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ORGANIC FOOD INTAKE EFFECTS IN HUMAN HEALTH

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ABSTRACT

The purpose hereof was to systematically evaluate the organic food intake effects in human health through controlled clinical studies. Articles with the descriptions *organic food*, *human* and *human intervention study* were included. The articles were selected by their titles and abstracts, according to the inclusion and exclusion criteria. At the end of the analysis, ten studies were used. The organic food intake presented positive effect on human health. A non-communicable chronic disease development risk reduction and lower oxidative damages on the DNA molecule were noticed due to a lower exposition to chemical compounds. Complications in chronic renal disease patients were reduced and their lean mass increased and fat mass reduced. However, no influence of the organic food intake was noticed on the antioxidant defense and immunologic systems of healthy subjects. Our conclusion is that a regular intake of organic food promotes benefits for our health, although there still are controversies in the literature.

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INTRODUCTION

The organic growth system was included in agricultural practices thousands of years ago. It began to be spread in Europe in 1920's. However, the phrase "organic agriculture" was used for the first time only in 1940's(Lotter, 2003). The continuously growing fight against the dependency of synthetic fertilizers and pesticides, the industrialization of agriculture, and the preservation of the soil's fertility encouraged the organic movement's development (Brantsaeter *et al.*, 2016). In the ranking of countries with greater extension of organic food producing plots are Australia (22.7 million hectares), Argentina (3.1 million hectares), United States (2 million hectares) and China (1.6 million hectares). The regions with greater organic growth predominance are Oceania (22.8 million hectares), Europe (12.7 million hectares), Latin America (6.7 million hectares), Asia (3.9 million hectares), North America (2.9 million hectares), Brazil (1.7 million hectares) and Africa (1.6 million hectares)(Blanc and Kledal, 2012).

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This expressive search for organic products is related to the hypothesis that these foods are safer and more nutritious (Lee *et al.*, 2013). In comparison with conventional products, the organic production is believed to result in animal welfare, environmental sustainability, and to greater benefits to the consumers' heath (Lazzarini *et al.,* 2016; Johansson *et al.,* 2014). The organic production system discards the use of synthetically produced fertilizers, biocides, growth regulators, and the growth of genetically modified organisms. It also does not allow the addition of antibiotics and growth hormones in animal nutrition(Brantsaeter *et al.*, 2016). According to the International Federation of Organic Agriculture Movements (IFOAM), the four principles of organic agriculture are health, ecology, justice, and care(IFOAM, 2015b). Although there is a regulation and specific monitoring procedures for the application and commercialization of agrochemicals and pesticides(Brazil, 2002; EPA, 2016;IFOAM, 2006a) the global use of these substances is still very disorganized, affecting more than 2 million tons of crops annually and it is increasing all over the world (Grube *et al.,* 2011). It happens because the use of agrochemicals and synthetic fertilizers, combined with intense irrigation, results in an increase of production. On the other hand, organic production intents to create a bigger and more complex production system that maintains a connection with several aspects, such as soil fertility, biodiversity, sustainability, animal welfare, and consumer health (LundandAlgers, 2003; FAO, 1999). Researches already show that there are differences in the nutritional composition between organic foods and those conventionally produced. Vrcek et al. (2014) and Gyore-Kis et al(2013) noticed the existence of greater levels of iron, zinc, vitamin C, and phenolic compounds in organic wheat flour and tomatoes. However, other investigations did not report a significant improvement in the nutritional profile of organic fruits and wheat grains, in comparison with those produced by the conventional system (Cardoso *et al*., 2011; Konopka*et al.,* 2012). Besides these controversies, there is no consensus about the beneficial effects of the organic food intake in human health in comparison with the conventional food. Positive effects of organic food in the immunological system of mice and chickens (Huber *et al.,* 2010; Finamore *et al.,* 2004)and in the reproductive system of rabbits (Paci *et al.,* 2003) were already reported. Other *in vitro* researches, with organic fruit extracts, reported a proliferation reduction of cancer cells (Olsson *et al.*, 2004; Olsson *et al.*, 2006).

Although these investigations report the benefits of the organic food intake for our health, we notice some shortage of *in vivo* evaluations. Consequently, the purpose hereof was to systematically evaluate the organic food intake effects in human health through controlled clinical studies.

