Literature review on organic farming with regards to health aspects

ORGANIKO LIFE+ project

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Introduction

Organic food consumption has increased during the last years, despite of the economic crisis and the higher price of the organic products (Katsarova 2015). Over the past 30 years, worldwide sales of organic foods have grown to over €66 billion in 2013. The European Union is a forerunner in the sector, with the organic market reaching over €22 billion in 2013. It is generally accepted that organic farming benefits the environmental sustainability; however, there is no clear evidence that organic food is associated with better health. The aim of this review is to synthesize the published literature regarding the effects of organic diet on health. Due to the fact that only a small number of studies investigating the association of organic diet with health exists, other studies are also described here in order to assist in the development of the study design of the children's intervention study which will be implemented later in the project (effect of organic diet on pesticides metabolites, association of pesticides and other environmental pollutants with health biomarkers, effect of short-term diet/exercise interventions on health biomarkers).

Methods

The database of PubMed was used for the search of studies. Search strategies were developed using title/abstract terms. Peer-reviewed, English-language human studies were included; In-vitro and animal studies were excluded.

Effect of organic diet on health biomarkers and outcomes

The search terms included relevant exposures and outcomes i.e. organic, conventional, health, food, diet, oxidative stress, inflammation and biomarker. Eligible studies were human studies that examined health biomarkers and outcomes.

Effect of organic diet on pesticides metabolites

The search terms included relevant exposures and outcomes i.e. organic, conventional, pesticides, food, diet, chlorpyrifos, malathion and organophosphate.

Association of pesticides and other environmental pollutants with health biomarkers

The search terms included relevant exposures and outcomes i.e. pesticides, environmental pollutants, oxidative stress and inflammation.

Effect of short-term diet/exercise interventions on health biomarkers

The search terms included relevant exposures and outcomes i.e. diet, exercise, intervention, oxidative stress and inflammation.

Results and Discussion

Effect of organic diet on health biomarkers and outcomes

Only a few human short-term intervention studies exist that assess the effect of organic diet on health biomarkers. Some of these studies examined the effects of specific food consumption such as apples, carrots, wines (Briviba et al. 2007; Akçay et al. 2004; Stracke et al. 2009; Stracke et al. 2010; Caris-Veyrat et al. 2004) and only in four studies the participants were exposed to controlled diets (Di Renzo et al. 2007; Grinder-Pedersen et al. 2003; Søltoft et al. 2011; De Lorenzo et al. 2010). These articles exhibit various differences in terms of study design and population, exposures tested and biomarkers measured. Some of the parameters examined in these studies were glucose, cholesterol, vitamin C, LDL, TBARS and SOD enzyme activity.

In most of them, no statistically significant differences were observed between the conventional and organic diet interventions. The only significant results were observed in two studies with controlled conventional and organic diet menus. In one of the studies, total plasma antioxidant capacity and protein oxidation decreased whereas the urinary excretion of two flavonoids (quercetin and kaempferol) was higher after intake of the organic diet compared to the conventional ($P<0.05$) in 16 adults (Grinder-Pedersen et al. 2003). In another study, the organic diet intervention resulted to decreased total homocysteine and phosphorus levels in 100 healthy subjects and 50 Chronic Kidney Disease (CKD) patients (De Lorenzo et al. 2010). Furthermore, total cholesterol, calcium and microalbuminuria decreased in CDK patients and TNF-α, IL-6 and IL-1 decreased in healthy subjects, following the organic diet period. Due to the heterogenic nature of the articles and to the fact that the results are not consistent, it is difficult to reach to any conclusions regarding the effect of organic diet on health.

