Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.6, No.3, 2016

Food Safety, Nutritional and Economic Value of Organically and Conventionally Produced Foods

Neelam Faiza[1] Tang Yu-Qing[2] Ruqyia Shehzadi[3] Hafiz Sohaib Ahmed Saqib[4*]
1. Faculty of Food, Nutrition and Home Sciences, University of Agriculture, Faisalabad-38040, Pakistan
2. College of Food Science, Fujian Agriculture and Forestry University, Fuzhou-350002, China
3. Department of Microbiology, Government College University, Faisalabad-38040, Pakistan
4. Institute of Applied Ecology, Fujian Agriculture and Forestry University, Fuzhou-350002, China

Abstract
Around the globe, maintaining the food safety, nutritional value and food quality are the major challenges for the near future. Agriculture intensification and industrialized food production system are the major causes for contamination throughout the food chain and in water reservoirs by accumulating pesticide residues and reducing nutritional or sensory value of food product. It is important to assess the well-controlled studies to make a valid comparison between two major food production systems (organic and conventional) by comparing the nutritional value, safety and quality of food. Several reports indicating that vegetables and fruits produced by organic and conventional agriculture production systems may vary in sensory quality, nutrition value and amount of accumulated contaminants, although these findings are not consistent. Form several comparison studies between organic and conventional food grown systems, major findings are; organically produced plant products contain high dry matter, minerals (Mg, Fe) and more anti-oxidants; organic vegetables and fruits contain far less amount of nitrates. In future, the typical organic food distribution or post-harvesting management system should be evaluated to maintain the freshness, maturity and nutritional value of produced food.
Keywords: Food production systems; Macronutrients; Micronutrients; Minerals; Mycotoxins; Pathogenic microorganisms; Phytochemical contaminants

Introduction

During the twentieth century in developed countries, although level of mass foodstuff production was achieved, but the problems originated from intensive agriculture production system emphasized by researchers; ecologists, nutritionist, environmentalist, agronomists and physicians (Bonti-Ankomah and Yiridoe, 2006; Brandt *et al.*, 2011). Briefly, high energy and chemical (pesticides and fertilizers) inputs was the major causes for food chain contamination by accumulation of chemical residues, lowering food nutritional value and flavor contents (De Pascale *et al.*, 2016). In recent years, creating awareness among peoples regarding food security and safety, environment protection and human well-beings significantly increased public concerns, importance and demands for ecologically grown foodstuffs (Niggli *et al.*, 2007; Scialabba, 2007; Forman *et al.*, 2012). On the other hand in developing counties, researchers are also focusing on to find out the suitable ways to ensure the food security concerns. More emphasize is being put to safety, quality, nutritional value and health of staple foodstuff, almost one billion peoples are malnourished with no decreasing trend for the next couples of decades (FAO; WHO, 2004; Lester, 2006; WCRF, 2007; Forman *et al.*, 2012).

During the last few decades, several review studies have been carried to address the potential importance for human well-being and to investigate the nutritional and toxicological value of ecologically produced foodstuff, only a few numbers specifically considered and exhibited an alternative and sustainable food production system (Lairon *et al.*, 1982; Finesilver *et al.*, 1989b; Woese *et al.*, 1997; Bourn and Prescott, 2002; Magkos *et al.*, 2006; Brandt *et al.*, 2011). The conclusion derived from the previous studies may differ up to some extent, but these review studies exhibited the some beneficial aspects of organic food production systems. Organic food production and processing are wide ranging but overall this could be substitutive and helpful for the development of agricultural food production system that would be ecologically, environmentally, socially, economically and globally sustainable (Bourn and Prescott, 2002).The key principles and practices in an organic food production system are; lowers the use of synthetic chemicals both pesticides and fertilizers; to enhance the nutritional recycling within a farming system to increase soil fertility by encouraging the soil micro and macro-biota; sufficient amount and high quality food production and consider social and ethical importance of the food production and provisioning system (IFOAM, 2000; Mitchell *et al.*, 2007).

In this review, both organic and conventional food production system will be compared by comparing their nutritional value, safety issue and processing system. First of all, the nutritional value of organically and conventionally produced food stuffs will be described including amount of dry matter in various vegetables and fruits, vitamins, minerals and numerous macro-nutrients in a number of staple foodstuff and plant micro-constituents. Secondly, safety issues associated with organic and conventional food will be exhibited by comparing levels of contamination by phytochemicals, myco-toxins, nitrates and pathogenic micro-organisms. In third part, economic importance of organic and conventional foodstuffs by comparing consumer choice will be reported.

1. Nutritional Value of Organic and Conventional Food

There are many factors has been evaluated in comparison studies between conventional and organic agricultural production systems i.e. agronomic factors, environmental factors, economical factors, soil physical characteristics (structure and texture) (Shepherd *et al.*, 2002; Mitchell *et al.*, 2007; Amedor *et al.*, 2015; De Pascale *et al.*, 2016), activity of soil micro-biota, farm biodiversity, pest and disease regulation (Niggli *et al.*, 2007), food product quality in terms of taste, nutritional value and shelf life, trade value of the products, farm management practices including farm nutrient and chemical inputs and political issues associated with both conventional vs organic food production systems (Knorr and Vogtmann, 1982; Finesilver *et al.*, 1989a; Lampkin *et al.*, 2000; Niggli *et al.*, 2007). Food quality in terms of food nutrition value, taste and shelf life is an era which has been caught much more attention and consideration in various comparison studies between organic and conventional food production systems (Knorr and Vogtmann, 1982; Boehncke, 1997; Forman *et al.*, 2012).

1.1. Dry matter

Most of dry matter content studies were carried out on numerous fruits and vegetables. Various types of organically produced root vegetables, tubers and leafy vegetables contained much higher dry matter contents as compared to conventionally produce vegetables (Wunderlich *et al.*, 2008; Hoefkens *et al.*, 2009), while no significant difference has been reported between conventionally and organically produced fruits and fruits vegetables (Bourn and Prescott, 2002; AFSSA, 2003; Guadagnin *et al.*, 2005; Amedor *et al.*, 2015).

