Food quality according to the production system and its relationship with food and nutritional security: a systematic review[1]

Qualidade dos alimentos segundo o sistema de produção e sua relação com a segurança alimentar e nutricional: revisão sistemática

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Abstract

The guarantee of Food and Nutrition Security (FNS) through the provision of quality food is essential for human development and a protective factor for better health conditions for the population. The aim of this study was to compare the quality of food according to the production system and its relationship with FNS. It is a systematic review of literature, based on the Preferred Reporting Items for Systematic Reviews (Prisma) method, whose data totaled 389 studies, 14 of which were included. Comparative studies between foods produced in conventional and alternative production systems based on ecology have shown beneficial effects of the latter on health since they have superior nutritional quality and are safer for consumption. Regarding the environmental impact, these foods favor sustainable production. On the other hand, the conventional production model showed limitations such as the worldwide contamination of the food chain by pesticide residues and synthetic fertilizers, which can cause damage to health and the environment, leading to food and nutritional insecurity. Information that contributes to the strengthening of sustainable agri-food systems is essential tools for the creation of public policies that act as an intersectoral strategy for the promotion of health and food and nutrition security.

Keywords: Food Quality; Food and Nutrition Security; Food Production Systems.

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Resumo

A garantia da segurança alimentar e nutricional (SAN) por meio da oferta de alimentos de qualidade é essencial para o desenvolvimento humano e fator de proteção para melhores condições de saúde da população. O objetivo deste estudo foi comparar a qualidade dos alimentos, segundo o sistema de produção, e sua relação com a SAN. Trata-se de uma revisão sistemática da literatura baseada no método *Preferred Reporting Items for Systematic Reviews* (Prisma), cujo levantamento de dados totalizou 389 estudos, sendo 14 incluídos. Os estudos comparativos entre alimentos produzidos em sistemas convencionais e alternativos de base ecológica mostraram efeitos benéficos destes últimos à saúde, uma vez que possuem qualidade nutricional superior e são mais seguros para o consumo. Em relação ao impacto ambiental, tais alimentos favorecem a produção sustentável. Ao contrário, o modelo de produção convencional mostrou limitações, como a contaminação mundial da cadeia alimentar por resíduos de agrotóxicos e fertilizantes sintéticos que podem causar danos à saúde e ao meio ambiente, levando à insegurança alimentar e nutricional. Informações que contribuam para o fortalecimento dos sistemas agroalimentares sustentáveis são ferramentas essenciais para criação de políticas públicas que atuem como estratégia intersetorial de promoção da saúde e de segurança alimentar e nutricional.

Palavras-chave: Qualidade dos Alimentos; Segurança Alimentar e Nutricional; Sistemas de Produção de Alimentos.

Introduction

Changes in agriculture have been gaining ground in terms of food and nutrition. Production systems that favor access to an inexpensive, diversified, and nutritionally balanced diet, made up of quality food and in an adequate quantity, agree with the principles of nutrition-sensitive agriculture, which is fundamental for promoting the human right to adequate food (HRAF), sovereignty, and food and nutritional security (FNS) (Maluf et al., 2015).

On the other hand, production systems that interfere with the availability, access, consumption, production and biological use of food appropriately and fairly prevent the realization of DHAA, leading to a situation of food and nutritional insecurity. This scenario expresses current food problems in Brazil and the world (Guerra; Cervato-Mancuso; Bezerra, 2019).

In recent years, there has been a growing recognition that human beings are exposed to a multitude of contaminants present in water, soil, air, and food, especially those used by the conventional agriculture system aimed at producing commodities. Also in these systems, the most vulnerable populations, such as people from traditional communities - indigenous and quilombolas, for example - and family farmers, are exposed to territorial conflicts involving the expansion of the agricultural frontier (Bombardi, 2017).

Both direct and indirect contact through continuous exposure or consumption of food contaminated by pesticide residues and heavy metals can cause damage to reproductive health and the immune system, in addition to the development of non-communicable diseases, such as cancer (Carneiro et al., 2015; Gomiero, 2018; Martinez-Ballesta et al., 2010).

Despite this, in Brazil, one of the world leaders in the consumption of pesticides, the volume of these toxic agents released for use in 2019 was the highest in the last ten years. According to data from the Ministry of Agriculture, Livestock and Supply, the overall total of registrations granted until December 2019 reached 474, with the biological and organic origin being only 8% (Brasil, 2017).

The risk assessment of human exposure to chemical contaminants poses challenges to researchers, scientists, public policy managers and health professionals. The increasing complexity of FNS associated with food quality requires effective approaches to prioritize the risks inherent to pesticide residues present in food and the creation of protection mechanisms for the population (Almeida; Carneiro; Vilela, 2009; Carneiro et al., 2015).

Foods produced by the organic system must not contain artificial inputs such as pesticides, hormones, antibiotics, chemical fertilizers, veterinary drugs, and genetically modified organisms, but must include actions to conserve natural resources and consider ethical aspects in the internal social relations of the farm and also towards animals (Ifoam, 2005).

Comparative studies between foods grown in conventional and alternative ecologically-based production systems[2] have shown beneficial effects of the latter on health since they have superior nutritional quality. Regarding the environmental impact, they favor the maintenance of organic matter in the soil, increasing its biodiversity and reducing the loss of nutrients and energy use. In this sense, access to food grown in alternative ecologically-based systems contributes to a healthy and sustainable diet (Arbos et al., 2010; Barański et al., 2017; Bohn et al., 2014; Maciel et al., 2011; Martinelli, Cavalli, 2019).

Thus, the objective of this study was to compare the quality of food according to the production system and its relationship with food and nutritional security.

Methodology

We conducted a systematic review of the literature, based on the recommendations of the Preferred Reporting Items for Systematic Reviews (Prisma) method, according to the following steps: (1) formulation of the guiding question; (2) location and selection of studies; (3) critical evaluation of the studies; (4) data collection; (5) data analysis; (6) synthesis and presentation of data; (7) writing and publishing the results (Galvão; Pansani; Harrad, 2015).