So far, four cohort studies have examined the association of organic food consumption with health biomarkers and outcomes. The focus of these studies are pregnant or breastfeeding women and infants. One of the studies assessed the effect of the incorporation of organic dairy and meat products in the maternal diet on the contents of conjugated linoleic acid isomers (CLA) and trans-vaccenic acid (TVA) in human breast milk (Rist et al. 2007). Participants were 312 breast-feeding women with varying lifestyles and they were divided in three groups according to their responses about the intake of meat and dairy products in a food frequency questionnaire: conventional, 50-90% organic, >90% organic and other (combination of organic dairy and conventional meat products and vice versa). It was shown that the levels of rumenic acid and TVA in breast milk were higher in women who consumed organic meat and dairy products compared to the ones who followed a conventional diet. It is highlighted that in the case of rumenic acid, higher levels were even observed in the milk of mothers with an almost exclusive organic dairy and meat diet (>90% organic) compared to mothers with moderately organic diet (50-90% organic). Another study investigated the association of early-life organic food consumption with the development of atopic manifestations in the first 2 years of life (Kummeling et al. 2008). It was shown that consumption of strictly organic dairy products was associated with a reduced risk of eczema.

Two other studies examined associations between reported organic food consumption during pregnancy and two different outcomes – the risk of pre-eclampsia and the prevalence of hypospadias and cryptorchidism in male infants (Torjusen et al. 2014; Brantsæter et al. 2016). A lower risk of pre-eclampsia was observed in pregnant Norwegian women who reported frequent and consumption of organic vegetables compared with those with no or low consumption of these food items (Torjusen et al. 2014). Similarly, pregnant Norwegian women who reported "sometimes, often or mostly" consumption of organic food were less likely to give birth to a boy with hypospadias compared to women who reported rare or no consumption of organic food (Brantsæter et al. 2016).

Effect of organic diet on pesticides metabolites

With regards to the association of organic diet and pesticides exposure, only five studies have been published that examine the effect of organic diet to urinary pesticide metabolites levels (Lu et al. 2008; Lu et al. 2006; Oates et al. 2014; Curl et al. 2003; Bradman et al. 2015). In four of them, the study population is children and in three of them, the pesticides analysed are organophosphate pesticides. It is observed that the metabolites of two organophosphate insecticides, malathion and chlorpyrifos (MDA and TCPy), decrease significantly in the urine of children consuming an organic diet compared to a conventional diet (Lu et al. 2008; Lu et al. 2006). Similar results have been shown in studies with children and adults since lower levels of total dimethyl metabolites of organophosphate pesticides have been found during consumption of an organic diet (Oates et al. 2014; Curl et al. 2003; Bradman et al. 2015). Moreover, total dialkylophosphates (ΣDAP) decreased during the organic diet phase in children and adults (Oates et al. 2014; Bradman et al. 2015). Another metabolite that was found to decrease significantly with the consumption of an organic diet in children was 2,4-D, a herbicide metabolite (Bradman et al. 2015). For dietary exposures of children to pesticides, it is better to analyse organophosphate pesticides due to the fact that children are exclusively exposed to them via their food (Lu et al. 2006).

Association of pesticides and other environmental pollutants with health biomarkers

Due to the fact that we needed to understand how the pesticide exposure affects oxidative stress and inflammation biomarkers, we found some articles examining the association of pesticides and other environmental pollutants with health biomarkers. A common biomarker that was found to be associated with organophosphate pesticides and nonylphenol is 8-OHdG (Muniz et al. 2008; Lee et al. 2007; Wang et al. 2015). More specifically, the 8-OHdG levels were significantly lower ($p \leq 0.01$) in the control population compared to applicators (Muniz et al. 2008; Lee et al. 2007) and urinary 8-OHdG significantly correlated with urinary DMP, DAP (Lee et al. 2007) and NP (Wang et al. 2015). Also, malondialdehyde (MDA) levels were found to be significantly lower in controls compared to farmers (Muniz et al. 2008; Madani et al. 2015). Another parameter of oxidative stress usually examined in these studies is C-reactive protein. Increased serum CRP levels were observed in farmers (Madani et al. 2015) and there was a positive association of organochlorine pesticides and CRP concentration (Kim et al. 2012). Furthermore, CRP was found to be strongly associated with homeostatic model assessment (HOMA-IR) among participants with high polychlorinated biphenyls or organochlorine pesticide concentrations (Kim et al. 2012).