1.2. *Macronutrient* (Starch, carbohydrates, proteins, lipids, fatty acids and fat)

Starch, carbohydrates, proteins, lipids, fatty acids and fat contents in foodstuff has been studied to compare the organic and conventional food production system (Amrein *et al.*, 2003). Studies regarding the difference in level of carbohydrates, starch and protein are too limited to make any conclusion between organic and conventional food production system (Puget *et al.*, 1998; Herencia *et al.*, 2011). It is reported that organic cereals, especially wheat crop, contain higher levels of protein as compared to conventionally grown (Schmidt *et al.*, 2005; Zörb *et al.*, 2006; Park *et al.*, 2015), but generally it showed lower protein levels in organic foodstuff as compared to conventional foodstuff (Woese *et al.*, 1997). Two comparison studies carried out cow's raw milk (Toledo *et al.*, 2002; Ghidini *et al.*, 2005; Croissant *et al.*, 2007) and on hen eggs (Kouba *et al.*, 2002) didn't show a significantly different levels of proteins. Few comparative studies have been carried out to compare the total lipid content in meat, pork, chicken and beef (Castellini *et al.*, 2002; Ghidini *et al.*, 2005; Angood *et al.*, 2008; Husak *et al.*, 2008). There was no significant difference found in pigs (Sundrum *et al.*, 2000; Millet *et al.*, 2004; Pietrosemoli *et al.*, 2016), but Hansson *et al.* (2000) reported that cows feeding on organic matter have more lean and bony meat as compared to conventionally-bred cows. More qualitative analysis showed that, cows and lamb feeding on concentrate grass led to 4X higher linolenic acid contents in muscles, an essential fatty acid of n-3 series, with associated decease in the level of linoleic acid and oleic contents in muscle (Ghidini *et al.*, 2005; Ponnampalam *et al.*, 2015). Organically- grown cows and lamb meat have higher levels of polyunsaturated fatty acids in contrast with conventionally grown cows (Angood *et al.*, 2008; Samman *et al.*, 2008). Same strain of chicken raised under organic husbandry showed two-three fold lower abdominal fat in meat, two-three fold less fat contents in filet and 1.8 folds lower fat contents in leg meat (Castellini *et al.*, 2002; Husak *et al.*, 2008). Although, the levels of n-3 fatty acid in filet was considerably higher with no prominent difference in levels of saturated fatty acids. Total fat contents in milk didn't showed significant difference between organically and conventionally produce milk, while some studies exhibited higher polyunsaturated fatty acids levels in organically produce milk (Toledo *et al.*, 2002; Croissant *et al.*, 2007). Few studied revealed that organically produced virgin olive oil and edible oil has higher level of oleic acid as compared to conventionally produced oil (Gutiérrez *et al.*, 1999; Samman *et al.*, 2008).

1.3. Minerals

Key mineral elements generally reported in surplus amount in vegetables and fruits are phosphorus (P), calcium (Ca), iron (Fe), copper (Cu), zinc (Zn), iodine (I), magnesium (Mg), sodium (Na), potassium (K) and selenium (Se) (AFSSA, 2003). In fruits, a case study especially on apple, there were not so obvious regulation of mineral contents in varying fruit production system (Baert *et al.*, 2006). But for vegetables i.e. leek, turnip, potato, carrot, kale, onion, celeriac, lettuce and tomato and lettuce, higher levels of magnesium and iron was observed in organically produced vegetables with no other significant changes in level of other mineral elements (Zhao *et al.*, 2006). A long-term fertilization treatment study showed no significant effects on the mineral composition in cereals by difference with production system gradient (Wszelaki *et al.*, 2005). Alföldi *et al.* (1996) reported a significant higher level of Cu, Ca and Zn in organically produced barley as compared to conventional production system. A review study by Rembiałkowska (2007) reported that organically produced foodstuffs contain 29 %

more Mg and 21% more Fe as compared to conventional food production practices. For meat, Woese *et al.* (1997) also reported higher levels of iron and magnesium in meat from four comparative studies. However, chickens grown in open fields exhibited higher levels of iron as compared to chicken grown in housing conditions (Castellini *et al.*, 2002).

1.4. Vitamins

Many studies were carried out to investigate the mineral contents only in eggs and fruits and vegetables. Ascorbic acid (vitamin C) is the most studied vitamin among all hydrophilic vitamins, studies carried out on tomato-fruits (Caris-Veyrat *et al.*, 2004; Barrett *et al.*, 2007), potato-tubers (Hajšlová *et al.*, 2005), apple (Stracke *et al.*, 2009b) and kiwifruit (Amodio *et al.*, 2007) indicated higher level of ascorbic acid in organically produced food with conventional counterpart. For carotenoids and fat soluble vitamins, higher level of vitamin E was reported in organically produced olive oil (Gutiérrez *et al.*, 1999; Samman *et al.*, 2008). A review of 27 studies by Woese *et al.* (1997) reported difference in levels of β-carotene in organically and conventionally produced vegetables (Caris-Veyrat *et al.*, 2004). A positive correlation was observed between nitrogen fertilization and the levels of β-carotene in carrots (Stracke *et al.*, 2009a; Bach *et al.*, 2015). Ghidini *et al.* (2005) reported that cows fed by grass-rich pastures as compared to fed with silage, produce milk with higher levels of carotene and vitamin E.

1.5. Plant micro-constituents

There are a large number of micronutrients, plant secondary metabolites i.e. resveratrol, polyphenols and non-pro-vitamin carotenoids present in vegetables and fruits (Hajšlová *et al.*, 2005). Several factors involve to regulate these plant secondary metabolites levels in fruits and vegetables such as plant cultivar, maturity of food product, some abiotic factors (temperature and light) and production system (Rico *et al.*, 2007). Mostly studies reported significantly a higher levels of polyphenolic and phenolic compounds in organically produced foodstuffs i.e. pepper (Pérez-López *et al.*, 2007), apple fruit (Stracke *et al.*, 2009b), potatoes (Amrein *et al.*, 2003), orange (Lester *et al.*, 2007), pear and peach (Carbonaro *et al.*, 2002), tomato (Barrett *et al.*, 2007; Mitchell *et al.*, 2007) and olive oil (Gutiérrez *et al.*, 1999). Levite *et al.* (2000) reported higher level of resveratrol in organically produced wines. Rembiałkowska (2007) reported in his review study organically produce foodstuffs contains two fold the amount of polyphenol and phenols compounds as compared to conventionally produced food stuff. The level of salicylic acid in organic vegetable soups and tomatoes were considerably higher as compared to inorganic vegetables (Rossi *et al.*, 2008). While some anti-proliferative and anti-oxidants compounds present in organically produced foodstuffs showed positive effects on cancer cells but the mechanism of the impact of diets on chronic diseases still need to be fully investigated (Olsson *et al.*, 2006; Rossi *et al.*, 2008).

