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# Conventional and organic foods: A comparison focused on animal products

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**Abstract:** The term "organic" denotes a product of a food production system that is socially, ecologically, and economically sustainable. The organic food market is growing in response to an ever increasing demand for organic products. They are often considered more nutritious, healthier, and free from pesticides than conventional foods. However, the results of scientific studies do not show that organic products are more nutritious and safer than conventional foods. In this work a comparison between conventional and organic foods is made, the focus is on animal products. The data available in the existing literature is often conflicting, even if the differences are often associated with breeds suited to organic vs. conventional production systems. In order to have a clear understanding of the role that "organic effect" plays on animal foods, further research is necessary.

**Subjects: Agriculture and Food; Food Science & Technology; Nutrition**

**Keywords: animal food; conventional food; organic food; sustainability**

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## PUBLIC INTEREST STATEMENT

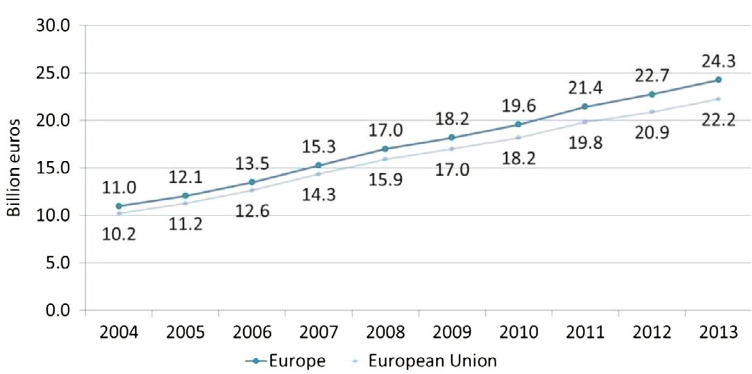
In recent years, there has been a growing interest in organic foodstuffs, due to the fact that their production is sustainable, being a low environmental impact. Moreover, the consumers generally believe that organic products are healthier than conventionally produced foods. These issues have prompted numerous studies to compare nutritional characteristics of organic with conventionally produced foods. However, the results of these studies are discordant. In this paper, a comprehensive and current overview of the widely available information about conventional and organic foods, with a focus on animal products, has been reported.

## 1. Introduction

According to the definition given by the Council of the European Union, organic production is a system of farm management and food production that combines the best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards, and a production method in line with the preferences of certain consumers for foodstuffs produced using natural substances and processes (EU, 834/2007). The common definitions for organic farming are the ones used by FAO—"Organic farming is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity" (Food & Agriculture Organization, 2013), IFOAM—"Organic agriculture is a production system that sustains the health of soils ecosystems and people" (International Federation of Organic Agriculture Movements, 2007), USDA—"Organic farming is a production system that excludes the use of synthetically produced fertilizers, biocides, growth regulators, and livestock feed additives such as antibiotics and growth hormones" (United States Department of Agriculture, 1980). Therefore, the term "organic" denotes a product obtained from a food production system that is socially, ecologically, and economically sustainable (International Federation of Organic Agricultural Movements, 1998). The sphere of organic foods includes fruits, vegetables, cereals, and animal products which are often considered healthier, safer and better for the environment and animal welfare than conventional foods, due to the fact that chemical pesticides and fertilizers are not used (Kouba, 2003). Prompted by these motivations, in spite of the higher price of organic products, European consumers spent approximately 24.3 billion euros in 2013, helping the European organic market grow by nearly 6% (Figure 1) (Willer & Schaack, 2015).

Nutrition and safety are considered to be two important aspects that prompt consumers to prefer organic over conventional foods; however, from the limited and contradictory data published, it seems that there is not enough evidence that organic foods are more nutritious or safer than conventional foods. Although some studies reported that organic foods have lower pesticide residues compared to conventional foods, they cannot be defined as pesticide-free (Lecef, 1995; Maruejouls & Goulard, 1999). In other studies, it was reported that there is no difference between organic and conventional in terms of pesticide residues (Woese, Lange, Boess, & Bogl, 1997). With regard to microbiological safety, Sundrum, Bütfering, Henning, and Hoppenbrock (2000), reported that there are no differences in the microbial count between organic and conventional foods. On the contrary, an EU report found that organic production leads to a higher *Salmonella* contamination in eggs, poultry, and pork meat compared with conventional foods (EU, 2001). According to Williams (2002), the application of manure and the reduced use of fungicides and antibiotics in organic farming might cause frequent contamination by micro-organisms and microbial products. Moreover, it has been suggested that organic foods are more susceptible to mold contamination, and consequently to mycotoxins, due to the limited application of anti-fungal agents (Kouba, 2003). In relation to product quality, Barrett, Weakley, Diaz, and Watnik (2007) reported a higher content of total soluble solids, higher titratable acidity, and firmness in organic tomatoes compared to conventional ones. On the contrary, in another study (Roussos & Gasparatos, 2009) no differences were found between organic and conventional apples in terms of food quality.