METHODOLOGY

This is a systematic revision of the literature focused on the orienting question: “What are the effects of the organic food intake in our health?” As a search strategy for selecting recent studies (last 15 years), the following databases were consulted: BVS (Virtual Library on Health), Sci ELO (Scientific Electronic Library On-line), Lilacs (Latin American and Caribbean Literature), Pub Med, and Science Direct, published between 2002 and 2017. A reverse search was also performed, on which we researched study reference lists to identify original papers. The following descriptions were used due to their recurrence in the indexation of articles involving the subject: *organic food, human*, and *human intervention study*. Words related to the interest results were not included to increase the research’s sensitivity. The Boolean description *and* was used between the terms for a greater qualification of the search results. The studies were selected by the following inclusion criteria: a) conduct controlled clinical trials with human subjects; b) present positive or negative results to human health regarding the organic food intake; c) be written in English or Spanish; d) be published between 2002 and 2017. As exclusion criteria, these were adopted: a) revision studies; b) investigations that did not used controlled clinical trials with human subjects; c) studies with no complete methodological description; and d) studies conducted with plants, animals and/or ages different from adult (20 to 59 years old).

The searches resulted in a total of 205.435 articles (BVS: 2.081, SciELO: 69, Lilacs: 107, PubMed: 6.363, ScienceDirect: 175.713, and reverse search: 15). The studies’ triage was made considering studies not conducted with human beings (197.893), articles not published in the last 15 years (6.195), studies without the description words on the title (1.286), and revision articles (21). At the eligibility phase, 40 articles were excluded because their methodology did not include controlled clinical trials and/or the age of the studied population to be classified was not of an adult. At the end of the analysis, ten studies satisfied the inclusion and exclusion criteria and were evaluated herein (Figure 1).

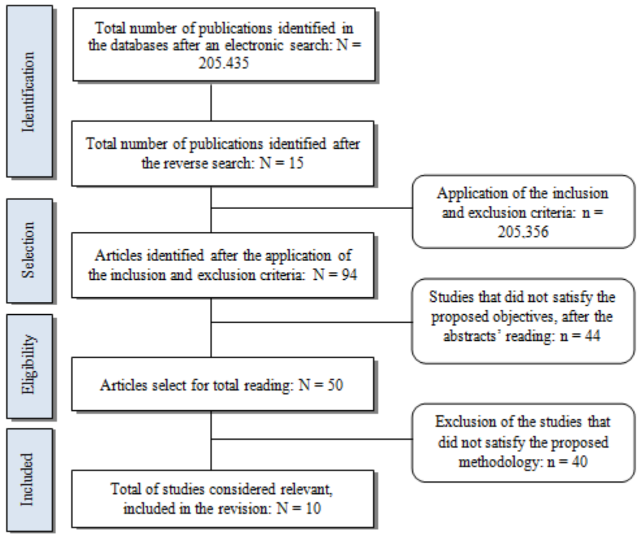

Figure 1. Flowchart of the controlled clinical study selection

RESULTS

In Box 1 are described the studies included in the research on the organic food intake effects in human health. From ten evaluated studies, two were conducted in Denmark, two in Germany, two in Italy, one in Austria, one in France, one in Australia, and one in the United States, all in the English language. Mostly, the studies were conducted with both genders. However, three papers analyzed only male subjects(Briviba *et al*., 2007; Strake *et al.,* 2009; De Lorenzo *et al.,* 2010) and another jus two men (Caris-Veyrat*et al.*, 2004). The participants’ age in the researches was of 18 to 85 years old, with a variation in the sample *n* of 6 to 4.466 subjects. Most studies evaluated the intake effect of organic fruits and vegetable in our health, except for three articles(Grinder-Pedersen *et al*., 2003; Oates *et al.,* 2014; Curl *et al.,* 2015) which also included meat, milk, and cereal products. A study (Akçay *et al.*, 2004) analyzed the organic drink intake (wine) and another (Whittaker *et al.*, 2015) analyzed the wheat intake, besides an organic growth system. The nutrient content difference between the conventional and organic growth system was also studied by most authors, except for three of them (De Lorenzo *et al*., 2010; Oates *et al.,* 2014; Curl *et al.,* 2015).

