claims on authenticity, safety and nutritional values of organic crops is necessary and discussed in this paper.

Background

The stakeholders

Organic farming is likely to receive a major boost in the European Union and most probably also worldwide since consumers have lost some trust in food derived from conventional production. This is due to recent crises (e.g. mad cow disease, foot-and-mouth epidemic, Belgian dioxin scandal), and also due to concerns regarding use of pesticides in farming and antibiotics in livestock feed. The large increase in organic farming stems from a variety of rationales: (i) to preserve the earning capability of farmers in a world that needs less producers to feed the well-fed part of the world's population; (ii) to preserve the rural countryside as such; (iii) to use cultivation methods that will conserve the soil and contribute to sustainability. (Mayfield, Holt, & Tranter, 2001). These drivers from the supply side are coupled with growing demand because of the safety worries mentioned above. However, potential customers do not get appropriate answers to the general marketing claims and to the public perception of organic food products. Thus, the organic market is growing fast, but market demand is not stable (Hamm, 2001).

It must, however, also be mentioned that organic food may not be safer than conventionally grown food. A recent scandal in Germany regarding contaminated organic meat products caused by contaminated animal feed suggests that organic products cannot be given total trust either.

Following the farmer's decision it takes at least 2–3 years to convert from conventional to organic farm. In order to take such a decision, the farmer should be convinced that the conversion will pay off and that there will be buyers for the organic crops. The consumers, on the other hand, want to know what they buy.

In the following we outline selected key players in the organic food markets, and will discuss their roles. We will present the need for answers for the customers in many aspects of this field, and will comment on few of the surveys of the research on organic agriculture and its products that were already carried out so far.

In order to have better answers to questions from customers and legislators, more and better-structured research on organic food should be carried out. This research work should involve farmers and farmers' organizations, rural authorities, food scientists, food industry experts and nutrition scientists, as well as social and market survey experts.

Fig. 1 shows the key stakeholders in organic agricultural products. The topic of organic food is affected by inputs from organic farming, the law, and the individual customer that eventually makes the market. The use of non-edible

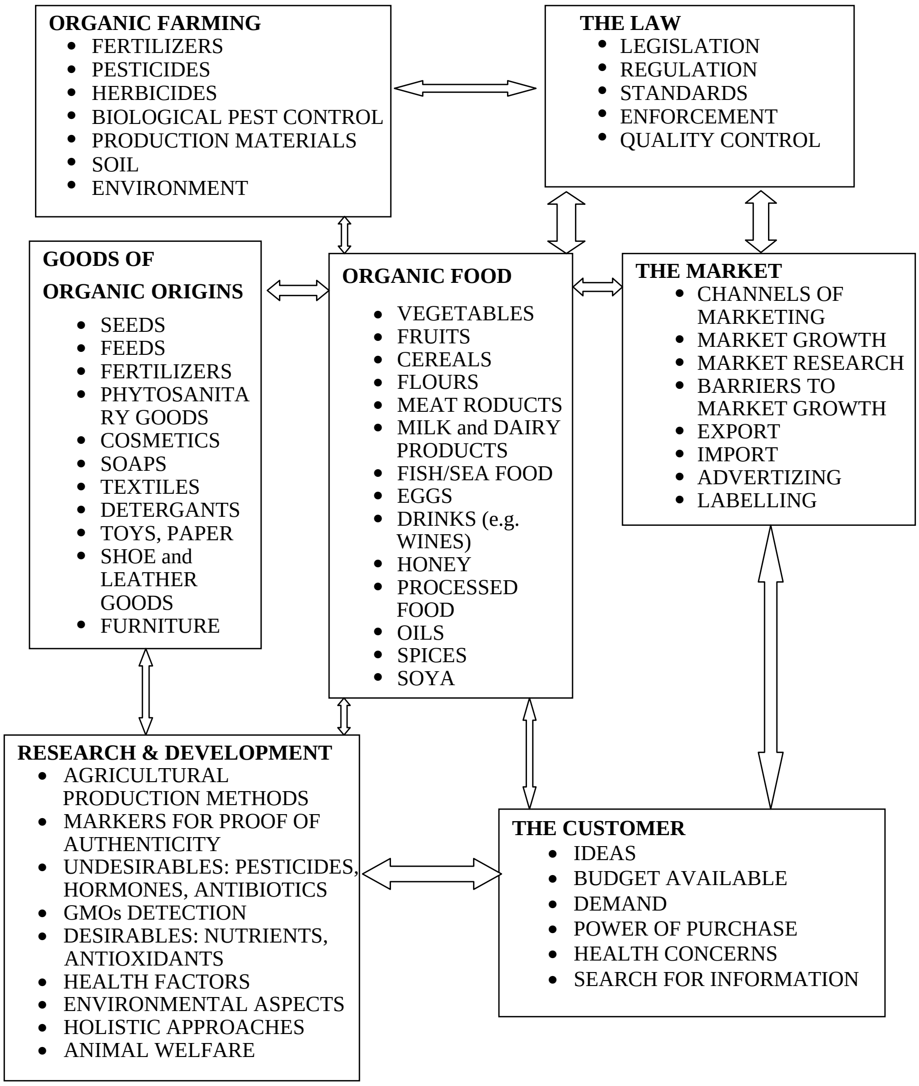

Fig. 1. The players in the organic game.

goods is not discussed here. There can be research work related to each of the subjects listed in this figure.