**Figure 1. Development of the organic market in Europe and the European Union 2004–2013 (Willer & Schaack, 2015).**



Studies on organic vegetables found that the level of vitamin C was significantly higher in organically rather than conventionally produced plant foods, such as peaches and tomatoes (Carbonaro, Mattera, Nicoli, Bergamo, & Cappelloni, 2002; Caris-Veyrat et al., 2004; Chassy, Bui, Renaud, Van Horn, & Mitchell, 2006). However, in other studies the vitamin C content in organic and conventionally produced tomatoes, broccoli, bell peppers, and pears was found to be similar (Barrett et al., 2007; Wunderlich, Feldman, Kane, & Hazhin, 2008). The results of research into the carotenoid and phenolic content in organic and conventional plant foods (Carbonaro et al., 2002; Caris-Veyrat et al., 2004; Chassy et al., 2006; Lombardi-Boccia, Lucarini, Lanzi, Aguzzi, & Cappelloni, 2004; (Mitchell et al., 2007) were found to be contradictory. Some studies compared the iron and zinc contents of organically produced crops with conventionally grown crops (Akbaba, Sahin, & Turkez, 2012; Vrček et al., 2014). In some cases, the results of the studies contradicted each other (Ciolek, Makarska, Wesolowski, & Cierpiala, 2012; Kristl, Krajnc, Kramberger, & Mlakar, 2013; Vrček et al., 2014), while in other cases no significant differences were found (He et al., 2013; Kristl et al., 2013; Martínez-Ballesta et al., 2010; Ordóñez-Santos, Vázquez-Odériz, & Romero-Rodríguez, 2011). As reported by Johansson, Hussain, Kuktaite, Andersson, and Olsson (2014) the mineral content in crops, as well as the carotenoid and phenol content, seem to be more affected by factors, such as the type of crop, year, place, environment, and harvest time than by the farming system.

Organic foods of animal origin are derived from animals fed on 100% organic food for at least 12 months. The use of antibiotics, synthetic growth promoters, genetically engineered vaccines is prohibited (Winter & Davis, 2006). Supplementation with enzymes, probiotics, and vitamins is allowed only if these substances have a natural origin (Chalova & Ricke, 2012). In particular, the animal feed involves the use of seasonal grazing and the reduction of feed concentrates. Several comparative studies showed lower nitrates, nitrites, and pesticide residues, but usually higher levels of vitamin C, dry matter, phenolic compounds, essential amino acids, and total sugars in organic plant products, as well as higher levels of omega-3 fatty acids and conjugated linoleic acid in milk from organically raised animals (Rembiałkowska, 2007). However, the results of comparative studies are highly variable, because of plant fertilization, ripening stage and plant age at harvest, and weather conditions (Huber, Rembiałkowska, Średnicka, Bügel, & van de Vijver, 2011).

Some studies investigated the effects of organically and conventionally grown feed on animal health. Vogtmann (1988) reported a lower mortality rate among newborn rabbits given organic feed compared with those given conventional feed. Balfour (1975) suggested that organic feed may positively influence animal health and performance (e.g. increased milk production from organically fed cows). Plochberger's (1989) did not observe any differences in the weight development of chicks fed with organic and chicks fed with conventional food. However, she did find significant differences in egg's weight and composition. In particular, it emerged that when chicks are fed organically, they produce heavier eggs with a heavier yolk, but less albumen. In another study, it was observed that organically fed chickens have lower body weights, higher immune reactivity, and stronger catch-up growth after a challenge compared with chickens which were given conventional feed (Huber et al., 2010). Velimirov, Plochberger, Huspeka, and Schott (1992) found that the fertility of rats may be improved through organic feeding. Also Lauridsen, Jorgensen, Halekon, Lars-Porsjer, and Brandt (2005) investigated the effect of organic feed on rats. They observed higher immune system reactivity in organically fed rats compared with rats given conventional feed. As for the effects on human health of the consumption of organic food, it is not possible to state with certainty that regular assumption of such foods leads to some benefit (Huber et al., 2011).

Therefore, as remarked by Sekkin and Kum (2013) the major qualitative differences of organic and conventional feeds seem to be due to differences in production of plants. In general, animal feed, including herbage, may be contaminated with organic and inorganic compounds; this can lead disorders for farm animals and also could lead to human illness. Among the animal feed's contaminants, there are the mycotoxin. In a recent study, Błajet-Kosicka, Twarużek, Kosicki, Sibiorowska, and Grajewski (2014) compared the co-occurrence of *Fusarium* toxins in conventional and organic grain showing that the concentrations of deoxynivalenol, zearalenone, T-2 toxin, and HT-2 toxin were significantly higher in samples of conventional products and similar results were obtained by Edwards (2009) that investigated the presence of mycotoxins in organic and conventional oats and by Bernhoft, Clasen, Kristoffersen, and Torp (2010) that evaluated different cereals.

Among the others undesirable contaminants which may be present in feeds, particular attention should be addressed to pesticide residues. In organic farming is allowed the use of approved pesticides of natural origin (e.g. extracts from plants or micro-organism). A list of the approved pesticides for organic agriculture in the EU can be found in Regulation 354, and it includes pyrethrins, azadirachtin, and quassia used as insecticides (EU, 354/2014). "Natural" does not mean "safe"; in fact the pyrethrins, a substance naturally occurring in the flower *Chrysanthemum cinerariifolium,* can have neurotoxic effects, as well as the rotenone (Forman et al., 2012). Pesticides that may contaminate feeds are potentially toxic to farm livestock, and this is even more worrying if the animal products are intended for human consumption (Sekkin & Kum, 2013). However, in a recent meta-analyses, conducted on the basis on 343 peer-reviewed publications concerning the composition of organic and conventional crops/crop-based foods, was shown that the prohibition of synthetic chemical pesticide use under organic farming standards results in a more than 4-fold reduction in the number of samples with pesticide residues (Barański et al., 2014).

In light of what's said above, an overview of the comparison between conventional and organic foods is given, with a focus on animal products in order to summarize existing scientific evidence. The results related to the influence of organic farming on nutritional and sensory characteristics of animal foodstuffs are reported.

## 2. Animal products

Reviews and articles of the last twenty years, concerning the comparison between conventional and organic animal products, were analyzed. A bibliographical search was conducted using the following keywords: organic food, conventional food, animal food, and sustainability.