From seven researches that analyzed nutriment contents, three of them got levels of phenolic compounds significantly higher ($p<0.05$)(Grinder-Pedersen *et al*., 2003; Caris-Veyrat *et al.,* 2004; Whittaker*et al.,* 2015) in organic food. All other got phenolic compound contents in the conventional product (Akçay *et al.*, 2004) or did not present significant differences ($p>0.05$) between different types of crops (Briviba *et al*., 2007; Strake *et al*., 2009; Soltoft*et al.,* 2011). The intervention period of the studies varied between nine days (Briviba *et al.*, 2007) and two years (Curl*et al.*, 2015). All researches had some interval between the interventions (washout), except for one of the studies (Curl *et al*., 2015). The intervals between the intervention were of one week (Briviba *et al*., 2007; Oates *et al.,* 2014), two weeks (De Lorenzo *et al.*, 2010), three weeks (Grinder-Pedersen *et al*., 2003; Caris-Veyrat*et al.,* 2004), four

Table 1. Characteristics of the selected clinical studies for the organic food intake effects in human health evaluation

Authors (year)	Sample/Country	Food/PI/PW	Purpose(s)	Evaluationmethod	Result(s)
Grinder-Pedersen *et al*. (2003)	n = 16 M = 6 F = 10 21 to 35 years Denmark	Cereal, fruits, vegetables, meats, milk and dairy, and sugars IP: 44days WP: 21 days	Compare the conventional diet and organic intake effects in the antioxidant defense and excretion human system of five types of flavonoids	The diets were consumed in two periods of 22 days with a 3-week interval between them. Blood and urine tests were performed in the 0th and 22nd days of each intervention period.	There was no difference ($p \geq 0.05$) in the antioxidant defense markers between the diets. There was greater urinary excretion of flavonoids (quercetin and kaempferol) in the organic diet consumers.
Akçay*et al*. (2004)	n = 8 M = 6 F = 2 24 to 45 years Austria	Wine IP: 2 days WP: 42 days	Determine the effects of the polyphenols present in organic red wine in the antioxidant defense human system, through antioxidant enzymes. Evaluatetheireffects in cardiovascular healththrough LDL oxidation.	In the 1st day of study, men ingested 200 mL of organic red wine and women 100 mL. Blood samples were collected after 60 and 360 minutes. The 2nd day of study happened after a 6-week interval in which the participants ingested conventional wine in the same amounts of the 1st day. Bloodsampleswerecollectedwithinthesameintervals.	There was no significant change in the evaluated parameters. However, it is probable that the organic red wine intake at long term will result in positive effects in the antioxidant defense human system due to its flavonoid storage capability.
Caris-Veyrat*et al*. (2004)	n = 20 F = 20 21–39 years France	Tomatoes IP: 21 days WP: 21 days	Evaluate the intake effects of organic tomato purees in the antioxidant defense human system. Also to compare the antioxidant levels between different types of crop.	A group of participants received a 100-g/day supplement of organic tomato puree and the other group, of conventional tomatoes for 3 weeks. Blood samples were collected before the intervention and after a 3-week interval (depletion period).	The contents of antioxidants were greater ($p<0.05$) in the organic tomato purees. However, it was not enough to increase the antioxidant plasma levels.
Brivibaet *al*. (2007)	n = 6 M = 6 $\chi = 27 \pm 3$ years Germany	Apples IP: 2 days WP: 7 days	Compare the levels of phenolic compounds in organic and conventional apples, and their effects in the antioxidant defense human system and in the DNA molecule.	In the 1st day of the experiment, the volunteers ate 1.000 g of organic apple. The 2nd day of the experiment happened one week after, in which the participants ate conventional apples (1.000 g). Blood samples were collected 1, 2, 3, 4.5, 6, 9, 12, and 24 hours before and after the consumption.	There was no difference in the phenolic compound level between the cultivars. The organic apple intake did not change the antioxidant capacity. It did not exert any effect on the endogenous DNA even. However, it reduced ($p<0.05$) the oxidative damages on the DNA molecule.
Strackeet *al*. (2009)	n = 36 M = 36 19–54 years Germany	Carrots IP: 14 days WP: 0 days	Evaluate the carotenoid level and the antioxidant capacity of organic and conventional carrots. Also, to compare the intake effect of these products in the antioxidant defense human system, in the immunological system, and on the DNA molecule.	A group of participants consumed 200 g of organic carrots for 14 days and another group consumed conventional carrots. Blood samples were collected before the intervention and 2, 7, and 14 days after the consumption.	There was not difference in the content of carotenoids of the several types of crop. Consuming organic carrots did not change the analyzed blood parameters ($p>0.05$).
De Lorenzo *et al*. (2010)	n = 130 M = 130 30–65 years Italy	Fruits and vegetables IP: 28 days WP: 0 days	Evaluate the effects of the Italian Mediterranean diet with organic and conventional foods in the body composition and renal health of subjects with chronic renal disease.	PA questionnaires were applied. An anthropometric and bioimpedance analysis was performed. The participants consumed, in the first 14 days of intervention, a diet with organic foods and, in the next 14 days, only with conventional products. Blood and urine samples were collected early in the morning during the 14 days of intervention.	The organic food intake promoted ($p<0.001$) an increase of lean mass and a reduction of fat mass, homocysteine, phosphorus, total cholesterol, and microalbuminuria.
Soltoftet *al*. (2011)	n = 36 18–40 years Denmark	Carrots IP: 24 days WP: 1 year	Compare the contents of carotenoid in organic and conventional carrots. Check the intake effects of organic carrots in the antioxidant defense human system through the carotenoid plasma contents.	The participants consumed organic carrots and derived products for 12 days. Blood samples were collected before the intervention and in the 13th day. The same methodology was applied after 1 year, with different subjects.	The carotenoid contents did not change ($p \geq 0.05$) between the different types of carrots. The carotenoid plasma contents increased after the consumption of organic and conventional carrots, but there was not difference ($p \geq 0.05$) between the types of production.