We established the guiding question: "Do organic foods have better nutritional and health quality when compared to conventional ones?". The selection of scientific documents was made in October 2019, through the survey of national and international studies listed on the Capes Journals Portal ("Portal de Periódicos Capes") and the Virtual Health Library (BVS), using the combined descriptors: "food safety system," "quality of food" and "organic food" using the Boolean operator AND.

The search criteria were related to papers in all languages without date delimitation, the main corresponding databases being: Scopus, Elsevier, Web of Science, MedLine, OneFile (Gale), ScienceDirect, SciELO, Directory of Open Access Journals (Doaj), and Lilacs.

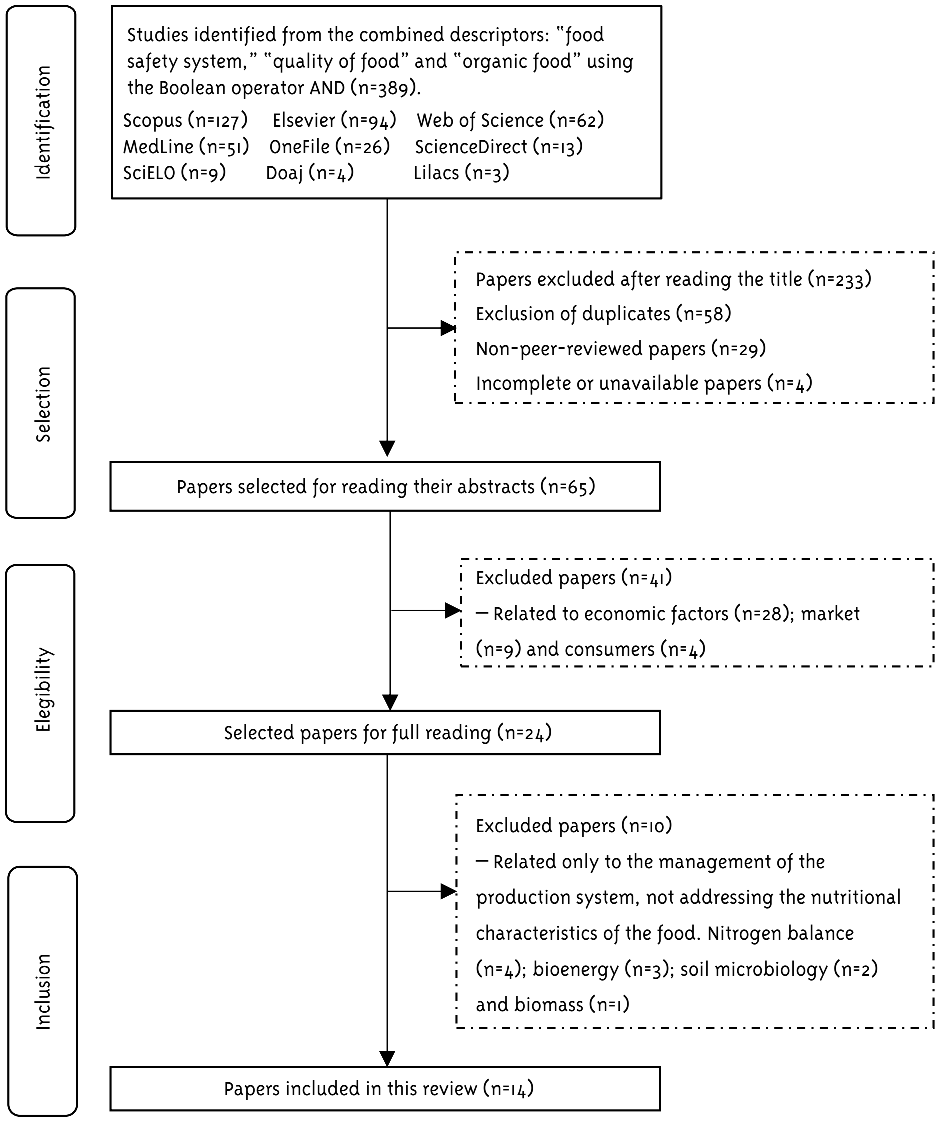
We considered only complete original and peer-reviewed studies, excluding review papers, case reports, expert opinion, brief communications, letter to the editor, book chapters, and those that did not establish a relationship with food and nutrition security (the topic relevant to the purpose of this review). The paper selection stage was carried out by two researchers independently. The first selection was based on examining the title and summary. In a second step, information such as title, year of publication, author, design and objective of the study, methods of analysis of the nutritional and sanitary quality of food, and main results related to the selected papers, were tabulated using spreadsheets in Microsoft Excel, 2010 version.

Results

Initially, the search totaled 389 selected papers. Of these, 365 were excluded after reading the titles and abstracts, eliminating duplicates or papers that did not meet the other established inclusion criteria. The remaining 24 papers were read in full and 14 were included in this review (Figure 1).

2 In this study, the concept of an ecologically-based production system encompasses the so-called organic, ecological, agroecological, biodynamic, natural, regenerative, biological, permaculture and others that meet the principles established by Law 10,831/2003, which provides for the organic agricultural production system in Brazil.

Figure 1 – Schematic representation of the methodology used for identification, selection, eligibility, and inclusion of studies



The characteristics of the studies such as authors, year of publication, location of the study, objectives, and main results are presented in Table 1. Of fourteen selected studies, eight were carried out in Brazil, four in European countries, and two in the United States. Most of them were experimental and, in two, rats and in vitro samples were used. The years of publication varied between 2008 and 2019.

In the studies, the nutrient content of leafy vegetables, tubers, grains, fruits, olive oil, milk, and sanitary quality of meat were evaluated, as well as their implications for human health and the environment, related to the production system.

Some parameters for determining the nutritional quality of food are multifactorial. Therefore, conditions of climate, soil, and genetic variability can imply significant differences between production systems, making the results of some studies not conclusive. For this reason, the selected studies were carried out with crops grown in the same area and on similar soils. This approach contributed to reducing possible sources of variation in nutritional parameters and food and nutrition security.