2. Conventional and Organic Produced Foods problems relating to Food safety

Scientific way for classifying well known threats and associated risks with reference to food safety is called risk evaluation. Main food contaminants are myco-toxins, agro-chemicals, worms, pathogens like bacteria, fungi and viruses, etc. (AFSSA, 2003; Forman *et al.*, 2012). Different researches focus various aspects of food safety relating threats, but less emphasis is given to viruses and worms. This article will enlighten applicable examples by reviewing previous and present studies.

2.1. Pathogens (microorganisms)

EU Scientific Committee (EU-SC) on Food raised voice about contaminating sources of food (vegetables and fruit) due to irrigation sources, animal feces and sewage sludge (SCF, 2002; Hoogenboom *et al.*, 2008). All these sources contain abundant pathogenic organisms that causing diseases in humans like pathogenic bacteria (Strauch, 1993), e.g., *Salmonella* sp. (Warnick *et al.*, 2001) and *Listeria monocytogenes* (Renterghem *et al.*, 1991). Utilization of sewage sludge and contaminated animal manures with chemical fertilizers are not permissible during organic farming system, composted manures with different phases of time. Aerobic compositing procedure with high temperature has ability to kill or eliminate pathogenic microorganisms like *Escherichia coli* and *Salmonella enteritidis* (Tiquia *et al.*, 1998; Lung *et al.*, 2001). *Clostridium botulinum* is quite resistant to this composting procedure (Böhnel and Lube, 2000) and relatively exogenous bacteria swiftly eliminated under unsuitable conditions (Dowe *et al.*, 1997; Hoogenboom *et al.*, 2008). So, it is systematic procedure of aerobic composting for prevention of organic foodstuffs due to pathogens with improvement of organic fertilizer quality.

Under an examination during 1997-99 in France, milk samples were analyzed from different regions for microorganisms count under two husbandries (Echevarria, 2001; Hoogenboom *et al.*, 2008). It showed that limiting feeding by silage during organic husbandry is a way of contamination reduction in ruminants against *E. coli* and *Listeria monocytogene* (Herriott *et al.*, 1998). A Danish study showed that 36-49% contamination of poultry samples with *Campylobacter* sp. observed under conventional poultry farms as compare to 100% samples in organic poultry farms (Heuer *et al.*, 2001; Castellini *et al.*, 2002). This comparative study is indicating lack of distinct source of organic foodstuff contamination as compare to conventionally produced food.

2.2. Mycotoxins

Mold growth on plants is the main source of mycotoxins (a big family of toxic substances). A vast variety of mold like *Aspergillus* spp., *Penicillium* spp. and *Fusarium* spp. are extensively toxic and heat-resistant and have ability to reach human beings through animals that feed infected or contaminated plants. Publically famous one health threating toxins are Deoxynivalenol (DON), Patulin, Zearalenone (ZEN), aflatoxins, Fumonisins and Ochratoxin A (OTA), etc. and their notorious effects like liver cancerogenesis, teratogenesis, nephrotoxicity, immune-toxicity and embryo-toxicity. Their least limit is 0.1–2 ppb/kg with reference to body weight (Piemontese *et al.*, 2005; Baert *et al.*, 2006).

Organic foodstuff in Germany was contaminated with DON and a small amount by OTA under analysis of organic cereals samples (Birzele *et al.*, 2000), but that conventionally produced foodstuff samples were more contaminated. Under French investigation organic foodstuff is more affected with mycotoxins in few cases as compare to conventionally one (Malmauret *et al.*, 2002). Recent experiments showed that organically produced wheat has less ZEN and *Fusarium* contamination as compare to conventionally produce after pigs feeding (Schneweis *et al.*, 2005) and similar results were obtained after analyzing wheat flour for mycotoxin contamination (Zörb *et al.*, 2006). Aflatoxin contamination variations in milk samples has also been analyzed, in few studies high (Croissant *et al.*, 2007) and low level in organically produced milk (Ghidini *et al.*, 2005). Organically and conventionally produced cereals or foodstuffs are not creating a clear line or overall variations. It is only way to maintain least level of contamination and preventing deadlines under organic farming or agriculture, even the lack of utilization of chemical products.

2.3. Phyto-toxins

In organic agriculture, utilization of chemical products like herbicides, fungicides, insecticides and pesticides are not allowed that is brilliant protection measure for environmental biodiversity and living organisms (Hoefkens *et al.*, 2009). But environmental pollutants are still answerable contaminants for organic farming or organic foodstuffs. Many studies conducted for explaining and handling this source of contamination. An inspection in Sweden showed organically produced vegetables and strawberries did not show contamination, as 17–50% conventionally produced foodstuff contain (Bourn and Prescott, 2002). A Danish market analysis of organically produced vegetables and fruits showed only 2.8% samples contamination with chemical products, even all were below the 'Maximum Residue Limit' (Poulsen and Andersen, 2003) and undetectable chemical products contamination studied in Italy after analyzing 3500 samples of organically produced foodstuff (Tasiopoulou *et al.*, 2007).

A huge amount of foodstuff is contaminated by phyto-toxins. It was reported by the EU-DG-SANCO (2007) after scrutinizing 62,500 samples of foodstuff collected in EU-member states for inspection 706 kinds of chemicals. With the utilization of natural plant extracts against pest, weeds or herbs and disease control like pyrethrums, copper salts, sulfur and rotenone, in organic farming, is real advantage. These chemicals have ability to quickly degrade or evaporate from foodstuff making them contamination free foodstuff (Moore *et al.*, 2000).