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Oates*et al*. (2014)	n = 13 M = 4 F = 9 18–65 years Australia	Cereal, fruits, vegetables, meats, milk and dairy, and sugars IP: 14 days WP: 0days	Evaluate if the organic food intake reduces the levels of exposure to agrochemicals.	The study's subjects consumed organic foods for 7 days, and conventional foods in the 7 following days. At the 8th days of each period, urine samples were collected.	The organic food intake reduced ($p<0.05$) the subjects' exposure to agrochemical in 90%.
Curl *et al*.(2015)	n = 4.466 M = 2.099 F = 2.367 45–84 years USA	Fruits, vegetables, beans, and meats IP: 2 years WP: 0days	Check if the organic and conventional food intake reduces the consumers' exposure to agrochemicals, analyzing their urinary concentration of urinary dialkyl phosphate.	A food intake questionnaire was applied to the participants of the study Multiethnic of Atherosclerosis. In thesameday, urine sampleswerecollected.	The concentrations of urinary dialkyl phosphate were smaller ($p<0.02$) in organic consumers at long term.
Whittaker*et al*. (2015)	n = 22 M = 13 F = 9 47–75 years Italy	Wheat IP: 112 days WP: 56 days	Evaluate the effects of a diet containing organic wheat-based products in the cardiovascular health of subjects with acute coronary syndrome.	The participants consumed organic (for 8 weeks) and conventional (for 8 weeks) wheat-based products in two different periods, with an interval of 8 weeks. Blood samples were collected at the 1st and 8th day of each period of intervention.	There was a reduction ($p<0.05$) of the levels of total cholesterol, LDL, glycemia, insulin, monocytes, and lymphocytes.

*IP: intervention period; WP: washout period; n: sample size; M: male; F: female; LDL: low-density lipoprotein; χ: age average; DNA: deoxyribonucleic acid; PA: physical activity; USA: United States of America

weeks (Stracke*et al*., 2009), six weeks (Akçay *et al*., 2004), eight weeks (Whittaker *et al*., 2015), and one year (Soltoft*et al*., 2011). The themes also varied between the clinical studies, analyzing the immunological system (one), the antioxidant defense human system (six), cardiovascular health (two), renal health (one), the DNA molecule (two), the body composition (one), and exposure to agrochemicals (two). As for the highlighted evaluation methods of the subjects they included blood tests (eight), urine tests (four), questionnaires (two), anthropometric evaluation (one), and bioimpedance evaluation (one). Positive and significant effects of the organic food intake for health were reported in five papers (Briviba*et al*., 2007; De Lorenzo *et al.,* 2010; Oates *et al.,* 2014; Curl *et al.,* 2015; Whittaker *et al.,* 2015). However, fivepapers (Grinder-Pedersen *et al*., 2003; Akçay *et al.,* 2004; Caris-Veyrat *et al.,* 2004; Strake *et al.,* 2009; Soltoft *et al.,* 2011) not report significant positive responses for health after these foods' intake.