Table 1 – Results of studies comparing nutritional safety and quality between food produced by ecological and conventional systems, 2020

Authors (year), country	Objectives	Results
Lima (2008), Brazil	To study the accumulation of nitrogen compounds and the activity of the nitrate reductase enzyme in lettuce produced under different cultivation systems.	Regardless of the part of the plant that was analyzed, there was always a greater accumulation of nitrate in the hydroponic system, followed by the conventional system and, finally, the organic system.
Rossi et al. (2008), Italy	To evaluate health-promoting substances and the heavy metal content in tomatoes grown using conventional techniques of integrated pest management (IPM) and organic agriculture.	Organic tomatoes contained more salicylic acid and slightly higher protein content than conventionally grown fruits. In addition, pesticide residues were not detected in organics.
Almeida; Carneiro; Vilela (2009), Brazil	To present the food insecurity scenario in Brazil associated with the contamination of vegetables by pesticides and the challenges of public policies to promote health by encouraging healthy consumption.	It was found that the group of vegetables represents 19.75% of the consumption of active fungicide ingredients in the country. The presence of pesticide residues, already banned in several countries, was detected in 87% of the crops.
Arbos et al. (2010), Brazil	To compare the antioxidant activity and the total phenolic content between lettuce, arugula, and common chicory from organic and conventional crops, planted in the same garden.	The antioxidant activity was higher in arugula, common chicory, and organic lettuce, respectively, when compared to conventional arugula, common chicory, and lettuce. The total phenolic content was higher in organic vegetables.
Maciel et al. (2011), Brazil	To evaluate the antioxidant activities of mangoes grown in biodynamic, organic, and conventional systems at three maturation stages.	Biodynamic mangoes had greater antioxidant activity in unripe and ripe fruits; in organic mangoes, the antioxidant activity was higher in unripe fruits and also showed higher values of phenolic compounds in all stages of maturation. Conventional mangoes showed lower values for all evaluated parameters.
Rosa et al. (2011), Brazil	To characterize the physical-chemical, nutritional, and instrumental characteristics of color and texture of Italian tomatoes (*Lycopersicum esculentum* Mill) of the *'heirloom'* type, produced under organic management for the preparation of concentrated pulp.	No residues of organophosphate and organochlorine pesticides were found in any of the samples. The *'heirloom'* tomato accessions evaluated showed good quality in relation to the acidity/sugar balance and lycopene levels.
Skwarlo-Sonta et al. (2011), Poland	To analyze the effects on feeding in conventional and organic cultures, on growth, chemical composition, hematological parameters, plasma antioxidant capacity, hormonal balance, and immune status of male Wistar rats.	The levels of flavonol, polyphenol, and lutein were higher in organic foods. Hemoglobin content, plasma oxidizing capacity, hormonal balance were also higher in rats fed with organic cultures. The rats fed with conventional cultures showed greater body fat and an imbalance of the immune system.

continued...

Table 1 – Continuation

Authors (year), country	Objectives	Results
Costa et al. (2012), Brazil	To evaluate in lettuces, from conventional and organic crops, two cleaning processes: the traditional and the proposed test method, using a specific detergent for vegetables and coliforms determinations at 45 8 C (thermotolerant) and *Salmonella* sp.	Conventional samples showed greater contamination of coliforms at 45 8 C than organic samples. Conventional and organic samples washed with detergent had a significant reduction in the thermotolerant coliform count of approximately 50%.
Średnicka-Tober et al. (2013), Poland	To quantify the effect on fertilization and application of pesticides in conventional and organic systems in rat diets and body composition, growth, parameters of the hormonal and immunological status of the animals.	Higher concentrations of polyphenols, protein and body ash were observed in organic foods. The use of mineral fertilizers increased Cd, Ni, Cu, and Pb compared to organic crops. No significant differences were found in the body composition, growth and immune system of the rats.
Rossa et al. (2013), Brazil	To comparatively evaluate the occurrence of pathogenic and indicator bacteria and the antimicrobial resistance of enterobacteria isolated from organic and conventional chicken carcasses.	Enterobacteria isolated from organic chicken carcasses showed lower antimicrobial resistance. The restricted or absent use of antibiotics in organic production may contribute to the lower risk of transmission of antibiotic-resistant bacteria through the consumption of chicken meat.
Benbrook et al. (2013), United States	To quantify the composition of milk fat on a large scale in the United States, comparing milk from organic and conventional farms.	Organic milk had a higher protein content and the national average ratios of linoleic acid/α-linolenic acid and ω-6/ω-3 were 2.6 and 2.3 respectively for samples of organic milk, compared to 6.3 and 5.8 for conventionally produced milk samples.
Bohn et al. (2014), United States	To investigate whether soybean cultivars produced under different agricultural practices are substantially equivalent in nutritional content, elemental characteristics, and herbicide/pesticide residues.	The glyphosate-tolerant transgenic soybean showed high glyphosate residues. Organic soy contained more sugars, proteins, and zinc and less saturated fat showing a healthier nutritional profile than transgenic soy. These cultivars are not substantially equivalent.
Kohn et al. (2015), Brazil	To study the postharvest quality of melon grown in an organic system.	The organic management produced fruits with higher levels of sugar, total carotenoids, ascorbic acid, and folates, obtaining more balanced fruits, with better phytochemical quality.
López-Yerena et al. (2019), Spain	Compare the content of polyphenols (secairidoids, flavones, phenolic alcohols, phenolic acids, and lignans) in extra virgin olive oil from the Hojiblanca variety, produced by organic and conventional production systems under the same environmental conditions.	Significantly higher levels of total phenols and secairidoids phenolic compounds (oleuropein, ligstroside, oleocanthal, and elenolic acid derivatives) were found in extra virgin olive oils when compared to conventional oils. The concentration of total phenolic alcohols was not affected by the production systems.

*Cd: cadmium; Ni: nickel; Cu: copper; Pb: lead

Discussion

Food quality and food and nutrition security

The concept of FNS and food quality encompasses several dimensions of human relations on access to food and is constantly under construction. When treated broadly, FNS has been discussed based on five axes: health, hygiene, authenticity, environment, and solidarity (Almeida et al., 2016).