2.4. Nitrates

In present situation with the intensive use of nitrogenous fertilizers or chemicals (Guadagnin *et al.*, 2005; Lairon, 2011), nitrates are becoming major health threating causes due to their ability to form nitrites that have competing capacity with oxygen during blood circulation, binding ability with secondary amines to create anoxia and naturally cancer-promoting moieties way (Herencia *et al.*, 2011; Øvsthus *et al.*, 2015).

Vegetables provide 80% of nitrates as human diet. Fruits, legumes, cereals and animal products have very low level of nitrates (Guadagnin *et al.*, 2005), whereas processed meat contains more (Sebranek and Bacus, 2007). Analysis of five vegetables showed significantly lesser nitrate amount under organically grown salad, potato, turnip and leek, however not in kale (Lairon *et al.*, 1982; Lairon, 2011). Similar results obtained in Austria after analyzing 17 vegetables and in Germany an assessment on carrots with lesser nitrate amount in organically grown excluding in spinach (Niggli *et al.*, 2007; Bach *et al.*, 2015). The previous results indicated that variations in nitrates levels in vegetables are due to fluctuations in temperature, light intensity absorption or exposure, root nitrogen availability, cultivars specifications and species, like a small example, Chili sodium-nitrate stimulates nitrate accretion in subtle vegetables (Chassy *et al.*, 2006; Pérez-López *et al.*, 2007).

3. Economic Value and Consumers Preference of Organic Food

Arbenz *et al.* (2015) reported that there were 43.1 million of hectares under the organic during 2013. Regions with largest organic cultivated are Oceania (17.3 million hectares, 40% of world total organic cultivated area), Europe 11.5 million hectares (27%), Latin America has 6.6 million hectares (15%), Asia 3.4 million hectares (8%), North-America 3 million hectares (7%) and Africa with 3.4 million hectares (3%). In 2013, there were about 2 million organic food producers, from total world organic producers 36% from Asia, Africa 29% and Europe contributes about 17%. About one fourth of total organic agricultural land and more than eighty percent (1.7 million) producers belong to developing countries (Arbenz *et al.*, 2015).

Likewise, during 2013, the global market sale value of organic commodities was $72 billion, and revenue increased five times since 1999. Over past few years, the global sales of organic food products increased with an increasing rate. Both Europe and North-America produce over 90% of total global sales of organic products. Whereas, USA was the largest market for organic food products €24.3 billion (43% of global organic market), France with €4.4 billion (40%) and followed by China €2.4 billion. The largest per-capita consumption of organic food products was in Switzerland, Luxembourg and Denmark with more than €100 (Arbenz *et al.*, 2015).

Many studies were carried out to investigate the reasons behind the considerable increase in demands of organic food by consumers (Grunert, 2005; Hughner *et al.*, 2007). While numerous factors have relative importance to influence the choice of organic food vs conventional food products, but recent surveys reported that pesticide residues (Hoefkens *et al.*, 2009) in food items is the most important factor involve in the decision to purchase the organic foodstuffs as compared to the environmental hazard by pesticides (Grunert, 2005; Bonti-Ankomah and Yiridoe, 2006; Croissant *et al.*, 2007). However, environment protection is also the most important factor in several developed countries (Shafie and Rennie, 2012). Consumer from Germany more concerned with the environmental problems than UK's consumers. However this trend may be changing with recent investigations, because of approximately 70% organic consumers having good health just because of consuming organic foodstuffs (Woodward and Meier-Ploeger, 1999). Consumer prefers organic food on conventional food products considering following characteristics; benefits for human health and environmental safety, food freshness, nutritional value and food quality (Dorais *et al.*, 2008). Some organic food buyers at a co-operative considered protection of wildlife, pesticides free water supplies, protection of consumers from chemical residues in foodstuffs, importance of health and environmental factors are the most important factors for supporting organic food production system (Hoefkens *et al.*, 2009; Lee and Yun, 2015). Health was to be identified as an important motive for individual organic food buyers (Dorais *et al.*, 2008), whereas environmental issues are more important factors for wholesale buyers of organic food products (Forman *et al.*, 2012).

Consumers were found more reluctant to buy organically grown foodstuffs for following reason including; too expensive (Aryal *et al.*, 2009; Lee and Yun, 2015); poor market accessibility and availability of organic products, difficult to find retail outlets in supermarkets; unsatisfactory quality (appearance/flavor of organic food commodities) (Zhao *et al.*, 2007); satisfied with current conventionally grown food items (Lee and Yun, 2015); not familiar with organic term, legislation system and organic food logos (McEachern *et al.*, 2005; Napolitano *et al.*, 2010).

Conclusion

A number of plant compositional factors such as genetics, cultural practices, climate and post-harvest processing, influencing the investigations to carry out to compare the nutritional value of conventionally and organically grown food products. While, many studies were carried out all over the world to compare the differences in nutrition level in conventional and organic foodstuffs, but results varied from study to study with a significant variation to make a certain conclusion. An exception in nitrate contents tend to be higher in organic food products due to the more use of composts in organic production system as compared to conventional foodstuff. In past, most of studies only focused to a narrow range of nutrients, which are not sufficient to make clear indication of nutrition value level. Recent work has been carried out to investigate the impact of non-nutrient components and bioavailability of nutrients. These two areas of study will provide a great plank for future than simply examining the nutrients level trends.

Some studies exhibited the effects of conventional and organic feeding on the animal fertility, high level of sperm concentration has been reported in organic food consumers. These studies are confounded to only some factors or parameters and not enough to make some certain conclusive statements. Therefore, it would be worthwhile in near future, to undergo for further well-managed and well controlled studies to compare the definite impacts of organic and conventional food consumption. Furthermore, it would be more productive to compare food from certified organic food producers with same conventional food products by excluding the other factors such as distribution methods, processing, and type of foodstuff and storage duration.