DISCUSSION

We noticed that there is a shortness of clinical studies in the literature that investigate the organic food effects in human health. The pinnacle of publications on organic foods began in 2000, with a greater focus in the differences between the organic and conventional foods' contents of vitamins and minerals. However, in the last decade, the investigations became more specific, focusing on the effect analysis of compounds present in organic foods in the consumers' health. During our analysis of the papers used herein, we noticed that several of them also underscored the occurrence of nutritional changes between organic and conventional foods, besides their effects on our health. Consequently, we chose to conduct a brief analysis on this subject because the foods' nutritional profile may interfere in our health. Briviba *et al*.(2007) and Stracke *et al*. (2009) did not see differences in the contents of phenolic and carotenoid compounds, respectively, in organic apples and carrots in comparison with the conventional product. However, eating organic apples reduced the amount of oxidative damage on the DNA molecule (Briviba*et al*., 2007). On the other hand, superior levels of antioxidants were noticed in organic tomato purees in comparison with the conventional. In spite of that, an increase of antioxidant plasma levels was not seen in healthy subjects (Caris-Veyrat*et al*., 2004). The levels of antioxidant compounds, phytochemicals, vitamin C, iron, magnesium, phosphorus, zinc, and omega 3 were usually superior in organic fruits and vegetables (Reganold and Wachter,2016; Średnicka-Tober *et al.,* 2016; Lairon, 2009)in comparison with the conventional ones. Likewise, the incidence of pests and diseases in organic cultures results in a greater resistance of the plant and, consequently, increases its antioxidant concentrations. Greater contents of antioxidants was noticed in an organic diet composed by cereals, fruits, vegetables, meats, milk and dairies, and sugars, tomatoes, and wheat (grinder-Pedersen *et al*., 2003; Caris-Veyrat *et al.,* 2004; Whittaker*et al.,* 2015) in comparison with the conventional ones. However, there was no significant difference ($p>0.05$) in the level of phenolic and carotenoid compounds of organic and conventional apples and carrots (Briviba *et al*., 2007; Stracke *et al.,* 2009; Soltoft *et al.,* 2011).Contrary effects, with higher levels of phenolic compounds in conventional wine were found in the literature (Akçay *et al*., 2004). In this specific case, the authors used sulfur dioxide only in the conventional product, which is an oenological product used due to its potential conservative, antioxidant, disinfectant, and fungicide effects. We underscore that there is an interference of several other factors in the nutritional composition of foods besides the use of chemical fertilizers, herbicides and/or pesticides. Examples of that are the crop's geographic location, the soil's characteristics, the climatic conditions (sunlight, temperature, rain), the maturation stages of the crop, storage, and transportation (Cardoso *et al.,* 2011; Vrcek *et al*., 2014; Brantsaeter *et al*., 2016). Consequently, it is possible that a set of agents may be responsible for the food nutritional profile modifications. The positive and negative effects of the organic and conventional food intake are still controversial in the world scientific community. In the study of Whittaker *et al.*(2015) , the ingestion of organic wheat resulted in a significant reduction of the key-marker levels related to cardiovascular diseases, such as: total cholesterol, LDL, glucose, monocytes, and lymphocytes. These markers are related to damages in the vascular endothelium and in the formation of the therosclerotic plaque, a condition that can cause hearth attack and cerebrovascular accidents(Autieri, 2012).

On the other hand, Akçay *et al*. (2004) did not find positive results for the cardiovascular system in subjects that consumed organic red wine for 2 consecutive days. This fact may be related to the organic product's elevated alcoholic level (12%), which influenced the polyphenol absorption. The Mediterranean diet composed of fish, whole grains, legumes, fruits, and vegetables has been related to lower risks of chronic diseases and cancer (Widmer *et al.,* 2015). It was proven that this diet composed of organic foods promoted positive results also in patients with chronic renal disease(De Lorenzo*et al.*, 2010). After 14 days of organic food intake, there was a reduction ($p \leq 0.05$) of the fat mass (23.36±8.88 to 16.18±3.34 kg), of the body mass index (26.95±3.30 to 25.36±2.60 kg/m²) percentage, and of the plasma concentrations of homocysteine, phosphorus, total cholesterol, and microalbuminuria in the subjects. Therefore, the daily intake of a diet composed of organic food may minimize the factors that worsen the chronic renal disease condition, improving the subject's prognosis and quality of life. Additionally, it was proven that consumers adept to organic food intake generally have a better quality of life because they have healthier life habits. In this case, in these subjects is noticed a more effective and constant physical activity practice and, with it, a lower body mass index. They are also highlighted due to their higher education level and more favorable socioeconomic conditions (Dimitriand Dettmann, 2012; Eisinger-Watzl *et al.,* 2015).

