

Organic Food and Health: A Systematic Review

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Abstract

The current knowledge regarding effects of organic food on health is unclear. In this study we have focused to yield a consolidated knowledge on health related aspects of organic food. We searched for the MeSH term "organic food" in Pubmed search engine (other terms used for search are: Organic food-18296 articles, organic food and health-4018 articles). Studies done on organic food, related to health, free full papers available in English were included for review. From the total of 2,215 articles, 1805 were excluded due to studies which were not related to organic food, studies without abstracts. Out of remaining 410 studies, 338 studies were excluded due to non-availability of full studies. Finally, 32 studies were selected after removal of articles not related to health. Out of 38 studies included, 9 studies focused on humans, in which 3 studies showed decreased pesticide content, 6 studies showed decreased risk of pre-eclampsia, hypospadias, cardiovascular diseases, etc. 14 studies focused on nutritional quality which showed increased lutein, PUFA and n-3 PUFA, antioxidants, analgesic and anti-inflammatory properties, etc. A total 9 studies focused on microbiological aspects which showed increased prevalence of microbial contamination, increased antibiotic susceptibility, etc. From the available studies, the effect of organic food on health is not convincing enough to recommend widely. More follow-up studies on humans, with large sample size might possibly enlighten the concept of organic food and its effect on health in future.

Keywords: Organic food; Health; Nutrition; Systematic review

Introduction

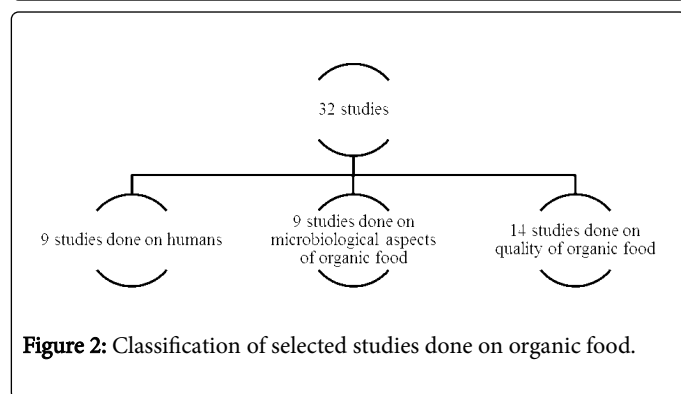
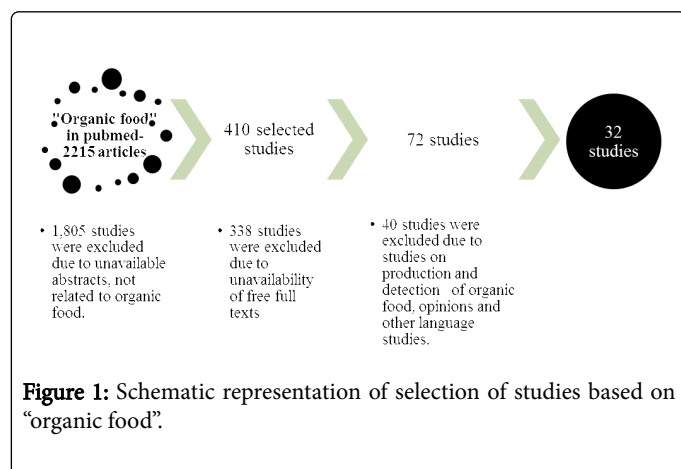
Malnutrition was one of the biggest problems faced by the world in 19th century. About 991 million people in the world did not have enough food to lead a healthy active life resulting in 5 million deaths per year in fewer than five populations. This problem of under nutrition was controlled with the help of green revolution, which led to use of pesticides and fertilizers. This, in turn reduced the under-nutrition to 793 million people in the 21st century, which was nearly 216 million people less than 20th century [1]. But unfortunately, green revolution has increased the use of pesticides and fertilizers which paved the way for variety of diseases like leukemias, Non-Hodgkin's lymphoma and some neurodegenerative disorders, fetal and congenital abnormalities. All these health problems led to the urgency of the world to shift its objective from increasing the quantity to improving the quality of food. This paved the way for entry of organic farming practices, which would help us overcome the problems related to the use of unwanted chemical substances, which affected the health of the people. In the recent years, there is widespread belief that organic food is safe and nutritious than conventional food [2]. The term organic farming was coined by Lord North Bourne in the year 1939 [3]. "Organic" or "organically grown" foods are commonly represented as "food grown without pesticides; grown without artificial fertilizers; grown in soil whose humus content is increased by the additions of organic matter and whose mineral content is increased with applications of natural mineral fertilizers and has not been treated with preservatives, hormones, antibiotics" [4]. Organic food has been shown to have many health benefits with wide variability. Organic plants have high content of polyphenols and ascorbic acid and organic