### *2.1. Milk and dairy products*

Milk is the most common organic product of animal origin (Ghidini et al., 2005). Several studies compare the composition of organic and conventional milk, but the interpretation of the results is complicated, because the quality and composition of milk is influenced by many factors, such as animal feed, breed, individual animal genetics, management, stage of lactation, and season (Capuano et al., 2014; Capuano, Gravink, Boerrigter-Eenling, & van Ruth, 2015; Schwendel, Morel, et al., 2015; Stergiadis et al., 2014). In Table 1, the differences in nutrient quality between conventional and organic milk and dairy products were reported. Many of these studies focus on potential differences in the fatty acid composition of organic and conventional milk (Bilal, Cue, Mustafa, & Hayes, 2012; Capuano et al., 2015; Kusche et al., 2015). Milk contains approximately 400 different fatty acids (FA), including polyunsaturated fatty acids (PUFA) and conjugated linoleic acid (CLA) isomer *cis*-9 *trans*-11 (C18:2); some FAs may have potential beneficial effects on human health. The principal n-3 FA in milk is $\alpha$-linolenic acid (C18:3), along with smaller amounts of docosahexaenoic acid (C20:5) and eicosapentaenoic acid (C22:6). The n-3 FA is implicated in the prevention of coronary artery disease, hypertension, diabetes, arthritis, other inflammatory, autoimmune disorders, and cancer (Ellis et al., 2006; Tsiplakou, Kotrotsios, Hadjigeorgiou, & Zervas, 2010). By contrast, negative consequences on health may result from saturated fatty acids (SFA), in particular for lauric (C12:0), myristic (C14:0), and palmitic acids (C16:0) (Temme, Mensink, & Hornstra, 1996) due to their effects on low-density lipoprotein cholesterol and coronary heart disease (Butler, Stergiadis, Seal, Eyre, & Leifert, 2011). Therefore, the effect of milk fat on human health cannot be described as either positive or negative; rather, it is necessary to consider the biological function of each FA separately (Schwendel, Morel, et al., 2015). Milk certified as organic in the European Union might have a favorable fat profile in n-3 FA, because the concentrations of specific PUFA increase when the animal consumes a large quantity of fresh grass, grass/clover forage, and low quantities of concentrate-based diets (Stergiadis et al., 2014). For example, Adler, Jensen, Govasmark and Steinshamn (Adler, Jensen, Govasmark, & Steinshamn, 2013) compared milk samples from organic and conventional farms and reported

**Table 1. Differences between organic and conventionally produced milk and dairy products**

| Food products | Country | Nutritional and technological aspects | References |
|---|---|---|---|
| Milk | Central Norway | Milk from organic farms had higher proportions of health-beneficial n-3 FA, but also higher proportions of total SFA in comparison with conventional samples | Adler et al. (2013) |
| Milk | The Netherlands | Milk from organic farms had higher concentration of health-beneficial n-3 FA in comparison with conventional samples | Bloksma et al. (2008) |
| Milk | Wales | Milk from organic farms had lower concentration of κ-casein in comparison with conventional samples | Stergiadis et al. (2014) |
| Buffalo milk/mozzarella cheese | Italy | Buffalo milk and mozzarella cheese from organic farms had higher n-3 FA and α-tocopherol concentrations in comparison with conventional samples | Bergamo et al. (2003) |
| Milk | Germany | Milk from organic farms had higher concentration of health-beneficial n-3 FA in comparison with conventional samples | Molkentin and Giesemann (2007) |
| Milk | New Zealand | Milk from organic farms had higher concentration of health-beneficial n-3 FA, whereas CLA and VA were higher in conventional milk, with significant seasonal variations | Schwendel, Wester, et al. (2015) |
| Milk and Grana Padano | Italy | Milk from organic farms had higher annual means of CLA, VA, and ALA in comparison with conventional samples | Prandini et al. (2009) |
| Milk | Spain | Compared with conventional milk, organic milk had significantly higher levels of phospholipids | Ferreiro et al. (2015) |
| Ewe's and goat's milk | Greece | No significant differences in relation to fat, protein and, lactose level were found for organic and conventional milk | Malissiova et al. (2015) |
| Milk | Poland | Conventional milk had a higher protein and casein content than organic. Cows from conventional farm were also characterized higher milk production compared with the organic one | Bilik and Lopuszanska-Rusek (2010) |
| Milk | Czech Republic | Total solids, whey volume, I and Cu were higher in conventional than in organic milk, whereas Ca, P, Mg, K, and Fe were higher in organic than in conventional one | Hanuš, Vorlíček, et al. (2008) |
| Milk | Poland | Milk from conventional farms had higher percentage of fat and lactose and a lower concentration of protein and somatic cell count in comparison to milk from organic farms | Kuczyńska et al. (2012) |
| Milk | Germany | Conventional milk had higher concentration of protein with respect to organic milk | Müller and Sauerwein (2010) |
| Milk | United States | Organic milk had higher concentration of protein with respect to conventional milk. | Vicini et al. (2008) |
| Milk | Latvia | Organic milk had higher concentration of fat and lactose but lower concentration of thiamine and riboflavin with respect to conventional milk | Zagorska and Ciprovica (2008) |
| Milk | United Kingdom | Organic milk had higher concentration nutritionally desirable FAs (CLA, ALA), α-tocopherol, and carotenoids compared with milk from conventional farm | Butler et al. (2008) |
| Milk | Denmark | Organic milk had higher concentration of α-tocopherol, carotenoids and α-linolenic acid with respect to conventional milk | Slots et al. (2008) |
| Milk | United Kingdom | No significant differences in $\alpha$-tocopherol and $\beta$-carotene concentration between organic and conventional milk | Ellis et al. (2007) |
| Milk | Sweden | No significant differences in $\alpha$-tocopherol and $\beta$-carotene concentration between organic and conventional milk | Fall and Emanuelson (2011) |
| Milk | Denmark | Conventional milk had higher concentration of protein, Ca, Mg, and P compared with organic milk with significant seasonal variation. Moreover, riboflavin concentration in organic milk was lower than conventional one | Poulsen et al. (2015) |
| Milk | Spain | Organic milk had a lower concentration of I and higher concentration of Cu compared to the conventional one | Rey-Crespo et al., 2013; |
| Milk | Czech Republic | Organic milk had higher concentration of Cu, but lower concentration of fat and protein compared to the conventional one | Hanuš, Brychtova, et al. (2008) |
| Milk | Latvia | Organic and conventional milk had comparable levels for Cd, Cu, Fe, and Zn | Zagorska et al. (2005) |
| Milk | United Kingdom | Organic milk had a lower concentration of I than conventional milk | Bath et al. (2012) |
| Milk | United Kingdom | Organic milk had a lower concentration of I than conventional milk | Payling et al. (2015) |
| Milk | Germany | Organic milk had a lower concentration of I than conventional milk | Johner et al. (2011) |