Some studies present different effects on the DNA molecule after the organic food intake (Briviba *et al*., 2007; Stracke *et al*., 2009). A positive effect, with the reduction of the oxidative damages, was noticed after the intake of organic apples (in 2 non-consecutive days) by healthy subjects (Briviba *et al*., 2007). The flavonoids, present in this food, were able to inhibit the genotoxicity of ions (iron and copper), responsible for inducing oxidative processes and damage to the DNA (Glei *et al.,* 2006; Briviba *et al.,* 2007).However, there was no influence of the flavonoids on the DNA molecule after the intake of organic carrots (14 consecutive days) by healthy subjects. This result was attributed to the short intervention period and low bioavailability of the compounds (Stracke *et al*., 2009). In this aspect, the scientific evidences reinforce the hypothesis of the possible positive effects of the organic food on the DNA molecule. However, they do not enable us to undoubtedly confirm its real benefits in comparison with conventional foods. Considering this context, it is fundamental to widen the definition of specific biomarkers for human beings that may expose more clearly the influence of the organic food intake in our health.

The organic food intake effect in the immunological system of healthy subjects was evaluated as well (Briviba *et al*., 2007). In this research, the authors investigated the proliferation of natural killer cells after the intake of organic and conventional apples for 2 non-consecutive days. The natural killer cells act directly on the immunological system, eliminating neoplastic cells and those infected by viruses. The results proved that the organic food intake did not increase the proliferation of natural killer cells in the subjects. Likewise, positive effects were not seen on the antioxidant defense human system(Briviba*et al.*, 2007), corroborating with other evaluations (Grinder-Pedersen *et al*., 2003; Akçay *et al*., 2004; Caris-Veyrat *et al*., 2004; Stracke *et al*., 2009; Soltoft *et al*., 2011). The explanation for these results may be, again, the short intervention period of these researches, since the organism has the ability to store antioxidant compounds at long term, mobilizing them in response to physiological requirements (Akçay *et al*., 2004; Stracke *et al*., 2011), strengthening the immunological system and reducing the risk of pathology development. The organ ophosphorus are a kind of agrochemical extensively used in agriculture. We believe that the human contact with this substance may result in neurological problems, respiratory arrest, and even death, in extreme exposure cases to the product (Ross *et al*., 2013), which may occur by dietetic intake, contact with the skin and mucous membranes, respiratory tract, and intestinal tract (Oates*et al*., 2014). The dialkyl phosphates, byproducts resulting from the metabolism of organ phosphorus, are used in studies like urinary biomarkers. Oates *et al*. (2014)and Curl *et al*. (2015)present a significant reduction of these markers ($p<0.5$) in the exposure to organ phosphorus in healthy subjects that consumed organic foods during 14 days and 2 years, respectively. In these studies, the urinary concentration of the metabolites were calculated based on the creatinine adjusted level.

The average concentration of the dimethyl thiophosphate and dimethyl phosphate, for example, was greater ($p<0.05$) in conventional food consuming subjects (29 and 3.9 μg/g of creatinine, respectively), in comparison with organic consuming subjects (0.98 μg/g of creatinine and non-quantifiable amount, respectively) (Oates *et al*., 2014). Similarly, the average concentration of the dialkyl phosphates metabolites in subjects that never/rarely consume organic products was significantly ($p<0.05$) superior (163 nmol/g of creatinine) in comparison with those who eventually (121 nmol/g of creatinine) or frequently did it (106 nmol/g of creatinine) (Curl *et al*., 2015). Researches that use urinary biomarkers have limitations due to these indicators' half-life short period and their lack of specificity. In spite of that, there is still no other gold-pattern method to investigate the exposure of organophosphorus. Similarly, many other aspects may influence a person's food intake. It is also possible that organic product consumers present healthier life habits and, consequently, a lower exposure to agrochemicals(Oates*et al*., 2014; Curl*et al*., 2015).

Conclusion

The organic food intake present positive effects in human health, such as the reduction of non-communicable chronic disease development risk and oxidative damages on the DNA molecule due to a lower exposure to chemical compounds. It is also possible to reduce complications of chronic renal disease patients, and to increase these subjects' lean mass and reduce their fat mass. However, the organic food intake does not exert influence on the antioxidant defense and immunologic systems in healthy subjects. Therefore, our conclusion is that a regular intake of organic food promotes benefits for our health, although there still are controversies in the literature.

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