animal foods have higher contents of PUFA and n-3 PUFA [5,6]. When compared with conventional food, organic food has high anti-mutagenic activities, inhibits the proliferation of cancer cells, prevents fetal abnormalities like hypospadias, reduces the risk of pre-eclampsia in pregnant women, increases the levels of conjugated linoleic acid in breast milk and has neuro-protective effect [7-12]. Organic farming also helps in increasing the biodiversity [13]. On the contrary, organic food also has some limitations. Substances like patulin, mycotoxin, and increased *Campylobacter* levels are found in certain organic foods and meat varieties, which are injurious to health [14,15]. Some studies claim that there are no significant nutritional differences between organic and conventional foods [16]. The current knowledge regarding the effects of organic food on health is not clear. Therefore, a systematic review of the available literature was planned to yield a consolidated knowledge on health related aspects of organic food.

Methodology

We searched for the MeSH term "organic food" in PubMed database from the time period of 1961 to 2016. Studies done on organic food, related to health, free full papers available in English were included in this study. From the total of 2215 articles, 1805 studies were excluded due to unavailable abstracts, not related to organic food and 410 studies were selected. From the 410 studies, 338 studies were excluded due to unavailability of free full texts and 72 full studies were selected. From the 72 full studies, 40 studies were excluded due to studies on production and detection of organic food, opinion based studies and other language studies. Thus, 32 full studies were selected for final review. Among the 32 studies selected, 9 studies were done on human regarding health aspects, 9 studies were done on microbiological aspects of organic food and 14 studies were done on quality related

aspects of organic food. The above description is schematically represented in Figures 1 and 2.



Studies done on human health aspects

Out of total 32 studies included in the review, 9 studies focused on health aspects of humans.

- Three studies showed decreased pesticide exposure by organic food consumption [17-19].
- Three studies were done on pregnant women,
 - a. Torjusen et al. showed increased levels of nutrients such as folate, beta-carotene and vitamin C, and lower density of sodium [20],
 - b. Torjusen et al. in another study showed decreased incidence of pre-eclampsia [10] and
 - c. LiseBrantsæter et al. showed decreased incidence of hypospadias in male newborns [9]
- Three studies were focused on various aspects of health,
 - a. Goncalves et al. showed, consumption of organic grape juice improved glucose homeostasis, antioxidant capacity, and microvascular function, which may be due to its high concentration of polyphenols [21],
 - b. Bradbury et al. showed that, little or no decrease in the incidence of cancer associated with consumption of organic food, except possibly for non-Hodgkin lymphoma [22].
 - c. Whittaker et al. showed that, decreased levels of circulating cardiovascular risk factors like total cholesterol, low density lipoprotein (LDL) cholesterol, Reactive oxygen species (ROS), lipoperoxidation of circulating monocytes and lymphocytes and Tumor necrosis factor- α (TNF- α) [23].

The above results are depicted systematically in Table 1.