several differences with regard to stearic acid (C18:0), oleic acid (C18:1 *cis*-9), α-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). In particular, concentrations of C18:0 and C18:1 *cis*-9 increased in conventional milk, while ALA was significantly higher in organic milk than in conventional milk ($p < 0.001$). Similar results were found by Bloksma et al. (Bloksma et al., 2008) who compared milk produced by cows fed on grass-clover silage and hay, with milk from cows fed on maize silage and concentrates on conventional farms, and found higher n-3 FA and CLA values in the organic milk compared with the conventional milk ($p < 0.001$). Moreover, it has been demonstrated that feeding regimes used in organic and other low-input, pasture-based dairy production systems increase concentrations of nutritionally desirable monounsaturated fatty acids (MUFA), such as vaccenic acid (VA) as rumenic acid (RA) and PUFA, as well as n-3 and n-6 concentrations ($p < 0.01$) (Stergiadis et al., 2015). Bergamo, Fedele, Iannibelli, and Marzillo (2003), found similar results in buffalo milk, where concentrations of CLA, ALA, and VA in organic buffalo milk were significantly higher than the buffalo milk produced by conventional systems ($p = 0.004$). Molkentin and Giesemann (2007) observed a large variation in the concentration of ALA in organic milk, caused by the greater variety of feed used, compared with conventional farm management. In particular, pasture grazing led to a significant increase in CLA concentration in milk compared with silage feeding. Diet is especially relevant when comparing concentrate-fed and pasture-based systems. Milk FA composition in pasture-based systems is subject to seasonal variations that influence the quality of the forage available and consequently the quality of the milk (Schwendel, Morel, et al., 2015). In fact, although the levels of linoleic acid and α-linolenic acid in organic milk were higher than in conventional milk, significant differences were found between spring and autumn milk with more abundant linoleic acid, ALA, and CLA in milk harvested in autumn ($p < 0.001$) (Schwendel, Wester, et al., 2015). The higher concentration of nutritionally desirable fatty acids in organic milk also affects products obtained from the organic milk; in fact Prandini, Sigolo, and Piva (2009) showed that the organic curds and Grana Padano cheese were characterized by higher CLA, VA, and ALA than conventional samples ($p < 0.05$) and the same was observed in mozzarella cheese produced with organic milk ($p = 0.004$) (Stergiadis et al., 2015). Furthermore, a recent study of organic milk showed that it has a significantly higher concentration of phospholipids with properties that are important for the development of so-called "functional foods" and technologically novel ingredients ($p < 0.05$) (Ferreiro, Gayoso, & Rodríguez-Otero, 2015). However, the results presented in the literature are often contradictory. For instance, Ellis et al. (2006) observed no significant difference in the comparative CLA values of organic and conventional milk. Also Malissiova et al. (2015) found no significant differences in the fat level in both ewe and goat's organic and conventional milk. The protein concentration in milk appears unresponsive to variations in nutrition management and is generally correlated with individual cow genetics, stage of lactation, and breed (Schwendel, Morel, et al., 2015). In the literature, there are different and discordant results. Bilik and Lopuszanska-Rusek (2010) found that conventional milk has a higher protein and casein content than organic milk. Similar results were shown by Hanuš, Vorlíček, et al. (2008) and Sundberg, Rydhmer, Fikse, Berglund, and Strandberg (2010). Also in a study conducted by Kuczyńska et al. (2012), the whey protein concentration in cow's milk collected in the late pasture and early indoor feeding seasons from conventional and organic farms in Poland was investigated; the percentage of protein was higher under conventional farming conditions than with organic farming ($p < 0.01$). Furthermore, Müller and Sauerwein (2010) highlighted a tendency for conventional milk to contain a higher concentration of protein compared with organic milk. This is probably due to an organic farming regulation, that limits the use of supplements, thus a lower protein concentration can be expected in milk from organic farms. Similar results were reported by Stergiadis et al. (2015) who showed that κ-casein level and casein: whey protein ratio was higher in conventional than in organic milk ($p < 0.05$). In particular, researchers (Stergiadis et al., 2015) have also underlined the relationship between protein concentration and monthly sampling, with a higher concentration of casein in the milk of March and a higher concentration of the whey proteins in the milk of May and August ($p < 0.05$). On the other hand, Vicini et al. (2008) reported slightly higher concentrations of protein in organic milk than in conventional milk ($p < 0.001$); the same was observed by Anacker (2007) who found that the casein content in organic milk was 0.21% higher than in conventional milk.

Lactose is the main sugar in milk which cannot generally be manipulated by dietary changes, except in extreme and unusual feeding situations (Jenkins & McGuire, 2006). In several publications it has been reported that there is no significant difference in the lactose concentration between organic and conventional milk (Bilik & Lopuszanska-Rusek, 2010; Ferreiro et al., 2015; Nauta, Veerkamp, Brascamp, & Bovenhuis, 2006). However, Zagorska and Ciprovica (2008) reported higher concentrations of sugar in milk from organic farms than conventional farms, attributing this difference to the animal's diet ($p < 0.05$).