The market

An overview compiled by the International Trade Centre (ITC) in January 2002 estimated world retail sales for organic food and beverages (in 16 European countries, USA and Japan) at about \$17.5 billion (US) in 2000 and about \$21 billion (US) in 2001. Based on estimates, they were set to reach \$23–25 billion (US) in 2003 (in 23 European countries, USA, Canada, Japan and Oceania), and will probably be around \$29–31 billion (US) in 2005 (Yussefi & Willer, 2003). In the United States alone, industry sources estimated that organic food sales reached \$9.5 billion (US) in 2001. Conventional grocery stores began integrating a wider selection of organic products in the late 1990s and now account for about 49% of total organic sales, about the same as natural food stores (48%). Direct markets, such as farmers markets, captured 3% of total organic sales to US consumers in 2000 (Greene, 2000).

The growth area devoted to organic agriculture is rapidly increasing all over the world. According to the Stiftung Oekologie and Landbau (SOEL-survey, February 2003), almost 23 million hectares are managed organically worldwide (Yussefi & Willer, 2003). Most of the area is in Australia/Oceania (*ca*. 10.5 million hectares), Latin America (*ca*. 4.7 million hectares; Argentina: *ca*. 3.2 million hectares), and the European Union, (*ca*. 4.4 million hectares). The countries in Europe that have the greatest land area of organic agriculture in comparison with conventionally grown products are Liechtenstein, Austria, Switzerland, and Italy. Oceania holds 46% of the world organic land. The organic agriculture share of the total agricultural area is the highest in Europe, about 2.2% (Yussefi & Willer, 2003).

Fig. 2 presents a flow chart of the stream of food from the field to the consumer. There is added economic value in each of these steps.

It was previously stated that much of the additional costs for organic food that consumers are facing are

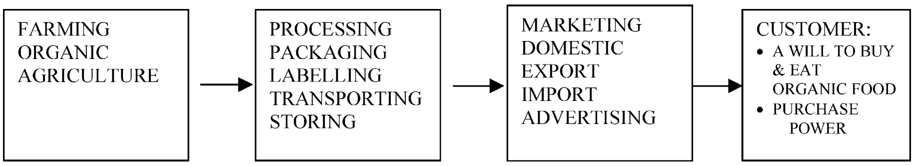

Fig. 2. Organic food flow chart.

generated in the distribution and processing network. That has to do with handling relatively small quantities of product. If supply increases in coming years, there is great potential for cost reduction due to economies of scale in the processing and distribution systems. For that reason, the premium paid by the consumer should be able to come down while not affecting to a great extent the premium received by the farmer. In this respect, the role of the large food chains is of importance. It was the penetration into organic sales and promotion by Sainsbury's supermarkets and other supermarket chains that increased greatly the exposure of organic food to the general public. This, in turn, increased the organic food processing industry and all the related market activities (Fig. 2), and caused reduction in some organic food prices (Wright & McCrea, 2000).

Voices that criticise the organic production system also claim that fresh conventional food that was grown near the market and was consumed close to the time it was picked in the field, has better nutritional value than food from an organic production system that sometimes has to be transported long distance. In addition to the perceived lower nutritional value, the cost of transportation in terms of energy consumption and the resulting contamination burden on the environment should make such production less favourable (Desai & Riddlestone, 2003).

Standards and legislation

The organic farming movement was started almost a century ago (Balfour, 1943). It gained a growing interest from the public and government in the 1960s, after the publication of Rachel Carson's book, 'Silent Spring' (Carson, 1963). During the past two decades, organic farming and organic food markets became large enough to call for legislation in order to organize farming procedures and marketing routes.

Organic products need written certification that the product is made according to the standards of the organic agriculture. This certification has several roles. It allows the customer to distinguish between organic and conventional products. The standards of the organic agriculture were developed in the past mainly by private organizations of farmers. These organizations allowed the farmers, who were complying with their standards, to use the logo of the organization (Kahal, 2000). In the past decade more standards were included in governmental regulations. These regulations dictate the terms that apply to a product marketed as an organic product. Nevertheless, there is no worldwide standard for organic agriculture. Different organizations and governments define differently what is an organic product and what certification process it needs, thus making international trade in organic products difficult. Harmonization of standards or an international process is necessary to make the comparison between various standards and for the development of worldwide trade in organic products.

The International Federation of Organic Agriculture Movements (IFOAM) developed a basic standard for organic production in 1998 that was revised in 2002 (IFOAM, 2002) as a framework for further developing organic standards around the world that are suitable to the specific growth conditions in each place. The aim of IFOAM is to achieve greater similarity between the various standards. IFOAM has established an organization named the International Organic Accreditation Service (IOAS) that certifies other organizations that control farmers and manufacturers according to standards and control methods accepted by IFOAM (2002).

Another international organization that develops standards for organic products is the Codex Alimentarius Commission (intergovernmental body under the auspices of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) of the United Nations). This organization established in 1999 (revised in 2001) a proposal for a worldwide standard of production and marketing for organic foodstuffs (Codex Alimentarius Commission, 2001). Its aim is to develop free international trade by creating international standards. These standards are the basis for solving trade conflicts by the World Trade Organization (WTO).

The European Union has regulated the organic products market in a set of laws such as EC Regulation No. 2092/91 and EC Regulation No. 1804/99. According to this legislation, a product can only be marketed as an organic product, when it is produced according to the production rules given in the law. The definition of the principles of organic production by the farmer, the materials that are allowed to be used for fertilization and plant protection, the minimal requirements for control and guidelines applied to processed products are also stated. European law is based in many parts on the basic standards of IFOAM and there are few essential differences.