A number of factors influence the organic food purchasing and consumer's perceptions and preferences such as product labeling (conventional and organic), age and awareness about organic farming. Previous studies on the pesticide residues didn't provide definite conclusions to effect the consumer decision for buying organic or conventional food products. However, the non-use of chemical inputs in a certified organic production system as compared to use of chemical pesticides and fertilizers in conventional production system, may influence the consumer's purchasing decision for organic and conventional food products. Because many consumers choose organic food only because they assume that organically grown food have much lower amount of residue level.

Recently, the organic foodstuff contaminated with E. coli caused severe infection in some cases and stimulate health concerns, regarding the use of animal manures in certified organic productions system may cause some health problems in organic food consumers. In future studies, these health problems associated with organic food consumption need to be investigated. Organic production agencies should compost the animal manure prior to use, which may decrease the chances for contamination of organic food by pathogens. General cultural practices are also very important to minimize the risk of contamination of organic foodstuff by pathogens. This review mainly explored the three factors food safety concerns, nutritional and economic value to compare the organic and conventional production system. To evaluate a mark differences between these production systems, there is need to also consider some other aspects such as environment, political and social concerns related to organic and conventional food production systems.

References

AFSSA, 2003. Report on Evaluation of the nutritional and sanitary quality of organic foods (Evaluation nutritionnelle et sanitaire des aliments issus de l'agriculture biologique, in French). AFSSA, http://www.afssa.fr, 164.

Alföldi, T., Mader, P., Niggli, U., Spiess, E., Dubois, D., Besson, J., 1996. Quality investigation in the long term DOC trial, Quality of plant products growth with manure fertilisation. Proceeding of the Fourth meeting (Juva Finland, 6–9 July 1996 Darmstadt Germany), Institut for Biodynamic research, pp. 34-43.

Amedor, E.N., Maalekuu, B.K., Kwesi, A.A., 2015. Effect of soil amendments on the nutritional quality of three commonly cultivated lettuce varieties in Ghana. African Journal of Agricultural Research 10, 1796-1804.

Amodio, M.L., Colelli, G., Hasey, J.K., Kader, A.A., 2007. A comparative study of composition and postharvest performance of organically and conventionally grown kiwifruits. Journal of the Science of Food and Agriculture 87, 1228-1236.

Amrein, T.M., Bachmann, S., Noti, A., Biedermann, M., Barbosa, M.F., Biedermann-Brem, S., Grob, K., Keiser, A., Realini, P., Escher, F., 2003. Potential of acrylamide formation, sugars, and free asparagine in potatoes: a comparison of cultivars and farming systems. Journal of Agricultural and Food Chemistry 51, 5556-5560.

Angood, K., Wood, J., Nute, G., Whittington, F., Hughes, S., Sheard, P., 2008. A comparison of organic and conventionally-produced lamb purchased from three major UK supermarkets: Price, eating quality and fatty acid composition. Meat Science 78, 176-184.

Arbenz, M., Willer, H., Lernoud, J., Huber, B., Amarjit, S., 2015. The World of Organic Agriculture–Statistics and Emerging Trends (Session at the BIOFACH 2015).

Aryal, K.P., Chaudhary, P., Pandit, S., Sharma, G., 2009. Consumers' willingness to pay for organic products: a case from Kathmandu valley. Journal of Agriculture and Environment 10, 15-26.

Bach, V., Kidmose, U., Kristensen, H.L., Edelenbos, M., 2015. Eating Quality of Carrots (Daucus carota L.) Grown in One Conventional and Three Organic Cropping Systems over Three Years. Journal of Agricultural and Food Chemistry 63, 9803-9811.

Baert, K., De Meulenaer, B., Kamala, A., Kasase, C., Devlieghere, F., 2006. Occurrence of patulin in organic, conventional, and handcrafted apple juices marketed in Belgium. Journal of Food Protection 69, 1371-1378.

Barrett, D.M., Weakley, C., Diaz, J.V., Watnik, M., 2007. Qualitative and nutritional differences in processing tomatoes grown under commercial organic and conventional production systems. Journal of food science 72, C441-C451.

Birzele, B., Prange, A., KrÄmer, J., 2000. Deoxynivalenol and ochratoxin A in German wheat and changes of level in relation to storage parameters. Food Additives and Contaminants 17, 1027-1035.

Boehncke, E., 1997. Broadening the concept of quality for animal products: a german perspective. Agricultural Production and Nutrition. Proceedings of an International Conference, Boston, Massachusetts, USA, pp. 59-67.

Böhnel, H., Lube, K., 2000. *Clostridium botulinum* and Bio-compost. A Contribution to the Analysis of Potential Health Hazards Caused by Bio-waste Recycling. Journal of Veterinary Medicine, Series B 47, 785-795.

Bonti-Ankomah, S., Yiridoe, E.K., 2006. Organic and conventional food: a literature review of the economics of consumer perceptions and preferences. Organic Agriculture Centre of Canada 59, 1-40.