Several studies investigated the concentration of water and fat soluble vitamins in milk in order to verify whether the concentration of these nutrients differs between organic and conventionally produced milk. The $\alpha$-tocopherol (a form of vitamin E) and $\beta$-carotene (a vitamin A precursor) content in milk are of interest for milk industries because they may prevent spontaneous milk oxidation. In general, milk fat is a good dietary source of retinol, $\alpha$-tocopherol, and $\beta$-carotene, which exert their antioxidant activity in biological tissues, as well as in foods. Moreover, $\beta$-carotene and retinal can act as a potent free radical scavenger, thus preventing or limiting the oxidation of fatty acid (Bergamo et al., 2003). Their concentration in milk depends on their content in the diet of the animal (Mogensen, Kristensen, Søegaard, Jensen, & Sehested, 2012). Higher concentrations of vitamins can be found in fresh forage than in stored or dried forages and cereals (Kay, Roche, Kolver, Thomson, & Baumgard, 2005). Indeed, Butler et al. (2008) reported higher amounts of $\alpha$-tocopherol and $\beta$-carotene in organic milk than conventional milk ($p < 0.001$) and the same results were also reported by other researchers (Schwendel, Wester, et al., 2015; Slots, Sorensen, & Nielsen, 2008; Stergiadis et al., 2014, 2015). It can also be assumed that the lower concentration of antioxidant in conventional milk is the consequence of dilution, resulting from the higher milk yields in conventional farming compared with organic farming (Ellis et al., 2007). No significant differences in $\alpha$-tocopherol and $\beta$-carotene concentrations between organic and conventional milk were observed by Ellis et al. (2007) and by Fall and Emanuelson (2011). Nevertheless, it should be noted that different results may occur depending on the different methods of quantification used. In particular, Slots, Sorensen and Nielsen (Slots et al., 2008) showed that contents of the natural stereoisomer RRR-$\alpha$ -tocopherol are higher for organic than for conventional milk, whereas the synthetic 2R stereoisomer of $\alpha$-tocopherol is significantly higher in conventional than in organic milk, due to fortification of concentrates. With regard to water soluble vitamins, Zagorska and Ciprovica (2008) reported that thiamine and riboflavin (vitamin $B_1$ and $B_2$) concentrations in organic milk are lower than in conventional milk ($p < 0.05$). The same was reported by Poulsen et al. (2015) regarding the content of riboflavin. This can be explained by the fact that both vitamins are found in cereals and the diet of conventional dairy cows contains a higher intake of grains than the diet of cows in organic farming (Gołda, Szyniarowski, Ostrowska, Kozik, & Rąpała-Kozik, 2004).

Some studies compared the mineral content of organic and conventional milk. Their concentrations in animal products are generally related to feed (Windisch & Ettle, 2008) Especially in conventional farming the main source of trace elements are the mineral supplements routinely added to the concentrate. On the contrary, in organic farming mineral supplements are not routinely used (Blanco-Penedo, Lundh, Holtenius, Fall, & Emanuelson, 2014; Rey-Crespo, Miranda, & López-Alonso, 2013). Due to restrictions on the type of feeding imposed by EU regulations, in organic dairy farms, a clear deficiency in zinc, molybdenum, selenium, copper, and iodine can occur (Rosati & Aumaitre, 2004). This has been demonstrated also by Rey-Crespo et al. (2013), who evaluated the main essential different trace elements in milk (Co, Cr, Cu, Fe, I, Mn, Mo, Ni, Se, and Zn) and highlighted a significantly lower concentration of these minerals in organic compared to conventional milk. In the same way, Rey-Crespo, Miranda, and López-Alonso (2013) and Hanuš, Brychtova, et al. (2008), observed higher concentrations of Cu in conventional than in organic milk ($p \leq 0.01$). This fact suggested that organic dairy cows could be exposed at a greater risk of deficiency of essential elements compared to animals kept in conventional herds. However, in a recent study, Ghidini et al. (2005) found comparable levels of Cd, Cu, Fe, and Zn in organic and conventional milk. These contrasting results could be attributed to the different experimental methods and to the physiological state of the cows. For example, a higher Cu serum level and a lower Mo in serum concentrations may depend on the stage of lactation. Iodine concentrations in organic and conventional milk have been extensively researched and were found to depend largely on dietary intake. In fact, as has been reported by several authors (Bath, Button, & Rayman, 2012; Johner, von Nida, Jahreis, & Remer, 2011; Payling, Juniper, Drake, Rymer, & Givens, 2015) conventional milk has a significantly higher iodine concentration than organic milk, regardless of the season in which it is produced.

The content of toxic elements in milk is generally low and within the admissible level (Gabryszuk, Sloniewski, Metera, & Sakowski, 2010; Gabryszuk, Słoniewski, & Sakowski, 2008), the content of heavy metals in milk depends on feed, on their presence in the soil, environmental contamination, as well as on the antagonistic interaction between bioelements and heavy metals, which influences their absorption and metabolism. For these reasons, the content of toxic elements in milk from organic farms is not lower than in milk from conventional herds (Gabryszuk et al., 2010).

In conclusion, although the composition of organic milk has become an important issue for debate, mainly due to higher consumer expectations, the results in the literature do not point in a clear direction, but are often contradictory. Certainly the effect of animal nutrition on the composition of milk, especially fat composition, is well documented. However, one must consider that there are numerous other factors that affect milk composition, such as breed, genetics, stage of lactation, management, and season. Consequently, any differences in milk composition cannot be attributed to the farming system alone.

### *2.2. Meat*

Currently meat consumption habits are changing and it has been found that consumers not only demand products with better physicochemical and sensory characteristics, but that are also safe, healthier, and environmentally friendly. In recent years, organic animal products have received significant attention in most developed countries, as environmentally friendly products are considered to be healthier and safer than those produced by intensive production systems (Hansen, Claudi-Magnussen, Jensen, & Andersen, 2006; (Sundrum, 2001). Major differences between organic and conventional animal nutrition are the ban on synthetic amino acid and products of genetically modified organisms. Moreover, antibiotics and growth promoters are prohibited (International Federation of Organic Agricultural Movements, 1996; Kim et al., 2009).