Results

Results of this review have been discussed in three heads (Human health aspects, microbiological aspects, quality aspects of food) based on focus of the studies.

| Study | Sample Size | Study Focus | Area and Year | Result: Effect of Organic Food Consumption |
|-----------------------|---|--------------------|---------------|--|
| Chensheng et al. | 23 children (3-11 yrs) | Pesticide exposure | U.S.A, 2006 | Decreased urinary metabolites of OP pesticides ($p < 0.01$) |
| Cynthia et al. | 4,466 participants in the multi-ethnic study of atherosclerosis | Pesticide exposure | U.S.A, 2015 | DAP concentrations were significantly lower ($p < 0.02$) |
| Bradman et al. | 40 children (3-6 years of age) | Pesticide exposure | U.S.A, 2015 | Reduced urinary concentrations of DAP(40%), dimethyl DAP(49%) insecticide metabolites and the herbicide 2,4-D(25%) in children |
| Torjusen et al. | 63,808 pregnant women | Pregnant women | Norway, 2012 | Increased levels of nutrients such as folate, beta-carotene and vitamin C, and lower density of sodium compared to participants with no or low organic consumption ($p < 0.001$) |
| Torjusen et al. | 28,192 pregnant women | Pregnant women | Norway, 2014 | Reduced risk of pre-eclampsia in pregnant women (OR=0.79, 95% CI 0.62 to 0.99) |
| LiseBrantsæter et al. | 35,107 women who delivered a singleton male infant. | Pregnant women | Norway, 2016 | Lower prevalence of hypospadias (OR=0.42; 95% CI: 0.25, 0.70) in the given study population |
| Goncalves et al. | 10 adult male triathletes | Disease Outcome | Brazil, 2011 | Organic grape juice intake improved glucose homeostasis, antioxidant capacity (Erythrocyte superoxide dismutase activity is decreased ($p = 0.04$)), and microvascular function. |

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|------------------|--|-----------------|-------------|---|
| Bradbury et al. | 623080 middle aged women | Disease Outcome | UK, 2014 | There was little or no decrease in the incidence of cancer, except possibly for non-Hodgkin lymphoma (RR=0.79, 95% CI: 0.65–0.96). |
| Whittaker et al. | 22 ACS patients (9 Females; 13 Males). | Disease Outcome | Italy, 2015 | Circulating cardiovascular risk factors, including lipid parameters, and markers of both oxidative stress and inflammatory status, were reduced (Total cholesterol (-6.8%), low-density lipoprotein cholesterol (LDL-C) (-8.1%) glucose (-8%) and insulin (-24.6%). |

Table 1: Studies done on human health aspects.

Studies done on microbiological aspects

Out of total 32 studies included in the review, 9 studies focused on microbiological aspects of organic food.

- Three studies were done on prevalence of infection in organic food. They showed, same prevalence of salmonella in organic and conventional pigs [24] same prevalence of enterobacteriaceae in both organic and conventional chicken [25] and increased prevalence of *Campylobacter* in organic turkey farms [26].
- Andreas Hofmann et al reported that colonization potential is strongly depending on the plant species under consideration [27].
- Two studies were focussed on antimicrobial susceptibility among which, Bombyk et al. showed increased antimicrobial susceptibility

of *Staphylococcus* in organic dairy farms [28]. Reinstein et al. showed no difference in antimicrobial susceptibility among organic and naturally raised beef cattle [29].

- Three studies focussed on contamination of organic foods among which, Loncarevic et al. reported occasional contamination of organic lettuce with *E.coli* and *L. monocytogenes* [30] while Walk et al. studies reported the pathogenic invasion of organic vegetables was dependent upon the usage of organic fertilizers, the bacterial inoculation dose and the plant species which varied widely [31]. Khalil et al. showed that potential fecal contamination of *E.coli* in both organic and conventional leafy greens in varied concentrations [32].

The above results are depicted systematically in the Table 2.