Other markers which were significantly different in farmers than in controls were higher APE activity (Muniz et al. 2008), serum glucose, ALT, ALT/AST ratio, prothrombin, fibrinogen, plasma O2-levels, erythrocyte MDA and carbonyl protein contents and decreased plasma vitamin C and E, erythrocyte GSH amounts and erythrocyte antioxidant enzyme (catalase and SOD) activities (Madani et al. 2015). Other associations were also found between pollutants and antioxidant or inflammatory biomarkers. It was shown that a significant partial correlation of DEP, DMTP, DMDTP and the combined methyl sum and the tail length of the lymphocytes exists (Muniz et al. 2008). Moreover, higher prepubertal serum OCPs were associated with lower serum leptin concentrations over 4 years of follow-up (Burns et al. 2014), prenatal concentrations of DDE, HCB or ΣPCBs were associated with increasing levels of IL10 measured at the age of 4 years, with the strongest associations found for HCB (Gascon et al. 2014) and significant correlations were found between NP and 8-NO2Gua in pregnant women (Wang et al. 2015).

Effect of short-term diet/exercise interventions on health biomarkers

In order to understand which biochemical parameters can be easily affected by a short intervention, we searched for articles examining inflammatory and oxidation biomarkers in relation to short-term diet/exercise intervention. A common parameter that was examined in three studies and was decreased significantly in all three cases is the C-reactive protein. It was shown that CRP was significantly reduced after a 6-week diet and exercise intervention in children (Huang et al. 2015), after an 8-week orange juice supplementation trial in both normal and overweight adults (Dourado & Cesar 2015) and after a 1-month placebo controlled trial in adults (Xie et al. 2015). Also, total cholesterol and LDL seem to be affected significantly after a short-term intervention. Specifically, following a 14-day diet and exercise intervention in overweight/obese children, all serum lipids improved significantly, with the exception of HDL both the total cholesterol/HDL and LDL/HDL ratios decreased (Izadpanah et al. 2012). Moreover, total cholesterol and LDL levels were significantly reduced following an 8-week supplementation of orange juice in normal overweight adults (Dourado & Cesar 2015).

With regards to interleukins, IL-12 was significantly increased following an 8-week supplementation of orange juice in normal overweight adults (Dourado & Cesar 2015) and significant decreases were observed for IL-6, IL-8 and IL-1ra, following a 14-day diet and exercise intervention in overweight/obese children (Izadpanah et al. 2012). Also, leptin was significantly decreased following a 6-week and 46-week intervention trials in children (Huang et al. 2015) and a 14-day diet and exercise intervention in overweight/obese children (Izadpanah et al. 2012). Following an 8-week orange juice supplementation trial in both normal and overweight adults, other parameters that were significantly affected were increase in vitamin C and folate and decrease in lipid peroxidation and malondialdehyde levels (Dourado & Cesar 2015). Following a 14-day diet and exercise intervention in overweight/obese children, other parameters that were significantly affected were decreased fasting insulin, TNF, PAI-1, resistin and amylin, increased blood glucose and adiponectin and improved HOMA-IR and QUICKI (Izadpanah et al. 2012). In a placebo-controlled trial of overweight smokers examining the effect of anthocyanins, it was shown that urinary 8-iso-PGF2a levels and plasma Ox-LDL decreased significantly in the anthocyanin group (Davinelli et al. 2015). Following a 1-month placebo controlled trial in adults examining the effect of a mangosteen drink, ORAC decreased significantly in the supplementation group (Xie et al. 2015).

Conclusion

In conclusion, there are only a few articles that assess the health effects of organic food consumption and they are very heterogeneous in terms of study design. Hence, it is recommended that randomized controlled trials in humans with sufficient sample sizes and longer dietary exposures should be conducted in the future in order to assess realistically the effect of organic food consumption to health.

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