Several studies have investigated the difference between organic vs conventional breeding for different animals by examining and evaluating chemical, physical, and sensory parameters of the meat. The results of these studies were reported in Table 2. Revilla et al. (2009) compared the meat from suckling lamb bred by different systems—organic and conventional. The sensory properties of the meat were investigated by a trained panel and the overall customer satisfaction of those consuming the product was also evaluated. In terms of homogeneous aspect, sinew content and juiciness in raw or grilled meat no significant differences were found. The grilled meat sample was also assessed for various chemical parameters, such as texture. Fibrous texture ($p \le 0.05$) and fatness sensation ($p \le 0.01$) were found to be significantly lower in the organic samples than in the conventional samples. The less fibrous texture found in organic meat may be related to the fact that the meat from organic suckling lamb was considered to be less tough; while the lower fatness sensation could be attributable to the higher proportion of unsaturated fatty acids in organic meat, due to its lower melting point (Revilla, Vivar-Quintana, Luruena-Martinez, Palacios, & Severiano-Perez, 2008).

Overall satisfaction expressed by habitual consumers was high for both samples, but the highest scores given to the organically produced samples ($p \le 0.05$). Husak, Sebranek, and Bregendahl (2008), did not detect any differences in the aroma, tenderness, chewiness, moistness, or flavor of chicken breast from organic, free-range, and conventionally farmed chickens. However, the sensory analysis indicated that conventional chicken thighs are more tender and less chewy than the legs from organic and free-range chickens, confirming the instrumental tenderness values observed. Castellini, Mugnai, and Boso (2002) found that panelists gave significantly higher scores for juiciness and overall acceptability to organic breast muscles than to conventional meat. Kishowar, Paterson,

**Table 2. Differences between organic and conventionally produced meat**

| Food products | Country | Nutritional, sensory, and technological aspects | References |
|---|---|---|---|
| Pigs | Korea | Organically reared pigs had higher myoglobin content and consequently higher CIE a*-values compared with those for the conventionally reared pigs | Kim et al. (2009) |
| Suckling lambs | United Kingdom | The appearance of the organic raw meat was more fibrous, darker, and with a lower aroma intensity than the conventional one. In grilled meat, the organic samples had less subcutaneous fat, less fibrous texture, less aroma intensity, but also less juiciness than the conventional one | Revilla et al. (2009) |
| Chickens | Midwest | Organically raised chickens had less yellow appearance for breast, thigh, and skin pieces when compared with conventional carcass components | Husak et al. (2008) |
| Chickens | The Netherlands | The meat from organic production has a lower fat content than conventional meat | Courtney et al. (2015) |
| Sirloin steaks | United Kingdom | The meat from organic production provides nutritionally more favorable FA profiles compared to conventional meat | Kamihiro et al. (2015) |
| Rabbits | Spain | The meat of organic rabbits is significantly richer in polyunsaturated FA compared with the conventional one | Pla et al. (2007) |

and Piggott (2005) concluded that for breast meat from organic, free-range, and corn-fed chickens, it was the appearance and texture of the meat that distinguished organic groups from conventional groups. Furthermore, the different farming systems have an effect on color: in the suckling lamb meat, a brown color ($p \leq 0.01$), was more common in the organic samples, and a pink color in raw meat. The sensory results for pink and brown colored meat were coherent with the higher values obtained by instrumental analysis of *a** (CIELab parameters) in raw meat from organic suckling lamb (Palacios, Revilla, Vivar-Quintana, Luruena-Martinez, & Severiano-Perez, 2008). A study on pork meat showed that the meat of organically reared pigs has significantly ($p < 0.05$) higher CIE a*(red) and b*(yellow) values than the meat of conventionally reared pigs of equivalent weight. The myglobin content (Kim et al., 2009) in these samples was also significantly ($p < 0.05$) higher. This could be attributed to the higher amount of exercise that is part of the organic farming management system (Kim et al., 2009; Revilla et al., 2009). The breast, thigh, and skin parts of conventionally raised chickens usually have a more yellow appearance than carcass components of organically raised chickens (Husak et al., 2008).

The superficial fat and intramuscular fat were lower in organic suckling lamb meat samples, although the results for raw meat revealed the opposite (Revilla et al., 2009). Odor intensity ($p \leq 0.01$) was lower in organic samples, also in raw meat (Revilla et al., 2009) because of the lower amount of n-3 PUFAs (Revilla et al., 2008), associated with a more intense lamb flavor (Angood et al., 2007) and this is due to a lower suckling lamb smell intensity found in raw meat. However, organically produced samples had higher country odor values. This result is attributable to the higher amounts of heptanal found in organic samples (Revilla et al., 2009). The anomalous smell was significantly lower ($p < 0.1$) in organic meat samples than conventional meat. Kim et al. (2009) studied the carcass characteristics of Korean-native black pigs, showing no noticeable differences in live and carcass weight. The organically reared pigs had lower shear force values than the conventionally reared ones. This contrasting result may be due to the differing diets and rearing conditions of the two farming systems. Heyer, Kristina Andersson, and Lundström (2006) observed that shear force tended to be lower for pigs in the outdoor systems than for pigs in the indoor systems. The meat quality characteristics of conventional and organic pigs were the same with regard to pH and cooking loss. The breeding system did not affect off-odor, acidulous taste, off-taste, or tenderness; moreover, the consumer preference tests showed no significant differences between organically and conventionally produced meats.