Organic products that are imported into the European Union have to meet standards and controls equivalent to those of the EU. There are two ways to fulfil this requirement: (i) The EU can certify that a third country acts according to the standards and control measures equivalent to those of the EU (Argentina, Australia, the Czech Republic, Hungary, Israel, New Zealand, and Switzerland are already holders of such certificates); (ii) Every country in the EU may certify an importer to import organic products from a country that is not listed above. In order to get such certification, documents are needed showing that the standards and control methods of the imported product are equivalent to the standards and methods of the EU. This is a complicated process that makes the export from the many countries that are not members of the EU and do not receive the third country status cited above rather difficult.

The list of regulations enacted in Europe, Japan, and the USA are given in Box 1. Other countries like Switzerland, Canada, Australia, New Zealand each have their own Organic Farming Regulations (Yussefi & Willer, 2003).

Inspection and certification

The inspection procedures called for in the various regulations consist of: checking the farm, it's storage house, discussing with the farmers the methods of cultivation used, and getting their signature for their statements. No systematic analytical control is called for; e.g. to verify the farming procedures used and the possible presence of pesticides, fertilisers, or other chemicals, in the soil or its products.

The European Commission (Directorate General Health and Consumer Protection) has appointed its inspectors to check the conformation of each state to the Regulation related to organic farming. Inspection reports are available on the web site of the European Commission at http://www.europa.eu.int/comm/food/fs/inspections/fnaoi/reports/organic_farming/index_en.html. In addition, each country or organization has established its regulatory, inspection, and accreditation system, in order to enforce its rules. Each country has its own inspectors who visit the farms, the processing industry, packaging and labelling sites. The inspections cover mostly the following: farm maps, distance from neighbouring fields, farm diary, inputs bought in, their storage and use, source of seed and plant supplies, irrigation water, details of packing.

Some findings by European Commission inspections were the following: (i) in some cases the same varieties

Box 1

- Council Regulation (EEC) No. 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. OJ L 198, 22.7.1991, p.1.
- Council Regulation (EC) No. 1804/1999 of 19 July 1999 supplementing Regulation (EEC) 2092/91 on organic production of agricultural products and indication referring thereto on agricultural products and foodstuffs to include livestock production. OJ L 222, 24.8.1999, p. 1.
- Council Regulation (EEC) No 2078/92 of 30 June 1992 on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside. OJ L 215, 30.7.1992, p. 85.
- Council Regulation (EEC) No 2081/92 of 14 July 1992 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs. OJ L 208, 24.7.1992, p. 1.
- Council Regulation (EEC) No 2082/92 of 14 July 1992 on certificates of specific character for agricultural products and foodstuffs. OJ L 208, 24.7.1992, p. 9.
- Council Regulation (EC) No 1257/1999 of 17 May 1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF) and amending and repealing certain Regulations. OJ L 160, 26.6.1999, p. 80.
- Commission Regulation (EC) No 331/2000 of 17 December 1999 amending Annex V to Council Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. OJ L 048, 19.2.2000, p. 1.The EU label for organic products is optional for the operators for promotion of products. Its use is on condition established by Article 10 of (EEC) Regulation No. 2092/91 amended by the Council Regulation (EC) No. 1935/95 of 22 June 1995.

Each European country has its own rules following the guidelines stated above. Yussefi and Willer, (2003) published recently (2003) a list of about 60 countries that have already implemented their system or are on the way to doing so.

Further information on organic farming including regulation in Europe is available at http://europa.eu.int/comm/agriculture/foodqual/sustain_en.htm.

- IFOAM—International Federation of Organic Agriculture Movements—Basic Standards 2002 (IFOAM, 2002). Though not a law by itself, the material gathered for the standards is used for preparing the laws. The full text is available on http://www.ifoam.org/standard/norms/cover.html.
- Codex Alimentarius: Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods (GL 32-1999, Rev. 1–2001) (FAO and WHO joint organization) (Codex Alimentarius Commission, 2001). The full text is available on http://www.codexalimentarius.net/publications.stm.
- In the USA, National Organic Program (NOP) was established recently under direction of the Agricultural Marketing Service (AMS), an arm of the United States Department of Agriculture 'USDA') in December 20, 2000. This program establishes national standards for the production and handling of organically grown agricultural products. This program is authorised under the Organic Foods Production Act of 1990, as amended. Further information on NOP is available on http://www.ams.usda.gov/nop/indexIE.htm.
- Japan—Two National Standards: 'Japanese Agricultural Standards of Organic Agricultural Products' and 'Japanese Agricultural Standards of Organic Agricultural Product Processed Foods', were issued by the Ministry of Agriculture, Forestry and Fisheries of Japan in January 2000. The full texts are available on http://www.maff.go.jp/soshiki/syokuhin/hinshitu/e_label/index.htm.

are grown organically and non-organically by the same farmer; (ii) the inspection system covers only plant products produced in the country and intended for export; (iii) sufficient guarantees could not be given that products not subject to the official market controls would not be exported; (iv) preventive measures to avoid accidental spraying or drift (e.g. of pesticides) from greenhouses in the neighbourhood were not sufficient; (v) an old registered trademark of the main exporter might be seen as a misleading reference to organic farming.