Bourn, D., 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., Leifert, C., Sanderson, R., Seal, C., 2011. Agroecosystem management and nutritional quality of plant foods: the case of organic fruits and vegetables. Critical Reviews in Plant Sciences 30, 177-197.
Carbonaro, M., Mattera, M., Nicoli, S., Bergamo, P., Cappelloni, M., 2002. Modulation of antioxidant compounds in organic vs conventional fruit (peach, *Prunus persica* L. and pear, *Pyrus communis* L.). Journal of Agricultural and Food Chemistry 50, 5458-5462.
Caris-Veyrat, C., Amiot, M.-J., Tyssandier, V., Grasselly, D., Buret, M., Mikolajczak, M., Guilland, J. C., Bouteloup-Demange, C., Borel, P., 2004. Influence of organic versus conventional agricultural practice on the antioxidant microconstituent content of tomatoes and derived purees; consequences on antioxidant plasma status in humans. Journal of Agricultural and Food Chemistry 52, 6503-6509.
Castellini, C., Mugnai, C., Dal Bosco, A., 2002. Effect of organic production system on broiler carcass and meat quality. Meat Science 60, 219-225.
Chassy, A.W., Bui, L., Renaud, E.N., Van Horn, M., Mitchell, A.E., 2006. Three-year comparison of the content of antioxidant microconstituents and several quality characteristics in organic and conventionally managed tomatoes and bell peppers. Journal of Agricultural and Food Chemistry 54, 8244-8252.
Croissant, A.E., Washburn, S., Dean, L., Drake, M., 2007. Chemical properties and consumer perception of fluid milk from conventional and pasture-based production systems. Journal of Dairy Science 90, 4942-4953.
De Pascale, S., Maggio, A., Orsini, F., Barbieri, G., 2016. Cultivar, soil type, nitrogen source and irrigation regime as quality determinants of organically grown tomatoes. Scientia Horticulturae 199, 88-94.
Dorais, M., Ehret, D.L., Papadopoulos, A.P., 2008. Tomato (*Solanum lycopersicum*) health components: from the seed to the consumer. Phytochemistry Reviews 7, 231-250.
Dowe, M.J., Jackson, E.D., Mori, J.G., Bell, C.R., 1997. *Listeria monocytogenes* survival in soil and incidence in agricultural soils. Journal of Food Protection 60, 1201-1207.
Echevarria, L., 2001. Qualité du lait livré par les élevages agrobiologiques de quatre régions françaises. Rencontres autour des recherches sur les ruminants.
EU-DG-SANCO, 2007. Monitoring of pesticide residues in products of plant origin in European union, Norway, Iceland and Liechtenstein, 2005 Report.
FAO, http://www.fao.org.
Finesilver, T., Johns, T., Hill, S., 1989a. Comparison of food quality of organically versus conventionally grown plant foods. Ecological Agriculture Projects Publication No 37.
Finesilver, T., Johns, T., Hill, S., 1989b. Comparison of food quality of organically versus conventionally grown plant foods Ecological Agriculture Projects, Report. MacDonald College, McGill University, Ste Anne de Bellevue, Quebec, Canada.
Forman, J., Silverstein, J., Bhatia, J.J., Abrams, S.A., Corkins, M.R., De Ferranti, S.D., Golden, N.H., Paulson, J.A., Brock-Utne, A.C., Brumberg, H.L., 2012. Organic foods: health and environmental advantages and disadvantages. Pediatrics 130, e1406-e1415.
Ghidini, S., Zanardi, E., Battaglia, A., Varisco, G., Ferretti, E., Campanini, G., Chizzolini, R., 2005. Comparison of contaminant and residue levels in organic and conventional milk and meat products from Northern Italy. Food Additives and Contaminants 22, 9-14.
Grunert, K.G., 2005. Food quality and safety: consumer perception and demand. European Review of Agricultural Economics 32, 369-391.
Guadagnin, S., Rath, S., Reyes, F., 2005. Evaluation of the nitrate content in leaf vegetables produced through different agricultural systems. Food Additives and Contaminants 22, 1203-1208.
Gutiérrez, F., Arnaud, T., Albi, M.A., 1999. Influence of ecological cultivation on virgin olive oil quality. Journal of the American Oil Chemists' Society 76, 617-621.
Hajšlová, J., Schulzova, V., Slanina, P., Janne, K., Hellenäs, K., Andersson, C., 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.
Hansson, I., Hamilton, C., Ekman, T., Forslund, K., 2000. Carcass quality in certified organic production compared with conventional livestock production. Journal of Veterinary Medicine, Series B 47, 111-120.
Herencia, J.F., García-Galavís, P.A., Dorado, J.A.R., Maqueda, C., 2011. Comparison of nutritional quality of the crops grown in an organic and conventional fertilized soil. Scientia Horticulturae 129, 882-888.
Herriott, D.E., Hancock, D.D., Ebel, E.D., Carpenter, L.V., Rice, D.H., Besser, T.E., 1998. Association of herd management factors with colonization of dairy cattle by Shiga toxin-positive *Escherichia coli* O157. Journal of Food Protection 61, 802-807.
Heuer, O.E., Pedersen, K., Andersen, J., Madsen, M., 2001. Prevalence and antimicrobial susceptibility of thermophilic *Campylo bacter* in organic and conventional broiler flocks. Letters in Applied

Microbiology 33, 269-274.

Hoefkens, C., Verbeke, W., Aertsens, J., Mondelaers, K., Camp, J.V., 2009. The nutritional and toxicological value of organic vegetables: Consumer perception versus scientific evidence. British Food Journal 111, 1062-1077.

Hoogenboom, L., Bokhorst, J.G., Northolt, M.D., Van de Vijver, L., Broex, N.J., Mevius, D.J., Meijs, J.A., Van Der Roest, J., 2008. Contaminants and microorganisms in Dutch organic food products: a comparison with conventional products. Food Additives and Contaminants 25, 1195-1207.

Hughner, R.S., McDonagh, P., Prothero, A., Shultz, C.J., Stanton, J., 2007. Who are organic food consumers? A compilation and review of why people purchase organic food. Journal of Consumer Behaviour 6, 94-110.

Husak, R., Sebranek, J., Bregendahl, K., 2008. A survey of commercially available broilers marketed as organic, free-range, and conventional broilers for cooked meat yields, meat composition, and relative value. Poultry Science 87, 2367-2376.

IFOAM, G.A., 2000. Basic Standards for Organic Production and Processing. Online report. International Federation of Organic Agriculture Movements. Tholey-Theley, Germany. September.< www. ifoam. org.

Knorr, D., Vogtmann, H., 1982. Quality and quality determination of ecologically grown foods. Sustainable Food Systems, 352-381.

Kouba, M., Enser, M., Whittington, F., Nute, G., Wood, J., 2002. Effet d'un regime riche en acide linolenique sur les activites d'enzymes lipogeniques, la composition en acides gras et la qualite de la viande chez le porc en croissance. Viandes Et Produits Carnes 22, N-Com2.

Lairon, D., 2011. Nutritional quality and safety of organic food. Sustainable Agriculture Volume 2. Springer, pp. 99-110.

Lairon, D., Lafont, H., Léonardi, J., Hauton, J., Ribaud, P., 1982. Comparaison de l'intérêt nutritif de légumes produits par l'agriculture conventionnelle ou biologique. Sci. Aliments 2, 203-205.