The structuring of FNS influenced the concept of contemporary healthy food, which surpassed the initial reductionist ideas based on quantitative nutrient prescription and incorporated the term "adequate" and the cultural and socio-environmental elements. In other words, it contributed to a greater articulation between food production and consumption, the environment, and rural development. Likewise, the biological aspect, inherent to health security, comes to assume the understanding of food quality free from contaminants, not only chemical and physical ones but also those of biological and genetic nature (Azevedo; Ribas, 2016).

Thus, the term food quality allows us a concept that groups important aspects for choosing those most suitable for human health, such as type of production and nutritional, organoleptic, sanitary, and environmental quality. Adequate and healthy food is both citizenship and a human right and it aims to guarantee the necessary conditions for FNS. Therefore, the consumption of quality food must become a habit increasingly present in the daily life of the population, accessible to all social classes (Rumiato; Monteiro, 2017).

Some of the specific fears about food quality include changes in nutritional quality, toxicity from pesticide residues, possible resistance to antibiotics from genetically modified crops, and potential allergenicity and carcinogenicity due to the consumption of transgenic foods (Baudry et al., 2018; Burlandy; Bocca; Mattos, 2012; Nitzke et al., 2012).

For this reason, conventional production models showed limitations, such as the worldwide contamination of the food chain by pesticide residues and synthetic fertilizers, and the reduction of nutrient contents and food flavors. This fact indicates the urgent need to replace this production model with those with an ecological base, based on agrobiodiversity and sustainability, whose food production is free of pesticides and capable of promoting FNS (Bombardi, 2017; Carneiro et al., 2015).

In this sense, agroecology shows itself as an alternative production model, whose responsible management of natural resources through the systemic approach encompasses the ecological, social, cultural, and economic dimensions. By strengthening democracy, citizenship, autonomy and community participation by social actors such as family farmers, it rescues traditional and popular knowledge and practices and promotes health, quality of life and sustainability, essential conditions for FNS (Pelicioni; Azevedo, 2011).

Nutritional quality

Foods have a complex composition, which highlights not only the diversity of macronutrients (proteins, sugars, and fats) with the corresponding caloric value but also micronutrients (vitamins and minerals).

According to a study by Arbos et al. (2010), the organic cultures of lettuce, arugula, and common chicory vegetables showed greater antioxidant activity, due to their content of total phenolic compounds. Increased intake of polyphenols and antioxidants has been associated with a reduced risk of chronic diseases, such as cardiovascular and neurodegenerative diseases, and certain types of cancer (Baudry et al., 2018).

Likewise, in research conducted by Maciel et al. (2011) and Kohn et al. (2015) with mango and melon, respectively, the organic fruit cultivation system favored an increase in postharvest quality, originating fruits with higher levels of sugars, total carotenoids, ascorbic acid, and folates. The fruits were also more balanced and with better phytochemical quality.

Biodynamic and organic mangoes had greater antioxidant activity in unripe and ripe fruits, in addition to presenting higher values of phenolic compounds in all stages of maturation. The nutritional relevance of these compounds, including flavonoids, is highlighted for their antioxidant activities and protective functions against the risk of diseases caused by oxidative stress, given their ability to capture free radicals in the body. Free radicals are related to pathophysiological processes such as aging, cancer, atherosclerosis, inflammation, among others (Maciel et al., 2011).

When analyzing wheat, barley, potatoes, carrots, and onions grown in organic and conventional systems, it was found that the levels of polyphenol, flavonol, and lutein were higher in organic food. These compounds represent a class of metabolites that have been associated with antioxidant properties and neuroprotective, cardioprotective, and chemopreventive activities, and with reducing the incidence of cancer, gastrointestinal, liver diseases, atherosclerosis, obesity, and allergies (Skwarlo-Sonta et al., 2011; Średnicka-Tober et al., 2013).

Tomato fruits contain a high level of antioxidants, such as vitamin C, polyphenols (including flavonoids), and carotenoids (such as lycopene and ß-carotene). A study by Rossi et al. (2008) with tomatoes produced under organic management demonstrated that the fruits contained more salicylic acid, an important natural anti-inflammatory used in the treatment of patients with heart disease, and slightly higher protein content than conventionally grown fruits. Another similar study with tomatoes produced under organic management, carried out by Rosa et al. (2011), showed that the evaluated fruits showed good quality in relation to the balance between the concentration of citric acid, represented by the acidity of the fruit and the soluble solids content that characterized an adequate flavor for the elaboration of tomato products.

The levels of lycopene in the range of 2,967 to 6,029µg/100g of pulp are considered high and demonstrate an important nutritional aspect, since this is a functional component because it is strongly related to the reduction of free radical production, thus acting in the prevention of several diseases like cancer and cardiovascular diseases. These findings showed the highest level of bioactive compounds in tomato fruits organically produced compared to conventional ones, supporting the idea that organic foods are healthier (Rosa et al., 2011; Rossi et al., 2008).

According to López-Yerena et al. (2019), an important difference between conventional and ecologically-based farming systems is the management of soil fertility that can affect the nutritional composition of plants, including levels of secondary metabolites. Conventional production systems use fertilizers that contain soluble inorganic nitrogen and other nutrients that are more directly available to plants.

However, when evaluating the total phenol content in extra virgin olive oil produced in an organic system, compared to conventional under the same environmental conditions, their levels were significantly higher in organic samples. This fact can be associated with the potential of organic agriculture to promote biodiversity and biological cycles, whose crops obtain nitrogen and nutrients from a diverse soil ecosystem (López-Yerena et al., 2019).

With regard to the substantial equivalence in nutritional content between foods produced in organic and conventional systems, Bohn et al. (2014), when investigating soybean cultivars, noticed that organic soybeans contained higher levels of zinc; sugars, such as glucose, fructose, sucrose, and maltose; and significantly more total proteins and amino acids, such as lysine, alanine, asparagine, serine, and glutamine.