Recommendations given after the visits were, for example, that the authorities should improve the technical supervision of the inspection bodies in order to ensure that (i) the internal quality control of the inspection work is satisfactory; (ii) the current practice of separation of organic and conventional plots in order to avoid accidental spraying or drift from neighbouring conventional fields must be reviewed; (iii) the inspection bodies must ensure that unannounced inspection is carried out on a regular basis, in particular at intensive farms, and at the establishment of processors; (iv) the competent authorities should request from inspection bodies that they take samples for residue analysis in case there is any suspicion of the use of unauthorised products; (v) positive results should be reported; and from there to the inspection bodies; (vi) the import authorisation process should be improved in order to prevent imports being released on the market prior to authorisations; and (vii) the authorities should take appropriate measures to address inadequacies in the inspection system.

Adding up some of the notes and recommendations of the inspectors, it could be assumed that it is not unlikely that a farmer who was not inspected for a while, and who is using organic and conventional cultivating methods, will, even by accident, send non-organic products to the organic market. This is only one of many erroneous, not to mention fraud, scenarios that could potentially happen.

Calls have been made for the simplification and harmonisation of organic farming regulations (Deane, 2001). One of the concerns is that the regulatory system may not offer sufficient guarantees to supply confidence in organic food.

There are about 100 different standards on organic agricultural products around the world. On top of these are government standards. Certification bodies are faced with the prospects of meeting those requirements for their exporting licences. But the system's biggest failure is that it makes the assumption that a product is produced in one country. This is often not the case with processed food. Governments do not have to undertake the work of evaluating a foreign certification system. The establishment of a worldwide international standard could be a solution. However, IFOAM standards are not integrated into the regulatory system.

Labelling

European legislation describes what is allowed to be labelled as 'organic' (see Box 1), the exemption of up to 5% of the ingredients from being of organic agriculture, and the list of ingredients that should appear on the label.

A report of the United States Department of Agriculture tracks the economic theory behind food labelling (Greene, 2000). A labelling tree is presented, in which labelled information is a result of an entire private standards system, including testing, certification and enforcement, or alternatively a whole government standards system, or a combination of both systems.

As organic producers want to stay in business, the organic premium must cover the differences in farm production practices as well as differences in processing and transportation cost, including segregation costs. They certainly have a financial incentive to advertise that information, as consumers cannot visually distinguish organic food from conventional food. Thus, consumers must rely on labels and other advertising tools for product information. Firms would have no way of acquiring a price premium without labels (Greene, 2000).

The following two examples illustrate the experience of one author concerning reading of organic labels and the difficulties of understanding the labels. The first example was the attempt to trace back the origin of ingredients in malt wafers bought in a local Italian organic food shop. The package had the ECO logo, with the words 'Biologisch, Ōkologisk, Organic, Biologique' surrounding the central ECO symbol. The list of ingredients on the cellophane packaging material, written in seven languages, included nine different ingredients. Eight of these, excluding salt, had an asterisk and a footnote stating '*Verified organically grown'. A written request was sent to the producer in order to gain knowledge about the origin of these ingredients. The answer obtained included attached documents showing the certificates of the company as a certified organic producer for a duration of two years. However the country of origin of all ingredients was not given. If organic labelling should relieve the consumer from worrying about the origin of food, in this case it only partly does so. Accreditation papers are useful but do not give the answer of where does what we eat come from, and whether in those countries of origin the ingredients exported were properly grown and inspected.

The second example relates to various food products also bought in an Italian organic food shop. Their logos are varied, the terms used are different and certification labels not recognisable. The labels have to be studied carefully in order to understand which one is of what kind of agricultural system. For instance, one apple juice container had a label of an organic producer using its own system of cultivation rules. Thus, if organic farming as a source of organic food is to grow further, harmonisation of methods, certification and labelling is called for. Moreover, the need of analyses and tests of merchandise, to verify their authenticity and safety should be considered.

Promotion of organic farming

European action plan

Organic food and farming is becoming a major opportunity for food producers in Europe, due to growing consumer interest for certified organic products. This is a precondition for developing a market for organic food and creates income for farmers.

Organic farming seems to be a highly relevant tool, which contains the potential to participate in solving simultaneously a range of problems related to food production, environment, animal welfare, and rural development. There is a trend that organic food and farming will be developed further in Europe. In order to facilitate partnerships and actions also at European level, the Copenhagen Declaration called upon the Council, the European Commission and the national governments to ensure that the process towards a European Action Plan will continue (The Danish Ministry of Food Agriculture and Fisheries, 2001). Barriers for further potential growth should be investigated and a consensus-oriented market based strategy prepared. It should include all stakeholders, and cover all aspects concerning the development of organic food and farming in Europe such as environmental protection, animal welfare, consumer behaviour, market development, food safety, food quality, regulation, certification and labelling, research, and international trade.

Since the Copenhagen conference, several European countries are developing national action plan (e.g. France (Saddier, 2003) or United Kingdom (DEFRA, 2002)).

United Kingdom

The UK Agriculture Committee on Organic Farming noted the need for the expansion of the organic sector to be sustainable and proposed the development of partnerships which will benefit all those in the supply chain for organic produce (House of Commons - Agriculture Committee, 2001; House of Lords - Select Committee, 1999). The Government agreed with these sentiments and noted particularly the Committee's view that there is a strong case for caution over the extent to which Government support helps expand and the rate at which land is brought into organic farming. It is the market that will be the principal determinant. The Committee drew attention to consumer demands for organic produce, and the perception, which some consumers have, of the benefits organic production methods provide. The Committee called for more work to be done to establish a scientific basis on which claims made for organic produce can be founded. The Government agreed entirely that consumers must be given sound information on which to base judgements about what they buy. Finally, the Government is presently addressing through its R&D program the need to conduct appropriate research on certain aspects of organic production, such as more effective organic production methods and environmental issues.