Lampkin, N., Padel, S., Foster, C., Brouwer, F., Lowe, P., 2000. Organic farming. CABI Publishing.

Lee, H.-J., Yun, Z.-S., 2015. Consumers' perceptions of organic food attributes and cognitive and affective attitudes as determinants of their purchase intentions toward organic food. Food Quality and Preference 39, 259-267.

Lester, G.E., 2006. Organic versus conventionally grown produce: quality differences, and guidelines for comparison studies. HortScience 41, 296-300.

Lester, G.E., Manthey, J.A., Buslig, B.S., 2007. Organic vs conventionally grown Rio Red whole grapefruit and juice: comparison of production inputs, market quality, consumer acceptance, and human health-bioactive compounds. Journal of Agricultural and Food Chemistry 55, 4474-4480.

Levite, D., Adrian, M., Tamm, L., 2000. Preliminary results of resveratrol in wine of organic and conventional vineyards. Conference Proceeedings, pp. 256-257.

Lung, A., Lin, C.-M., Kim, J., Marshall, M., Nordstedt, R., Thompson, N., Wei, C., 2001. Destruction of *Escherichia coli* O157: H7 and *Salmonella enteritidis* in cow manure composting. Journal of Food Protection 64, 1309-1314.

Magkos, F., Arvaniti, F., Zampelas, A., 2006. Organic food: buying more safety or just peace of mind? A critical review of the literature. Critical Reviews in Food Science and Nutrition 46, 23-56.

Malmauret, L., Parent-Massin, D., Hardy, J.-L., Verger, P., 2002. Contaminants in organic and conventional foodstuffs in France. Food Additives and Contaminants 19, 524-532.

McEachern, M., Seaman, C., Padel, S., Foster, C., 2005. Exploring the gap between attitudes and behaviour: Understanding why consumers buy or do not buy organic food. British Food Journal 107, 606-625.

Millet, S., Hesta, M., Seynaeve, M., Ongenae, E., De Smet, S., Debraekeleer, J., Janssens, G., 2004. Performance, meat and carcass traits of fattening pigs with organic versus conventional housing and nutrition. Livestock Production Science 87, 109-119.

Mitchell, A.E., Hong, Y.-J., Koh, E., Barrett, D.M., Bryant, D., Denison, R.F., Kaffka, S., 2007. Ten-year comparison of the influence of organic and conventional crop management practices on the content of flavonoids in tomatoes. Journal of Agricultural and Food Chemistry 55, 6154-6159.

Moore, V.K., Zabik, M., Zabik, M., 2000. Evaluation of conventional and "organic" baby food brands for eight organochlorine and five botanical pesticides. Food Chemistry 71, 443-447.

Napolitano, F., Braghieri, A., Piasentier, E., Favotto, S., Naspetti, S., Zanoli, R., 2010. Effect of information about organic production on beef liking and consumer willingness to pay. Food Quality and Preference 21, 207-212.

Niggli, U., Leifert, C., Alföldi, T., Lück, L., Willer, H., 2007. 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, March 20–23,

2007. Ökologie and Landbau 141, 32-33.
Olsson, M.E., Andersson, C.S., Oredsson, S., Berglund, R.H., Gustavsson, K.-E., 2006. Antioxidant levels and inhibition of cancer cell proliferation in vitro by extracts from organically and conventionally cultivated strawberries. Journal of Agricultural and Food Chemistry 54, 1248-1255.
Øvsthus, I., Breland, T.A., Hagen, S.F., Brandt, K., Wold, A.-B., Bengtsson, G.B., Seljåsen, R., 2015. Effects of Organic and Waste-Derived Fertilizers on Yield, Nitrogen and Glucosinolate Contents, and Sensory Quality of Broccoli (*Brassica oleracea* L. *var.* italica). Journal of Agricultural and Food Chemistry 63, 10757-10767.
Park, E.Y., Baik, B.-K., Miller, P.R., Burke, I.C., Wegner, E.A., Tautges, N.E., Morris, C.F., Fuerst, E.P., 2015. Functional and nutritional characteristics of wheat grown in organic and conventional cropping systems. Cereal Chemistry 92, 504-512.
Pérez-López, A.J., López-Nicolas, J.M., Núñez-Delicado, E., Amor, F.M.d., Carbonell-Barrachina, Á.A., 2007. Effects of agricultural practices on color, carotenoids composition, and minerals contents of sweet peppers, cv. Almuden. Journal of Agricultural and Food Chemistry 55, 8158-8164.
Piemontese, L., Solfrizzo, M., Visconti, A., 2005. Occurrence of patulin in conventional and organic fruit products in Italy and subsequent exposure assessment. Food Additives and Contaminants 22, 437-442.
Pietrosemoli, S., Moron‐Fuenmayor, O.E., Paez, A., Villamide, M.J., 2016. Effect of including sweet potato (*Ipomoea batatas* Lam) meal in finishing pig diets on growth performance, carcass traits and pork quality. Animal Science Journal.
Ponnampalam, E.N., Lewandowski, P.A., Fahri, F.T., Burnett, V.F., Dunshea, F.R., Plozza, T., Jacobs, J.L., 2015. Forms of n-3 (ALA, C18: 3n-3 or DHA, C22: 6n-3) Fatty Acids Affect Carcass Yield, Blood Lipids, Muscle n-3 Fatty Acids and Liver Gene Expression in Lambs. Lipids 50, 1133-1143.
Poulsen, M.E., Andersen, J.H., 2003. Results from the monitoring of pesticide residues in fruit and vegetables on the Danish market, 2000-01. Food Additives and Contaminants 20, 742-757.
Puget, P., Angers, D., Chenu, C., 1998. Nature of carbohydrates associated with water-stable aggregates of two cultivated soils. Soil Biology and Biochemistry 31, 55-63.
Rembiałkowska, E., 2007. Quality of plant products from organic agriculture. Journal of the Science of Food and Agriculture 87, 2757-2762.
Renterghem, B.V., Huysman, F., Rygole, R., Verstraete, W., 1991. Detection and prevalence of *Listeria monocytogenes* in the agricultural ecosystem. Journal of Applied Bacteriology 71, 211-217.
Rico, D., Martin-Diana, A.B., Barat, J., Barry-Ryan, C., 2007. Extending and measuring the quality of fresh-cut fruit and vegetables: a review. Trends in Food Science and Technology 18, 373-386.
Rossi, F., Godani, F., Bertuzzi, T., Trevisan, M., Ferrari, F., Gatti, S., 2008. Health-promoting substances and heavy metal content in tomatoes grown with different farming techniques. European Journal of Nutrition 47, 266-272.
Samman, S., Chow, J.W., Foster, M.J., Ahmad, Z.I., Phuyal, J.L., Petocz, P., 2008. Fatty acid composition of edible oils derived from certified organic and conventional agricultural methods. Food Chemistry 109, 670-674.
SCF, 2002. Risk profile on the microbiological contamination of fruits and vegetables eaten raw, Report on the Scientific Commmittee on Food. European Commission, http://europa.eu.int/comm/food/fs/sc/scf/out125_en.pdf.
Schmidt, H.-l., Roßmann, A., Voerkelius, S., Schnitzler, W.H., Georgi, M., Graßmann, J., Zimmermann, G., Winkler, R., 2005. Isotope characteristics of vegetables and wheat from conventional and organic production. Isotopes in Environmental and Health Studies 41, 223-228.
Schneweis, I., Meyer, K., Ritzmann, M., Hoffmann, P., Dempfle, L., Bauer, J., 2005. Influence of organically or conventionally produced wheat on health, performance and mycotoxin residues in tissues and bile of growing pigs. Archives of Animal Nutrition 59, 155-163.
Scialabba, N., 2007. Organic Agriculture and Food Security, Food and Agriculture Organisation of the United Nations. Available at: ftp:/ftp.fao.org/paia/organicag/OFS-2007-5. pdf.
Sebranek, J.G., Bacus, J.N., 2007. Cured meat products without direct addition of nitrate or nitrite: what are the issues? Meat Science 77, 136-147.
Shafie, F.A., Rennie, D., 2012. Consumer perceptions towards organic food. Procedia-Social and Behavioral Sciences 49, 360-367.
Shepherd, M., Harrison, R., Webb, J., 2002. Managing soil organic matter–implications for soil structure on organic farms. Soil Use and Management 18, 284-292.
Stracke, B.A., Rüfer, C.E., Bub, A., Briviba, K., Seifert, S., Kunz, C., Watzl, B., 2009a. Bioavailability and nutritional effects of carotenoids from organically and conventionally produced carrots in healthy men. British Journal of Nutrition 101, 1664-1672.
Stracke, B.A., Rüfer, C.E., Weibel, F.P., Bub, A., Watzl, B., 2009b. Three-Year Comparison of the Polyphenol