| Study | Sample Size | Focus | Area and Year | Result |
|-------------------|---|--------------------------------|----------------|---|
| Jensen et al. | 163 organic weaning pigs | Prevalence of bacteria | Denmark, 2006 | Salmonella infections are prevalent among both organic and conventional pigs |
| Kolal et al. | 399 chicken meat samples | Prevalence of bacteria | Germany, 2012 | High prevalence of TEM-, CTX-M- and SHV-type ESBLs in Enterobacteriaceae (43.9%) are isolated from retail chicken meat (both organic and conventional) |
| Ahmed et al. | 5 organic meat turkey farms | Prevalence of bacteria | Germany, 2016 | High prevalence and genotypic diversity of <i>Campylobacter</i> sp. Isolated from organic turkey flocks (90-100%) |
| Hofmann et al. | Spinach and corn salad model plants. | Prevalence of bacteria | Germany, 2014 | Colonization potential is strongly depending on the plant species under consideration |
| Bombyk et al. | Milk samples from 339 (conventional) and 501 (organic) | Antimicrobial susceptibility | U.S.A, 2007 | Organic dairy management was associated with more overall antimicrobial susceptibility among <i>Staphylococcus</i> than was conventional management |
| Reinstein et al. | 30 fecal samples, 30 recto anal mucosal swabs | Antimicrobial susceptibility | U.S.A, 2009 | No major difference in antibiotic susceptibility patterns among the isolates was observed (14.8% and 14.2% for organically and naturally raised cattle, respectively). |
| Loncarevic et al. | 179 samples of organically grown lettuce | Contamination of organic foods | Norway, 2005 | Contamination of organic lettuce with <i>E.coli</i> and <i>L.monocytogenes</i> do occasionally occur |
| Walk et al. | 678 <i>E.coli</i> strains | Contamination of organic foods | Michigan, 2007 | The genetic composition for the <i>E.coli</i> populations on organic farms was the same and phylogroup B1 strains with low multidrug resistance were significantly associated with organic farms |
| Khalil et al. | 380 samples of conventional and 84 organic leafy greens | Contamination of organic foods | Egypt, 2014 | Conventional radish and organic parsley samples had the highest AMC of 7.17 and 7.68 log CFU/g respectively, while conventional green cabbage and organic basil had the lowest AMC of 3.63 and 3.23 log CFU/g respectively. |

Table 2: Studies done on microbiological aspects.

Studies done on quality aspects

Out of total 32 studies included in the review, 14 studies focused on quality of organic food.

- Among these, three studies on crops showed possibility of introducing arsenic contamination in organic food [33], and other

studies showed increased antioxidants [34], lutein content [35], and decreased levels of cadmium, pesticide exposure [34].

- Three studies were done on milk which showed increased PUFA, conjugated linoleic acid (cis-9, trans-11), α -linolenic acid, α -tocopherol, iron and lower levels of iodine and selenium in organic milk [36-38].

- Three studies were done on vegetables, of which one showed increased carotenoids and vitamin C, second showed a healthy impact of pre-processed organic carrots on baby food and the third showed no quality differences between organic and conventional vegetables [39-41].

- Two studies were done on egg which showed increased serum lutein [42], anti-inflammatory and analgesic effects of oil produced from egg yolk [43].

- Reganold et al. focused on fruits, which showed increased quality of fruits when cultivated on organic farms [44].

- Średnicka-Tober et al. focused on meat, which showed decreased content of Saturated Fatty Acids (SFA) and Mono Unsaturated Fatty Acids (MUFA), increased content of Poly Unsaturated Fatty Acids (PUFA) and n-3 PUFAs when compared with conventional meat [45].

- Chhabra et al. focused on the health effects of organic food consumption which was demonstrated with a fruit fly (which is a convenient model system to experimentally test potential health effects of dietary components), which showed greater fertility and longevity [46].

The above results are depicted systematically in the Table 3.