The UK Government response to claims made for organic food is that there is no evidence to enable it to state unequivocally that any of the many claims made for organic food are always and invariably true. All claims need to be properly evaluated in order to help consumers make their own judgements on the benefits of organic produce.

Comparison of organic with conventional food products

As there is a strong need for analytical work to be carried out in order to answer questions on organic food authenticity and safety, we consider several reviews comparing organically and conventionally grown food products (AFSSA, 2003; Bourn & Prescott, 2002; Finesilver, Johns, & Hill, 1989; Heaton, 2001; Saffron, 1998; Woese, Lange, Boess, & Werner Bögl, 1997). The possibility of including analytical tests in the inspection process and labelling regulation will also be discussed.

Different research methodologies such as market-oriented supply studies, surveys, and cultivation tests have been applied to compare conventionally and organically produced foods (Vetter, von Abercron, Bischoff, Kampe, Klasink, & Ranff, 1987). In Table 1 the main findings cited by Woese *et al*. (1997) are summarised. It is interesting to point out that the conclusions of the studies are hard to evaluate, partly because the number of samples for each crop is not large enough, partly because different methods are used in different studies.

Food quality

The papers of Finesilver *et al*. (1989), Woese *et al*. (1997), and Worthington (1998) review the quality of conventionally or organically produced foods or food produced with the aid of different fertilisation systems. Woese *et al*. (1997) examine more than 150 comparative studies on the foods produced, including cereals, potatoes, vegetables, fruit, wine, beer, bread, cakes and pastries, milk, eggs, and honey as well as products made from them. Most of the studies evaluated are physico-chemical investigations of concentrations of desirables and undesirable ingredients, pesticide residues and environmental contaminants as well as sensory tests and feeding experiments on animals.

Despite difficulties in the compilation and generalisation of results, some differences in quality between conventionally and organically produced foods or food produced with the aid of different fertilisation systems were revealed.

Conventionally cultivated or mineral fertilised vegetables seem to have a far higher nitrate content than organically produced or fertilised vegetables. Higher nitrate contents are to be found above all in what are known as nitrophillic leaf, root and tuber vegetables. A trend towards this difference could also be identified in the case of potatoes.

In respect to the pesticides permitted in conventional agriculture, lower residue levels could be expected in both vegetables and fruit from organic production. But there has

Table 1. Summarising comparative studies of crops and foods from organically and conventionally growth systems

Food	No. of compared studies	Parameters	Discussion	Conclusion
Cereals and cereal products	30	Nutritional quality; processing properties	Only one survey observed cadmium content in malting barley was significantly higher in conventional cultivation	Pesticides: no general comment; heavy metals contents: no clear difference
Potatoes	22	Pesticides	No sufficient data	Nitrate difference due to difference in the intensity of fertilisation
		Nutritional and/or sensory properties; vitamin C	No clear difference in nitrate content, or slight trend towards a lower nitrate content in organic potatoes	Clear difference in mineral content or trace elements could not be derived from 8 evaluated studies. Higher P and K values in organic potatoes. Contradicting results on Vitamin C. No clear answer for starch.
Vegetables and vegetable products	70	Contamination of harvested crops	Half—shortcoming. Small number of samples so that general statement cannot be made	A slight trend towards lower levels of pesticides' residues in organic produced vegetables
		Nitrate; vitamin A, B1, B2, C	Vitamin C–no clear statement	Lower nitrate content in organic vegetables. No difference–A, B1, B2
Fruit and fruit products, nut products and oil seed	10–15	Heavy metals contamination	Very few comparative studies addressed the issue of qualitative differences between fruits, nuts and oil seeds from organic and conventional cultivation.	No differences in two studies.
		Nitrate concentration	Limited spectrum of species examined in different studies: apples, pineapples, strawberries, oranges and lemons. Thus general statements are scarcely possible on the basis of the data available.	Very low nitrate concentration. No differences were found between conventional and organic fruit.
		Desirable ingredients: vitamins, carbohydrates, proteins, free amino acids		No major differences could be observed between fruit (apples, pineapples, strawberries) from organic and conventional production. The concentration of dry matter and the sensory properties did not vary much. In apples, the difference between varieties has greater influence on the ingredients than different cultivation forms.
		Aflatoxin content in peanut butter		Products from alternative production had higher contents of total aflatoxin and aflatoxin B_1.
Wine	5	Contamination of plant by pesticides	No significant differences between grape must and wine from organic and conventional production in respect to concentration of desirable ingredients, and parameters such as ethanol, sugar, total acid and extract.	It is not generally possible to differentiate between the cultivation methods on the basis of residue levels of fungicides and insecticides.
Beer	2	Quality	Apart from the protein content, the beers did not show any differences in desirable ingredients. The contents of nitrate and nitrite and highly halogenated hydrocarbons are the same in alternative and conventionally produced beer. Beer brewed with organically grown raw material had a lower protein content, due to lower protein content of the barely used.	No definite statement, two different methods of classification.
Bread	6	Quality	No major differences could be determined in connection with the pollutant content and the content of desirable ingredients	
Milk and dairy products	9	Quality	Production form differed mostly in respect with the feed given to the animals. Problem: Inclusion of animals of different breeds within the individual studies.	
Meat and meat products	4 (pork only)		No general conclusion; not uniform studies at all	