Courtney, Kirsty, and Given (2015) have shown that the meat from organic production has less fat than conventional meat; a finding confirmed by Castellini et al. (2002) and by Husak et al. (2008) observed that the most significant differences between broilers provided to consumers as organic and conventional chickens included: color, fatty acid composition, and tenderness. Kamihiro, Stergiadis, Leifert, Eyre, and Butler (2015) reported how organic and conventional production systems and the end-of-season production can affect the meat and fat quality of sirloin steaks. They observed little difference in meat quality (pH, shear force, and color), but found that the fat profiles varied considerably between production systems and seasons. Organic, summer-finished beef provides nutritionally more favorable FA profiles with higher n-3 (ALA, EPA, DPA, and DHA), CLA, and VA compared to non-organic, winter finished samples.

The different diets used in organic and conventional production systems may influence the nutrient and fatty acid composition in pork (Bosi, 1999). Differences in space allowance, stocking density, and climatic conditions might also influence the composition and quality of pigs reared out-of-doors. A number of studies reported that organic pork contained a higher content of unsaturated fatty acid (Danielsen, Hansen, Møller, Bejrholm, & Nielsen, 2000; Hansen et al., 2006; Nilzén et al., 2001). In the Korean native black pigs, Kim et al. (2009), found higher levels of C18:2n6, C20:3n6, and C22:4n6 in pigs produced organically ($p < 0.05$) and lower levels of C14:0, C16:0, C16:1n7, C18:1n9, C20:1n9, and C20:4n6 than in conventionally produced pigs ($p < 0.05$). This was supported by the findings of Hansen et al. (2006). In organically produced pork meat, the proportion of SFA and MUFA was significantly lower than in conventional pork meat, while unsaturated fatty acid (USFA) and PUFA were significantly higher. The higher content of PUFA in organically produced pigs may be not only the result of the different feed, but may also be a consequence of a higher percentage of lean meat (Hansen et al., 2006). Högberg, Pickova, Andersson, and Lundström (2003), observed that the fatty acid composition varies substantially between the organic and conventional feed. The conventional feed had a higher SFA, MUFA, and PUFA. These differences consisted in higher levels of n-6 and n-3 PUFA in the neutral fraction of intramuscular fat and higher levels of n-3 PUFA in the polar lipids of the conventional pigs compared with organic pigs.

In rabbit meat, the main fatty acids are palmitic, linoleic, and oleic acid (Cambero, de la Hoz, Sanz, & Ordóñez, 1991; Högberg et al., 2003; Ramírez et al., 2005). Pla, Hernández, Ariño, Ramírez, and Díaz (2007) observed that the meat of organic rabbits is significantly poorer in MUFA and richer in PUFA than that of conventional rabbits. However, a real comparison between organic and conventionally produced meat is difficult, because different breeds are used (Kouba, 2003) therefore, the detected differences can be explained by the production system, mainly due to the diet and age at slaughter. Cambero et al. (1991) comparing rabbits fed different diets and slaughtered at different ages, reported that it is difficult to establish a clear relationship between the fatty acid content in rabbit meat and age, sex, diet, or breed.

Organic chicken breasts and thighs had significantly greater percentages of PUFA, including n-3 and n-6 FA, compared with conventional chickens (Revilla et al., 2008). The same results were reported by Courtney et al. (2015) except that they found a lower n-3 FA content in organic chicken meat than in conventional meat. Chicken meat is a rich source of cis-MUFA; however, organic meat contained less than conventional meat. The lower total n-3 PUFA concentration in organic meat is due to lower 18:3 n-3; whereas organic meat contains more EPA and DHA than conventional meat (Courtney et al., 2015). Bianchi et al. (2007), Fanatico, Pillai, Emmert, and Owens (2007) and Ponte et al. (2008) showed that genetics, production methods, and season influence the meat quality of broilers. Finally, it is clear that the farming method affects both nutritional and sensory characteristics of livestock products. However, also factors such as the age, the breed of the animal, and the season can affect the overall meat quality. Moreover, the storage, transportation, and preparation of the foodstuffs may have an effect on the quality of meat products (Dangour et al., 2009).

### *2.3. Fish*

In organic aquaculture the research primarily regards organic feed and fish nutrition; differences in feed and nutrition compared to conventional systems lead to differences in the quality of the flesh (Mente, Karalazos, Karapanagiotidis, & Pita, 2011). Moreover, the nutrition of fish accounts for over 50% of the variable operating costs (Rana, Siriwardena, & Hasan, 2009). In organic aquaculture the animals must be fed in a way that ensures all the nutrients required for the animals' growth and health, high quality of the final edible product, and in way that has low environmental impact (EU, 2009; KRAV, 2009; Soil Association, 2009). In conventional aquaculture diet formulations include vitamins and minerals, carotenoids (naturals and/or synthetics), and other pigments (astaxanthin and canthaxantin) responsible for the skin and flesh color of the fish; moreover, the use of antibiotics and immunostimulants is permitted. Also in an organic system, either the use of synthetic vitamins identical to natural vitamins, or the use of pigments from organic or natural sources, is allowed. However, with regard to antibiotics, the European Union allows a maximum of two annual treatments. However, the use of alternative treatments to antibiotics is recommended, such us natural substances in homoepathic dilutions, plant extracts, minerals, natural immunostimulants, and probiotics (EU, 2009).