Contents and Antioxidant Capacities in Organically and Conventionally Produced Apples (*Malus domestica* Bork. Cultivar Golden Delicious'). Journal of Agricultural and Food Chemistry 57, 4598-4605.

Strauch, D., 1993. Survival of pathogenic microorganisms and parasites in excreta, manure and sewage sludge. Part I.-a review. Medycyna Weterynaryjna 49, 59-59.

Sundrum, A., Bütfering, L., Henning, M., Hoppenbrock, K., 2000. Effects of on-farm diets for organic pig production on performance and carcass quality. Journal of Animal Science 78, 1199-1205.

Tasiopoulou, S., Chiodini, A.M., Vellere, F., Visentin, S., 2007. Results of the monitoring program of pesticide residues in organic food of plant origin in Lombardy (Italy). Journal of Environmental Science and Health 42, 835-841.

Tiquia, S., Tam, N., Hodgkiss, I., 1998. *Salmonella* elimination during composting of spent pig litter. Bioresource Technology 63, 193-196.

Toledo, P., Andrén, A., Björck, L., 2002. Composition of raw milk from sustainable production systems. International dairy journal 12, 75-80.

Warnick, L.D., Crofton, L.M., Pelzer, K.D., Hawkins, M., 2001. Risk factors for clinical salmonellosis in Virginia, USA cattle herds. Preventive Veterinary Medicine 49, 259-275.

WCRF, W.C.R.F., 2007. Food, nutrition, physical activity, and the prevention of cancer: a global perspective. American Institute of Cancer, Washington, DC, USA, 517.

WHO, 2004. Food and health in Europe: A new basis for action. World Health Organization Regional Publications 96, 385.

Woese, K., Lange, D., Boess, C., Bögl, K.W., 1997. A Comparison of Organically and Conventionally Grown Foods-Results of a Review of the Relevant Literature. Journal of the Science of Food and Agriculture 74, 281-293.

Woodward, L., Meier-Ploeger, A., 1999. Raindrops on roses and whiskers on kittens": consumers' perceptions of organic food quality. Organic agriculture the credible solution for the XXIst century. IFOAM, 81-88.

Wszelaki, A.L., Delwiche, J.F., Walker, S.D., Liggett, R.E., Scheerens, J.C., Kleinhenz, M.D., 2005. Sensory quality and mineral and glycoalkaloid concentrations in organically and conventionally grown redskin potatoes (*Solanum tuberosum*). Journal of the Science of Food and Agriculture 85, 720-726.

Wunderlich, S.M., Feldman, C., Kane, S., Hazhin, T., 2008. Nutritional quality of organic, conventional, and seasonally grown broccoli using vitamin C as a marker. International Journal of Food Sciences and Nutrition 59, 34-45.

Zhao, X., Chambers, E., Matta, Z., Loughin, T.M., Carey, E.E., 2007. Consumer sensory analysis of organically and conventionally grown vegetables. Journal of Food Science 72, S87-S91.

Zhao, X., Rajashekar, C., Carey, E.E., Wang, W., 2006. Does organic production enhance phytochemical content of fruit and vegetables? Current knowledge and prospects for research. HortTechnology 16, 449-456.

Zörb, C., Langenkämper, G., Betsche, T., Niehaus, K., Barsch, A., 2006. Metabolite profiling of wheat grains (*Triticum aestivum* L.) from organic and conventional agriculture. Journal of Agricultural and Food Chemistry 54, 8301-8306.