(*continued on next page*)

Table 1 (*continued*)

Food	No. of compared studies	Parameters	Discussion	Conclusion
Eggs	1	Effect of living conditions of hens on contents of protein, lecithin and carotenoid in eggs	Lower protein content, higher lecithin values and higher total carotenoid contents in hens from free-range husbandry in comparison with eggs from hens in cages	One comparative study only; thus no general conclusions
Honey	1		No difference in the concentration of desirable ingredients, pesticide residues, veterinary medicinal products or sensory properties	No General statement
Nutritional tests			No nutritional tests in man. Difficult tests to carry out and evaluate since all the factors, which influence human health, must be kept constant for the test persons. Also, ethical reservation.	No extensive conclusions can be drawn from the available few results (1940s tests)
Feeding experiments with animals	22			In 5 out of 6 studies it was clearly recognisable that the test animals preferred organically produced products.
Further studies	11		Alternative, holistic methods—ascending imaging method, round filter chromatography and copper chloride crystallisation	Organic products have higher form-shaping ability and thus have more vital activity than the corresponding conventionally produced products or minerally fertilised foods.

been very little documentation on residue levels. In addition, few pesticides families have been analysed (SETRABIO, 2000). In the case of conventionally cultivated produce, the European Commission has published the report of the 2001 pesticide residue monitoring programme (European Commission, 2003). The report compiles EU-wide analyses of pesticide residues in 46,000 samples of fruits, vegetables and cereals. The residue levels found fall within a range that would not cause harm if eaten: 59% of the samples contained no detectable residues at all while 37% of the sample contained detectable residues at or below the maximum residue level (MRL). On average, 3.9% of samples exceeded the MRL, ranging from 1.3 to 9.1% in different Member States.

However, the recent scandal in 2002 regarding the use of a banned pesticide shows how important the analysis of substances beyond those permitted is. The compound nitrofen has been identified firstly in wheat from organic farming, that was used as poultry feed, but has been found in conventionally produced food as well (Anonymous, 2002a,b).

Contamination with banned persistent, chlorinated hydrocarbons did not appear to constitute in any products a suitable criterion of differentiation for products of both production systems. The dioxin scandal in Belgium of 1999 showed that there is no guarantee that these persistent compounds are only present in food at low concentrations (from environment) as fraudulent practice can never be excluded. Contrary to the nitrofen scandal, the evidence of high concentrations of polychlorinated biphenyls and dioxins were primarily discovered in conventionally produced meat products.

It has been observed that dry matter concentration is higher in organic food especially in the case of vegetables and in particular leaf vegetables in comparison with conventionally grown or mineral fertilised products. This supports the view that excessive fertilisation stimulates rapid growth that increases the yield of crops partly by simply swelling them with a higher water content (Heaton, 2001). In fact, there is a positive correlation between dry matter and nutrient content, and a negative correlation between dry matter and nitrate content in plants. Therefore, it is important that nutrient and nitrate levels are reported and compared on a fresh weight basis.

Nutritional value and technological aspects

Nutritional value studies comprising chemical analysis of organic and conventional foods purchase from retailers examined the effect of different fertiliser treatments on the nutritional quality of crops, analysis of organic and conventional foods produced on organically and conventionally managed farms, and the effect of organic and conventional feed/foods on animal and human health (Bourn *et al*., 2002; Finesilver *et al*., 1989; Heaton, 2001; Woese *et al*., 1997; Worthington, 2001). However, it is again very difficult to compare findings because of the varying study designs and study duration.

With regard to other desirable nutritional values, either no major differences were observed in physico-chemical analyses between the products from different production systems or contradictory findings did not permit any clear statement. The same applies to sensory tests, although there is evidence that organically grown potatoes taste better than conventionally grown after a period of storage.

High nitrogen application to plant foods can increase crude protein concentration but decrease the nutritional value of that protein. This may be because nitrogen from organic fertiliser sources is often released slowly and is therefore less readily available to plants than from chemical sources. Nonetheless, sufficient data do not exist to support or reject this speculation. In cereals, there are differences in terms of processing properties. Given its higher protein content and superior protein quality for baking requirements (Worthington, 1998), conventionally grown or mineral fertilised wheat corresponds better with common baking requirements.

The ultimate test of the nutritional value of food is its ability to support health, growth and reproduction over successive generations of animals or humans. In feed selection experiments it has been shown that animals differentiate between foods from the various agricultural systems and prefer organic produce. Feed experiments with animals, in which fertility parameters and rearing performance were determined, produced a contradictory picture. Nonetheless, it is possible that carefully controlled studies might show real differences in the quality of organically versus conventionally grown foods.

A comprehensive review of existing research has found significant differences between organically and non-organically grown food (Heaton, 2001). These differences relate to food safety, primary nutrients, secondary nutrients, and health outcomes demonstrated by feeding trials. This review claims to be different from previous inconclusive studies as a result of extracting criteria that have been introduced to establish the adequacy of the methodologies of research. It is stated that each comparative study had been screened against clear criteria before inclusion in the review. The content of vitamin C was higher, on average, in organically grown crops. Mineral contents were also found to be higher, on average, in organically grown crops, although the small number and heterogeneous nature of the studies included means that more research is needed to confirm this finding. In addition, the large number of variables affecting vitamin and mineral composition of plants have made it very difficult to draw conclusions on the effect of agricultural practices on these parameters of food quality. Research results indicated a clear long-term decline in the trace mineral content of fruit and vegetables during storage (Wright S., Personal communication, 2001). Therefore the influence of farming practices requires further investigation.