Also according to Bohn et al. (2014), organic soy showed lower levels of saturated fatty acids, such as palmitic acid, whose intake should be as low as possible within the context of nutritionally adequate diets. Regarding polyunsaturated fatty acids such as linoleic acid, organic soybeans also showed lower levels. Although its consumption is important, a high and unbalanced intake – with a high content of omega 6 (ω-6) and low content of omega 3 (ω-3) – is a risk factor for the development of obesity, metabolic syndrome, and diabetes. These data showed that organic soy had a more balanced nutritional profile than conventional soy and that these crops were not substantially equivalent (Bohn et al., 2014).

When quantifying the fat composition of milk produced in the United States, comparing milk from organic and conventional farms, the low ratios of the ratio of ω-6/ω-3 in organic milk indicated increased amounts of ω-3, α-linolenic acid, conjugated linoleic acid and eicosapentaenoic and docosahexaenoic acids, which are beneficial for the heart, brain, eyes and other tissues and functions, being a protective factor against chronic non-communicable diseases (Benbrook et al., 2013).

The comparison of macro and micronutrient content between organic and conventional production systems is important, as it showed that ecologically based cultivation systems, in addition to being less harmful to the environment, promoted improvements in the composition of the levels of nutritional elements in food. The hypothesis is that organic foods increase the resilience of living organisms (Barański et al., 2017). For this reason, organic foods can be recommended not only for their nutritional health benefits but also because their production has a smaller environmental impact (López-Yerena et al., 2019).

Sanitary quality

Despite the importance of nutritional quality, food can often be a source of chemical, physical and biological contaminants with toxic potential, such as nitrogen compounds, heavy metals, pesticide residues, and environmental contaminants that, whether intentionally or not, are harmful to health (Azevedo; Ribas, 2016).

Currently, compounds with endocrine-disrupting activity are found in many of these food contaminants. They are complexes foreign to the organism that "mimic" our hormones, interfering in several ways in which the hormones act, either in their synthesis, degradation, and excretion or even binding to their receptors and leading to activation or inhibition of the pathways of cell signaling. Thus, the presence of these compounds in the body, mainly due to the consumption of contaminated food, can interfere with one or more hormones and lead to consequent health impacts (Gomiero, 2018).

Studies associate continuous exposure to endocrine disruptors present in foods with diseases such as cancer, endocrine disorders, reduced fertility, increased abortion rate in women, obesity, among others (Bohn et al., 2014; Huber et al., 2011; Skwarlo-Sonta et al., 2011).

Microbiological contamination

One of the points questioned the organic production system is the possibility of contamination caused by the intensive use of animal waste as a natural feedstock.

When assessing the levels of microbial and parasitic contamination in lettuce from conventional and organic crops, Costa et al. (2012) showed that conventional samples showed greater contamination of coliforms at 45°C than organic ones. This type of contamination indicates the quality of the soil and water used in the handling of vegetables regardless of the type of cultivation and, therefore, it can be inferred that the conventional samples were grown in inappropriate places and received fertilizers containing fecal manure from animals or humans or even were irrigated with contaminated water.

This fact shows that the use of manure is also common in conventional systems and that waste that does not undergo proper treatment can be a source of contamination, regardless of the production system. The use of organic farming techniques in which the composting process is well done reduces the risk of contamination (Costa et al., 2012).

Regarding products of animal origin, a study by Rossa et al. (2013), showed that there was less frequency of antimicrobial resistance in the carcasses of organic chickens when compared to the conventional ones, indicating a lower risk of transmission of resistant bacteria by the consumption of organic chicken meat. Antimicrobial resistance in microorganisms such as enterobacteria is an important cause of abdominal, urinary tract, bloodstream, and pneumonia infections and, therefore, is a cause for concern (Rossa et al., 2013).

It is important to note that good agricultural practices and food storage, regardless of the production system, are essential to reduce the risk of contamination and must be carried out always.

Nitrate content

Nitrogen chemical fertilizers are used in conventional agriculture to quickly increase productivity, mainly of leafy vegetables such as lettuce, cabbage, watercress, and chicory. However, the excessive use of these chemical compounds not only contaminates the environment but also causes the accumulation of nitrate (NO_3^-) and nitrite (NO_2^-) in the leaves of plant cultures, being the main source of toxic NO that can be absorbed by the diet (Martinez-Ballesta et al., 2010).

The results of experiments carried out by Lima et al. (2008) showed that the concentrations of nitrate (NO_3^-), regardless of the part of the plant that was analyzed, were positively correlated with doses of nitrogen fertilizers used in vegetable cultivation, with the order of the nitrate content in lettuce leaves varying as follows: organic < conventional < hydroponic.

Other studies carried out in Spain and the Czech Republic corroborate the results found by Lima et al. (2008), showing that nitrate rates in organic vegetables are, in most cases, lower than those cultivated by conventional agriculture (Gomiero, 2018; Martinez-Ballesta et al., 2010).

The ingested nitrate passes into the bloodstream and can be reduced to nitrites, which when combined with amines form nitrosamines, potentially carcinogenic substances. Such a reaction can occur in an acidic environment of gastric juice, the stomach being a favorable environment (Lairon, 2011).

Thus, the monitoring of these substances is essential to guarantee the quality of the food consumed by the population.

Pesticide, heavy metals and transgenic residues

It is unquestionable that the conventional model of food production, when compared to the ecological base, causes food and nutritional insecurity due to the worrying levels of pesticide residues in food. Expanded access to information and the dissemination of the effects of food contaminants on health are fundamental tools for consumers to start questioning what they consume and changing their eating habits (Almeida; Carneiro; Vilela, 2009).

Data from the Ministry of Health, through the Water Quality Surveillance Information System for Human Consumption, showed that there is contamination by all types of pesticides tested in 25% of Brazilian municipalities, which makes up 27 different products in total. Of these 27 pesticides, 16 are considered extremely or highly toxic by the National Health Surveillance Agency (Anvisa), and 11 are associated with the development of chronic diseases, such as fetal malformation, hormonal and reproductive disorders, and cancer (Gaberell; Hoinkes, 2019).[3]

In Brazil, Anvisa monitors food through the Program for Analysis of Pesticide Residues in Food (Para). An activity report between 2011 and 2012 pointed out that one-third of the food habitually consumed by Brazilians was not considered suitable for consumption and health maintenance, as they were contaminated by pesticide residues, according to an analysis of samples collected in all 26 states of Brazil (Anvisa, 2013).