Several studies showed that the rearing system and feeding regimes affect the flesh quality, the fatty acid profile, and the appearance of fish (Table 3) (Grigorakis, 2007; Poli et al., 2001; Xiccato, Trocino, Tulli, & Tibaldi, 2004). Also Trocino et al. (2012) investigated the influence of different rearing systems (organic or conventional) on the quality of sea bass (*Dicentrarchus labrax*). The authors reported that the rearing system does not affect the texture of the fish; however, they found a correlation between the size of the fish and its characteristics; firmness of the sea bass increased with size. Also the color was affected by the size of the fish; in fact, the skin and the fillets were darker, the red index of the skin had higher values and the yellow index of fillet increased in medium-sized sea bass. The differences in color may be due to differences in moisture content between small and medium-sized sea bass. The most significant difference between organic and conventional bred fish was observed in their fatty acid composition. The fish from organic farms had a higher content of n-3 PUFAs compared to the fish from conventional farms. The high content of PUFAs was due to the composition and fatty acid profile of their diet. The concentration of n-3 PUFAs was higher in the organic diet than that conventional diet. The organic diet was supplemented with herring oil characterized by a high level of ecosanoic acid, cetoleic acid, and a high content of n-3 PUFAs. Costa, Menesatti, Rambaldi, Argenti, and Bianchini (2013), investigated color differences in European sea bass reared under organic protocols. The authors found a color difference between conventional and organic fish; however, further investigations are required on several fish species to demonstrate that

**Table 3. Differences between organic and conventionally produced fish flesh**

| Food products | Country | Nutritional, sensory and, technological aspects | References |
|---|---|---|---|
| Fish (*Dicentrarchus labrax*) | Italy | No effects of the rearing system on the texture of the fish. In the fish from organic farm was found a higher content of n-3 PUFAs | Trocino et al. (2012) |
| Fish (*Dicentrarchus labrax*) | Italy | Color differences between conventional and organic fishes | Costa et al. (2013) |

there is a real difference in the color between conventional and organic animals. In such cases, the colorimetric analyses can be used to discriminate the fish produced under different farming protocols (conventional or organic). From the different data analyzed it emerged that the fatty acid composition of the fish is affected by the feeding. Specifically, the fish from organic farms have a higher content of PUFAs than fish from conventional farms. However, other aspects such as color and texture of the fish flesh seem to be more influenced by the physiology of the animal rather than the farming system.

### *2.4. Eggs*

In poultry production organic farmers adhere to strict rules regarding stock density, access to outdoor pens, animal feed which must be formulated using only organic raw materials. These rules may lead to some differences between eggs obtained from organic or conventional farmers, as showed in Table 4. Minelli, Sirri, Folegatti, Meluzzi, and Franchini (2007) examined the characteristics of organic eggs compared to conventional eggs. From this study, it emerged that organic eggs are significantly lighter ($p < 0.01$) than conventional eggs with a weight of 64.4 and 66.2 g, respectively. Also the yolk/albumen ratio is significantly lower ($p < 0.01$) in the organic product compared to conventional eggs. Moreover, it was found that the resistance of the eggshell to breakage is higher in conventional than organic eggs ($p < 0.01$), confirming the findings reported by Brand, Parmentier, and Kemp (2004). On the contrary, Hughes, Dun, and McCorquodale (1985) observed a higher thickness and better breaking strength in eggshell of laying hens kept in outside pens but fed with conventional diets. Furthermore, in conventional eggs Minelli et al. (2007) observed that the Haugh index is lower in conventional than organic eggs ($p < 0.01$), probably due to the higher concentration of ammonia in conventional systems which influences albumen pH and its consistency. The yolk of organic eggs showed a lower pigmentation than conventional products, due to the exclusion in organic diets of synthetic pigments ($p < 0.01$). With regard to the chemical composition of organic yolk, a significantly higher content of cholesterol and proteins was found ($p < 0.01$). van Ruth, Alewijn, Rogers, Newton-Smith, and Tena (2011) suggested that the carotenoid content can be used to discriminate organic and conventional eggs. In fact, carotenoids are common colorants of egg yolk and their presence is influenced by the hens' feeding. In the study the yolks of the organic eggs were subjected to carotenoid fingerprint analysis. It was found that organic eggs contained a greater quantity of lutein and zeaxanthin compared to free range and barn eggs. Lutein and zeaxanthin are important antioxidant compounds, representing about 85% of all carotenoids. These results confirm the findings of Breithaupt, Weller and Grashorn (Breithaupt, Weller, & Grashorn, 2003) which revealed a higher lutein concentration in organic eggs compared to conventional eggs.

In conclusion, as a result of different diets, organic eggs are lighter, less pigmented, with a lower yolk/albumen ratio but also more fragile than conventional eggs. However, the number of studies concerning eggs is limited, so it is necessary to conduct further studies.

**Table 4. Differences between organic and conventionally produced eggs**

| Food products | Country | Nutritional, sensory and, technological aspects | References |
|---|---|---|---|
| Eggs | Italy | Organic eggs are significantly lighter, it was found a lower yolk/albumen ratio, lower eggshell breaking strength and higher Haugh index in organic eggs than in conventional eggs. Was also observed a lower pigmentation of organic yolk | Minelli et al. (2007) |
| Eggs | The Netherlands | Lower eggshell breaking strength in organic eggs | Brand et al. (2004) |
| Eggs | Scotland | Lower eggshell breaking strength in conventional eggs | Hughes, Dun, and McCorquodale (1985) |

## 3. Conclusions

In all animal foods, some differences between organic and conventional were observed. Existing data is conflicting, even though differences can often be associated with breeds favored for use in organic vs. conventional production systems. Sometimes these differences affected the appearance of foods (the color, the texture, etc.); other times the nutritional value of the product, particularly the fatty acid content, was affected. The different composition of fatty acids found repeatedly in organic products is certainly an advantage for the consumer's health. In fact, the polyunsaturated fatty acids found in greater concentrations in organic foods are associated with the prevention of various diseases. Therefore, the consumer would also benefit from the fatty acid composition of organic food. However, as reported by almost all the researchers, other aspects must be considered, such as race, age, the season, before starting with absolute certainty that these differences are the consequence of the farming system alone. Further investigations are necessary to understand more clearly the role of "organic effect" on animal foods. Regardless of the scientific evidence, consumers perceive organic foods as more nutritious and safer than conventional food, so the consumer preference is for organic foods.

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