In the review by Heaton (2001) it was stated that research would begin to confirm the expectation that organic crops contain an increased range and volume of naturally occurring compounds known variously as secondary plant metabolites: i.e. polyphenol activity as antioxidants, and other phytonutrients. Phytonutrients increase the capacity of plants to withstand external challenges from pests and diseases, and an increasing number of them are also known to be beneficial to humans (Fjeld, 1998).

Bourn *et al*. (2002) referring to 209 works concluded that studies comparing foods derived from organic and conventional growing systems were assessed for three key area: nutritional value, sensory quality, and food safety. It is evident from this assessment that there are few well-controlled studies that are capable of making a valid comparison. With the possible exception of nitrate content, there is no strong evidence that organic and conventional foods differ in concentrations of various nutrients. Considerations of the impact of organic growing systems on nutrient bioavailability and non-nutrient components have received little attention and are important directions of future research. While there are reports indicating that organic and conventional fruit and vegetables may differ on a variety of sensory qualities, the findings are inconsistent. In planning future studies, the possibility that typical organic distribution or harvesting systems may deliver products differing in freshness or maturity should be taken into consideration. There is no evidence that organic foods may be more susceptible to microbiological contamination than conventional foods.

Health aspects

The somewhat optimistic results obtained for organic food while encouraging are, however, far from being sufficient. There are still many open questions about pesticide levels and accumulation, harmful natural ingredients (as nature is producing many toxic substances as well), more health and nutritional aspects that are not yet answered (Brandt & Mølgaard, 2001). One publication deals with the question: 'Is organic food nutritionally 'better' for us? Is it safer? Is there any evidence?' (Merson, 2001). In this report, the author cites a UK report stating the use of 25,744 tonnes of pesticides in the UK during 1999, that were made up of about 400 different pesticide formulations (PAN UK, 2000). It was shown that a proportion of this total ends up in water sources and therefore infiltrates into our conventionally farmed food chain. However, it is possible that presence of these pesticides is also almost inevitable even on organic farms. But since pesticides levels in conventional foods have been found either negligible or below the maximum residue level in most studies, it would not be strictly correct to claim that conventional foods were more contaminated than organic food.

A study of cancer risk from the consumption of conventional food was recently carried out (Saffron, 1998). The aim was to answer the question whether conventional agriculture has an important influence on cancer risk in the UK and whether organically grown food reduce the risk of cancer or can play a significant role in the promotion of health of those with cancer. The author states that although, for many people, it would be common sense that organic food is healthier than conventionally grown food, a review of the scientific research would not confirm this point of view: 'The strongest and most direct evidences of the health benefits of organic food would come from studies on people. No such studies have been carried out so far. No one has yet done a study comparing the health of people who eat a healthy diet of organic food with the health of people who eat an equally healthy diet of conventional food.' Saffron concludes that 'there are large gaps in research and many uncertainties about the health effects of organic food. The best way to fill the gaps would be to carry out well designed epidemiological studies of health outcomes in people. The next best way is to improve the quality of the nutrient content studies by agreeing on a protocol which takes all the important variables into account and which avoids the biases of many of the existing comparative studies.'

Another study is concerned with the amount of pesticides' residues in various food portions of conventional growth (Keon, 2000). The risk of breast cancer and other cancers by eating conventional food is discussed, and the purchase of organically grown products is recommended. However, there is to-date no scientific evidence for these statements.

The complexity of confirmimg authenticity and nutritional value: case studies

Wine authenticity

A study to distinguish organic wines from normal wines on the basis of the concentrations of phenolic compounds and spectral data was carried out recently (Tinttunen & Lehtonen, 2001). This study was undertaken to determine whether it is possible to distinguish organic wines from normal wines on the basis of chemical composition and spectral data. A total of 58 wine samples including organic and normal red and white wines from France and Germany were analysed. The concentrations of several phenolic compounds, including trans-resveratrol (a compound with anti-oxidative property) and of total phenols, total acids, pH and SO_2 were determined. Despite several different combinations of variables, a separation of organic wines from conventionally grown wines was only achieved when they had the same geographical origin, e.g. organic Burgundy and normal Burgundy wines. However, it was not possible to differentiate organic white wine from the corresponding normal white wines by chemical analysis. The chemical and physical properties of normal and organic wines showed smaller differences than expected. However, the trans-resveratrol content was significantly higher in organic wines than in normal wines. Due to the low number of samples analysed it is difficult to judge if this study really does indicate that organic viticultural techniques without synthetic pesticides increases phytoalexin (e.g. trans-resveratrol) synthesis in grapes.

Markers in organic fruits

Another example is a study on the comparison of the polyphenoloxidase (PPO) activity and polyphenol levels in organically and conventionally grown peaches and pears (Carbonaro & Mattera, 2001). Organic fruits were obtained by using three different organic fertilisation methods. All organically grown peaches showed a significant increase in their polyphenol contents compared with conventional peaches, while, of the three organic pears samples only two displayed increased polyphenol content with respect to the conventionally grown sample. The activity of PPO was shown also to be significantly higher in most of the organic peach and pear samples analysed with respect to the conventional samples. It was concluded that PPO could serve as an endogenous marker for the organic versus conventional plant products. However, it was stressed that the results must be confirmed in longer-term field trials. It was found that the results were more prominent for the peach cultivars, but not sufficiently so for the pear fruits.