The values released by the last report, in 2019, presented 1,072 samples (23%) as unsatisfactory in relation to compliance with the maximum residue limit. However, they considered that only 0.89% of the samples analyzed between 2017 and 2018 represented potential for acute health risk (Anvisa, 2019).

The results obtained showed a considerable drop in pesticide residues in the analyzed foods. However, it is important to note that Para recognizes that currently, its monitoring does not include analysis of the two pesticides most used in Brazil, glyphosate and 2,4-D (2,4-dichlorophenoxyacetic acid), since they require different analysis methods of those employed by Anvisa, which may represent a gap as to the real risks to consumers' health (HRW, 2018).

According to a report by the Swiss Federal Office for the Environment (Ofev, 2019), organophosphate pesticides such as profenofos are extremely toxic

3 BRASIL. Ministério da Saúde. Sistema de Informação de Vigilância da Qualidade da Água para Consumo Humano (Sisagua). *Detecção e concentração de agrotóxicos na água de 2014 a 2017*. Brasília, DF, 2018. Available at: <https://bit.ly/2IwHbnU>. Access on: Sep. 29, 2019.

to aquatic organisms, birds, and bees, leading to death on disastrous scales for the latter. Bees are the main pollinating agents and pollination is one of the essential mechanisms for maintaining biodiversity and producing quality food. Without them, agro-ecosystems and, consequently, FNS are threatened (Costa; Oliveira, 2013).

The contamination of food by pesticide residues in Brazil is mainly due to the lack of governmental inspection in relation to the substances that are used by the conventional production system. Some of these substances are even banned in other countries. In addition, they are often applied in doses greater than allowed or in a "disastrous" manner, such as aerial spraying, which in addition to being inefficient in several cases, poses risks to human health and the balance of the ecosystem (Carneiro et al., 2015).

In a study by Skwarlo-Sonta et al. (2011) with rats, it was demonstrated that the levels of body fats were higher in those fed by conventional cultures when compared to those fed by organics. According to the study, the overweight of these animals may be related to exposure to fertilizer residues. Regarding hematological parameters, leukocyte numbers were affected, being higher in the blood of rats fed diets based on organic cultures, which indicates their better immune function.

In a similar study, Średnicka-Tober et al. (2013) showed that the content of pesticides and residues of heavy metals cadmium (Cd), copper (Cu), lead (Pb), and nickel (Ni) in mineral fertilizers used in conventional crops increased compared to organic cultures. Heavy metals differ from other toxic agents in that they are neither synthesized nor destroyed by man. Its effect on humans can vary according to the time of exposure, causing problems in several organs. If there is chronic exposure, it can also result in cancer due to vascular disorders.

Generally, most crops produced by conventional production systems are transgenic. According to Camara et al. (2009), research and studies that involve the potential risks to human consumption of genetically modified foods, such as transgenics, are still restricted. The *Codex Alimentarius Commision*, from the United Nations Food and Agriculture Organization and the World Health Organization, adopted, in 2003, a list of principles for the analysis of risks arising from the application of the transgenic technique (FAO; WHO, 2003).

These assessment principles require the investigation of: (1) direct health effects (toxicity); (2) tendency to cause allergic reactions (allergenicity); (3) specific components that promote nutritional or toxic properties; (4) stability of the inserted gene; (5) nutritional effects associated with specific genetic modification; and (6) any unintended effect that may result from genetic insertion (Camara et al., 2009; Ribeiro; Marin, 2012).

Bohn et al. (2014), when investigating glyphosate-tolerant transgenic soybeans, observed that the crop presented high residues of glyphosate, a broad-spectrum systemic herbicide and desiccant of crops that bind essential amino acids and some minerals, preventing their absorption. Glyphosate has also been shown to interfere with molecular mechanisms that regulate plant development. The authors emphasize the role of pesticide residues in transgenic plants and argue about their toxic effects. Thus, the lack of data on pesticide residues in the main crops is a knowledge gap with potential consequences for human and animal health (Bohn et al., 2014).

Studies by Rossi et al. (2008) and Rosa et al. (2011) in tomatoes grown in organic systems revealed that no pesticide residues were detected, as well as organophosphate pesticides were not identified in any of the samples. This shows that the risk of contamination by pesticide residues through the consumption of organic tomatoes is less than the consumption of conventionally produced ones.

Almeida, Carneiro and Vilela (2009) presented the food insecurity scenario in Brazil associated with the contamination of vegetables by pesticides, due to the presence, mainly, of acephate, an organophosphate insecticide banned in several countries and detected in 87% of the cultures. In this perspective, the concept of healthy eating cannot be applied in the face of contamination of both vegetables and other foods by pesticides in the country.

Given this scenario, the reflection of Rumiato and Monteiro (2017) in relation to contaminants present in food, as well as nutritional guidance, are necessary, since the situation is consolidated in a contradiction. On the one hand, encouraging the population to consume fresh foods, such as fruits and vegetables, and on the other, the need to offer food free from contamination, that is, foods that are truly health-promoting and not potentially harmful.

Quality food and adequate nutrition are vital for maintaining health (Guerra; Cervato-Mancuso; Bezerra, 2019). For this reason, the experiences of public policies focused on the socio-environmental context of the risk of contamination, which reinforce actions aimed at the production of food in diversified, ecologically based, and nutritionally appropriate systems – such as agroecological ones – encourage the possibilities of the approach on nutrition-sensitive agriculture. Such an approach is contrary to the dominant models of food production and consumption (Maluf et al., 2015).

Final remarks

The studies covered in this review, when discussing the relationship between food quality and food and nutritional security, from the perspective of the sustainability of production systems, pointed out an important contribution in the field of agriculture, in which ecologically-based farming systems must be encouraged. They allow the production of food of better nutritional and sanitary quality to the detriment of the conventional production model that showed limitations, such as the worldwide contamination of the food chain by pesticide residues and synthetic fertilizers, which can cause damage to health and the environment and lead to food and nutritional insecurity.