The results of these two examples help to stress our concern of the difficulty, and at the same time the potentiality of such natural markers, of further analytical studies for evaluation and determination of analytical tools to help market assessment of the origin of specific products.

Holistic approaches

As nutrition studies and current comparative quantitative measurements of the presence of specific molecules in organic and non-organic cultivated products have been shown not to be sufficient so far to give answers and to point on the health benefit of organic products, holistic approaches were developed to assess food as a whole, rather than its constituents. For instance, assessment of the picture forming properties of plant extracts through crystallisation techniques (Pfeiffer, 1931) and circular chromatography (Pfeiffer, 1960) and storage degradation tests as a measure of quality (Heaton, 2001).

It is also claimed that, although not in accordance with Western science, the presence of 'life force' or 'organising activity' in food should not be ruled out, and the kind of food we eat should affect our health.

Picture forming methods, including bio-crystallisation, reveal consistent differences between food samples that differ from each other by level of freshness and by methods of production. While the interpretation of these differences is subjective and their relevance to human health unknown, further development of these qualitative assessments may prove valuable in the search for improved food quality.

Biocrystallisation, also known as copper chloride crystallisation, is the most recognised of the methods. It is based on the crystallographic phenomenon that when adding biological substances, such as plant extracts, to aqueous solutions of dihydrate copper chloride, bio-crystals with reproducible dendritic crystal structures are formed during crystallisation (Andersen, Henriksen, Laursen, & Nielsen, 1999). The quality of these crystals was visually interpreted in terms of the number of centres, and the structure of the needles formed and kind of branches and the formation of hollow structure (Balzer-Graf, 2000a,b). These crystals have different patterns, according to the nature of the added food extracts

(Barth, 1997). According to many experiments, the more artificial inputs used to grow the plants, the more time since harvest, and the more processing it has undergone, the more coarse, broken and disrupted the crystal patterns formed by the extracts (Balzer-Graf, 2000a,b). It was concluded that organically produced products have a higher form-shaping ability and thus have more 'organising activity' than the corresponding conventionally produced or minerally fertilised foods (Woese *et al*., 1997). A major limitation for a wider application of the biocrystallisation method is the lack of standardised and objective methods of quantifying and classifying the morphological features. Computerised image analysis technique may meet the demand for such methods (Andersen *et al*., 1999; CORSS, 1998).

The plant extract having some organising force on the crystallisation of metal salts is clear. In water alone, crystallisation of copper chloride occurs according to the inorganic laws of metal salts and is generally poor in form and structure. In contrast, the crystallographic picture formed by copper chloride in plant extracts can be more structured. Non-organic or organic products extracts added to the copper chloride result in different crystal forms.

Consistently in these analyses, over two decades and many thousands of pictures in blind and double blind tests, high reproducibility of pictures has been observed leading to the statement that the method can distinguish between various samples because they differ in their characteristic organising and form developing qualities, and the picture forming methods make those qualities visible (Balzer-Graf, 2000a,b). It is speculated that this organising ability reflects some inherent quality in crops or food, usually referred to as 'vitality' (Woese *et al*., 1997). However, there are several scientific groups who do not accept these interpretations and give other explanations to the detected variations in crystals. Moreover, 'there remains, however, no scientific proof that a higher integral organising ability in a crop reflects its vitality, or indeed is more favourable for the consumer's well being. Also the impact of storage and cooking by consumers or processors on any potential 'life force' in foods remains unknown' (Heaton, 2001).

Conclusions and recommendations

The organic farming and organic food markets are growing fast. The customers, due to health concerns, environmental consciousness, social status consideration and other reasons, are interested in the products of organic farming. At the same time, they want to have more information on these products they buy usually at higher prices and eat. After studying the regulatory and inspection system, it can be revealed that the inspection procedures for confirming the origin of products may be not sufficient and should be supported by scientific findings and analytical tools. Research work should accompany the expansion of organic farming and organic food production. Research related to organic farming is an important aspect of the growth process, and should be well supported.

The questions of health benefits, although they are of great interest and importance to the public, are even more difficult to answer and need the collaboration in studies of food and nutrition experts. Similar views were presented by participants in a recent workshop hosted by the Food Standard Agency, United Kingdom. They concluded that unless specific health effects were identified, it would not be possible to test the hypothesis that organically produced food is generally 'healthier' than non-organic (FSA, 2003). Nutrition studies should be carried out with population groups under well-controlled conditions. These questions of nutritional benefits should be planned and carried out by a scheme of itself, not necessarily together with the food authenticity and safety studies. Furthermore, in few cases, research that involves the whole food chain, from farming methods, through the resulting food content and on to the nutritional effects of these, might be conceived.

Update

Organic farmers and stakeholders face new challenges in the EU agricultural policy area: the EU Action Plan for Organic Food and Farming launched in 2004 and the Luxemburg Agreements (CAP reform). With the European Action Plan, the EU recognises the dual societal role of organic farming: i) organic land management generating public benefits; and ii) organic food as a direct responses to consumer concerns relating to quality, safety and health. The 2003 CAP reform emphasised the long-term economic and social viability of the agricultural sector, providing safe, high quality products by methods offering a high degree of consideration for the environment. The CAP reform can therefore be expected to provide a positive framework for the future development of organic farming in Europe.

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