Furthermore, at a time when Brazilian society is following the dramatic dismantling of environmental policies, food security, sovereignty, and social welfare, which violate the human right to adequate food, information that contributes to the strengthening of sustainable agri-food systems are essential tools for the creation of public policies that act as an intersectoral strategy for the promotion of health and food and nutritional security.

References

ALMEIDA, L. M. M. C. et al. Índice UFSCar de segurança alimentar para agricultores familiares. *Revista de Política Agrícola*, Brasília, DF, v. 24, n. 4, p. 82-96, mar. 2016. Disponível em: <https://bit.ly/3eUqyP7>. Acesso em: 17 set. 2019.

ALMEIDA, V. E. S.; CARNEIRO, F. F.; VILELA, N. J. Agrotóxicos em hortaliças: segurança alimentar, riscos socioambientais e políticas públicas para promoção da saúde. *Tempus*: Actas em Saúde Coletiva, Brasília, DF, v. 4, n. 4, p. 84-99, 2009.

ANVISA – AGÊNCIA NACIONAL DE VIGILÂNCIA SANITÁRIA. *Programa de análise de resíduos de agrotóxicos em alimentos (Para)*: relatório de atividades de 2011 e 2012. Brasília, DF, 2013.

ANVISA – AGÊNCIA NACIONAL DE VIGILÂNCIA SANITÁRIA. Programa de análise de resíduos de agrotóxicos em alimentos (Para): relatório das amostras analisadas no período de 2017-2018. Brasília, DF, 2019. Disponível em: <https://bit.ly/2JUatow>. Acesso em: 17 dez. 2019.

ARBOS, K. A. et al. Atividade antioxidante e teor de fenólicos totais em hortaliças orgânicas e convencionais. *Ciência e Tecnologia de Alimentos*, Campinas, v. 30, n. 2, p. 501-506, 2010.

AZEVEDO, E.; RIBAS, M. T. G. O. Are we secure? Reflections on indicators for evaluating food and nutritional security. *Revista de Nutrição*, Campinas, v. 29, n. 2, p. 241-251, 2016.

BARAŃSKI, M. et al. Effects of organic food consumption on human health: the jury is still out! *Food & Nutrition Research*, Lund, v. 61, n. 1, art. 1287333, 2017.

BAUDRY, J. et al. Association of frequency of organic food consumption with cancer risk findings from the NutriNet-Santé prospective cohort study. *JAMA Internacional Medicine*, Chicago, v. 178, n. 12, p. 1597-1606, 2018. Disponível em: <https://bit.ly/3kqpTX4>. Acesso em: 27 jul. 2019.

BENBROOK, C. M. et al. Organic production enhances milk nutritional quality by shifting fatty acid composition: a United States-wide, 18-month study. *PLoS ONE*, São Francisco, v. 8, n. 12, art. e82429, 2013. Disponível em: <https://bit.ly/35oBodj>. Acesso em: 1º set. 2019.

BOHN, T. et al. Compositional differences in soybeans on the market: glyphosate accumulates in roundup ready GM soybeans. *Food Chemistry*, Amsterdam, v. 153, p. 207-215, 2014. Disponível em: <https://bit.ly/2GT3Fz5>. Acesso em: 14 jul. 2019.

BOMBARDI, L. M. (Org.). *Geografia do uso de agrotóxicos no Brasil e conexões com a União Europeia*. São Paulo: USP, 2017.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. *Informações técnicas*. Brasília, DF, 2017. Disponível em: <https://bit.ly/3ltszo3>. Acesso em: 30 dez. 2019.

BURLANDY, L.; BOCCA, C.; MATTOS, R. A. Mediations among concepts, knowledge and policies on food, nutrition and food and nutrition security. *Revista de Nutrição*, Campinas, v. 25, n. 1, p. 9-20, 2012.

CAMARA, M. C. C. et al. Transgênicos: avaliação da possível (in)segurança alimentar através da produção científica. *História, Ciências, Saúde - Manguinhos*, Rio de Janeiro, v. 16, n. 3, p. 669-681, 2009. Disponível em: <https://bit.ly/3ni7gqa>. Acesso em: 18 jun. 2019.

CARNEIRO, F. F. et al. (Org.). *Dossiê Abrasco*: um alerta sobre os impactos dos agrotóxicos na saúde. Rio de Janeiro: EPSJV; São Paulo: Expressão Popular, 2015.

COSTA, C. C. A.; OLIVEIRA, F. L. Polinização: serviços ecossistêmicos e o seu uso na agricultura. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*, Pombal, v. 8, n. 3, p. 1-10, 2013.

COSTA, E. A. et al. Evaluation of microbiological lettuces (Lacuta sativa L.) conventional and organic and efficiency of two cases of sanitation. *Alimentos e Nutrição*, Araraquara, v. 23, n. 3, p. 387-392, 2012.

FAO - FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS; WHO - WORLD HEALTH ORGANIZATION. *Safety assessment of foods derived from genetically modified animals, including fish*. Rome, 2003. (Food and Nutrition Paper, 79). Disponível em: <https://bit.ly/3kE7KoC>. Acesso em: 18 jun. 2019.

GABERELL, L.; HOINKES, C. *Lucros altamente perigosos*: como a Syngenta ganha bilhões vendendo agrotóxicos nocivos. Lausanne: Public Eye, 2019. Disponível em: <https://bit.ly/3pmcanE>. Acesso em: 11 nov. 2019.

GALVÃO, T. F.; PANSANI, T. S. A.; HARRAD, D. Principais itens para relatar revisões sistemáticas e meta-análises: a recomendação Prisma. *Epidemiologia e Serviços de Saúde*, Brasília, DF, v. 24, n. 2, p. 335-342, 2015.

GOMIERO, T. Food quality assessment in organic vs. conventional agricultural produce: findings and issues. *Applied Soil Ecology*, Amsterdam, v. 123, p. 714-728, 2018.

GUERRA, L. D. S.; CERVATO-MANCUSO, A. M.; BEZERRA, A. C. D. Alimentação: um direito humano em disputa - focos temáticos para compreensão e atuação em segurança alimentar e nutricional. *Ciência e Saúde Coletiva*, Rio de Janeiro, v. 24, n. 9, p. 3369-3394, 2019. Disponível em: <https://bit.ly/2UhEB8a>. Acesso em: 7 jan. 2020.

HRW - HUMAN RIGHTS WATCH. "Você não quer mais respirar veneno": as falhas do Brasil na proteção de comunidades rurais expostas à dispersão de agrotóxicos. Nova York, 2018. Disponível em: <https://bit.ly/39gnNaq>. Acesso em: 12 nov. 2019.

HUBER, M. et al. Organic food and impact on human health: assessing the status quo and prospects of research. *NJAS*: Wageningen Journal of Life Sciences, Amsterdam, v. 58, n. 3-4, p. 103-109, 2011.

IFOAM – INTERNATIONAL FEDERATION OF ORGANIC AGRICULTURE MOVEMENTS. *The principles of organic agriculture*. Bonn, 2005.

KOHN, R. A. G. et al. Physical and chemical characteristics of melon in organic farming. *Revista Brasileira de Engenharia Agrícola e Ambiental*, Campina Grande, v. 19, n. 7, p. 656-662, 2015.

LAIRON, D. Nutritional quality and safety of organic food: a review. *Médecine & Nutrition*, Les Ulis, v. 47, n. 1, p. 19-31, 2011.

LIMA, J. D. et al. Accumulation of nitrogen compounds and nitrate reductase activity in lettuce cultivated in different crop systems. *Pesquisa Agropecuária Tropical*, Goiânia, v. 38, n. 3, p. 180-187, 2008.

LÓPEZ-YERENA, A. et al. Effects of organic and conventional growing systems on the phenolic profile of extra-virgin olive oil. *Molecules*, Basel, v. 24, n. 10, 2019. Disponível em: <https://bit.ly/3lqCWZT>. Acesso em: 1º set. 2019.

MACIEL, L. F. et al. Antioxidant activity, total phenolic compounds and flavonoids of mangoes coming from biodynamic, organic and conventional cultivations in threematuration stages. *British Food Journal*, Bingley, v. 113, n. 9, p. 1103-1113, 2011.

MALUF, R. S. et al. Nutrition-sensitive agriculture and the promotion of food and nutrition sovereignty and security in Brazil. *Ciência e Saúde Coletiva*, Rio de Janeiro, v. 20, n. 8, p. 2303-2312, 2015. Disponível em: <https://bit.ly/2Iu91BL>. Acesso em: 5 nov. 2019.

MARTINELLI, S. S.; CAVALLI, S. B. Alimentação saudável e sustentável: uma revisão narrativa sobre desafios e perspectivas. *Ciência e Saúde Coletiva*, Rio de Janeiro, v. 24, n. 11, p. 4251-4262, 2019. Disponível em: <https://bit.ly/38Dhw8q> . Acesso em: 9 fev. 2020.

MARTINEZ-BALLESTA, M. C. et al. Minerals in plant food: effect of agricultural practices and role in human health: a review. *Agronomy for Sustainable Development*, Paris, v. 30, n. 2, p. 295-309, 2010.

NITZKE, J. A. et al. Segurança alimentar: retorno às origens? *Brazilian Journal of Food Technology*, Campinas, v. 15, p. 2-10, 2012. Número especial.

OFEV – OFFICE FÉDÉRAL DE L'ENVIRONNEMENT. *Rapport explicatif concernant la modification de l'ordonnance sur la réduction des risques liés aux produits chimiques (ORRChim)*: paquet d'ordonnances du printemps 2020. Ittigen, 2019. Disponível em: <https://bit.ly/3pmou7A>. Acesso em: 19 dez. 2019.

PELICIONI, M. C. F.; AZEVEDO, E. Promoção da saúde, sustentabilidade e agroecologia: uma discussão intersetorial. *Saúde e Sociedade*, São Paulo, v. 20, n. 3, p. 715-729, 2011.

RIBEIRO, I. G.; MARIN, V. A. A falta de informação sobre os organismos geneticamente modificados no Brasil. *Ciência e Saúde Coletiva*, Rio de Janeiro, v. 17, n. 2, p. 359-368, 2012.

ROSA, C. L. S. et al. Caracterização físico-química, nutricional e instrumental de quatro acessos de tomate italiano (*Lycopersicum esculentum Mill*) do tipo '*Heirloom*' produzido sob manejo orgânico para elaboração de polpa concentrada. *Alimentos e Nutrição*, Araraquara, v. 22, n. 4, p. 649-656, 2011.

ROSSA, L. S. et al. Resistência antimicrobiana e ocorrência de micro-organismos patogênicos e indicadores em frangos orgânicos e convencionais: estudo comparativo. *Biotemas*, Florianópolis, v. 26, n. 3, p. 211-220, 2013.

ROSSI, F. et al. Health-promoting substances and heavy metal content in tomatoes grown with different farming techniques. *European Journal of Nutrition*, Berlin, v. 47, n. 5, p. 266-272, 2008.

RUMIATO, A. C.; MONTEIRO, I. Contaminants in food and nutritional guidance: theoretical reflection. *Revista de Salud Pública*, Bogotá, DC, v. 19, n. 4. p. 574-577, 2017.

SKWARLO-SONTA, K. et al. Response of animal physiology to organic versus conventional food production methods. *NJAS*: Wageningen Journal of Life Sciences, Amsterdam, v. 58, n. 3-4, p. 89-96, 2011.

ŚREDNICKA-TOBER, D. et al. Effect of crop protection and fertilization regimes used in organic and conventional production systems on feed composition and physiological parameters in rats. *Journal of Agricultural and Food Chemistry*, Washington, DC, v. 6, n. 61, p. 1017-1029, 2013.

Authors' contribution

Pereira designed the study. Franceschini and Priore analyzed the data and reviewed the paper.

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