| Study | Sample Size | Area and Year | Focus | Result |
|------------------------|---|-------------------|------------|--|
| Jackson et al. | 3 commercial Organic brown rice syrup(OBRS) samples | U.S.A, 2012 | Crops | OBRS products may introduce significant concentrations of Arsenic into an individual's diet |
| MarcinBaran'ski et al. | 343 peer-reviewed publications | U.K, 2014 | Crops | Organic crops, on average, have higher concentrations of antioxidants, lower concentrations of Cd and a lower incidence of pesticide residues |
| Hussain et al. | 33 spring and winter wheat genotypes | Sweden, 2015 | Crops | 40% of the daily requirements of lutein can be achieved from the genotypes with the highest lutein content (Öland 8) produced using organic farming through the average human consumption of 200 grams of wheat per day |
| Butler et al. | 22 milk brands, 10 of which indicated organic production systems | U.K, 2011 | Milk | Organic milk had higher concentrations of beneficial fatty acids (FA) than conventional milk, including total polyunsaturated fatty acids, conjugated linoleic acid cis-9, trans-11 and α -linolenic acid |
| Florence et al. | Commercial organic and conventional UHT whole milks | Brazil, 2012 | Milk | The use of organic milk led to a higher acidification rate and cultivability of <i>Lactobacillus bulgaricus</i> . Fatty acids profile of organic fermented milks showed higher amounts of trans-octadecenoic acid and polyunsaturated fatty acids, including cis-9 trans-11, conjugated linoleic, and α -linolenic acids, as compared to conventional fermented milks |
| Średnicka-Tober et al. | 170 published studies | U.K, 2016 | Milk | Higher α -tocopherol and Fe, but lower I and Se concentrations in organic milk |
| Hallmann et al. | 45 kg of tomatoes | Poland, 2013 | Vegetables | The tomato juice from 2008 contained significantly more carotenoids and some flavonoids compared to the one produced in 2009, which contained significantly more dry matter, vitamin C, as well as quercetin and its derivatives |
| Seidel et al. | 10 t Swiss Demeter carrots | Switzerland, 2015 | Vegetables | Samples processed from frozen carrots show increased moisture content and decrease of several chemical constituents |
| Drakou et al. | 10 types of table olives, 11 types of tomatoes and tomato products and 18 types of legumes from conventional or organic farming | Greece, 2015 | Vegetables | The nutritional properties of olives, tomatoes and legumes tested were different among the various cultivars but, in most cases, not between products from organic or conventional farming |
| Whitmore et al. | 20 healthy lacto-ovo-vegetarian (LOV) adults | U.S.A, 2010 | Eggs | n-3 fatty acid enriched eggs and organic eggs may both significantly increase serum lutein in healthy LOV consuming a predominately plant-based diet |
| Mahmoud et al. | Three various sources of egg yolk (organic | IRAN, 2013 | Eggs | Anti-inflammatory and analgesic properties of organic egg yolk are observed |

| | | | | |
|------------------------|---|-------------|--------|--|
| | hens, duck and machine made) | | | |
| Reganold et al. | 13 pairs of organic and conventional strawberry farm fields | U.S.A, 2010 | Fruits | Organic strawberry farms produced higher quality fruit and that their higher quality soils may have greater microbial functional capability and resilience to stress |
| Średnicka-Tober et al. | 67 published studies | U.K, 2016 | Meat | SFA and MUFA were similar or slightly lower, respectively, in organic compared with conventional meat. Larger differences were detected for total PUFA and n-3 PUFA, which were higher in organic meat |
| RiaChhabra et al. | <i>Drosophila melanogaster</i> | U.S.A, 2013 | Flies | Flies raised on diets made from organically grown products had greater fertility and longevity |

Table 3: Studies done on quality aspects.

Discussion

The health effects of increased consumption of pesticides include increased prevalence of Non-Hodgkin's lymphoma, certain birth defects, multiple myeloma, low birth weight, etc. Certain studies reported anti-atherosclerotic properties for organic food. Torjusen et al. showed that consumption of organic food reduced the risk of pre-eclampsia in pregnant women [20]. Oken et al. showed that dietary intake of n-3 fatty acids reduced the risk of pre-eclampsia and Średnicka-Tober et al. in their study, reported increased levels of n-3 fatty acids in organic food, which might indirectly relate to the reduced risk of pre-eclampsia after consumption of organic food [47]. Brantsæter et al. reported that organic food consumption reduced the prevalence of hypospadias [21]. Kort et al. in their study showed that there is association between dietary pattern of pregnant women and hypospadias [48]. Christensen et al. showed that there is association between hypospadias in the offspring and the mother not choosing the organic diet, and having a high intake of nonorganic butter and cheese [48].

Organic foods contain decreased content of pesticides and fertilizers. Lu et al., Cynthia et al., Bradman et al. in their studies showed that consumption of organic food reduces the risk of pesticide exposure which might indirectly relate to the decreased risk of ill effects due to the pesticide exposure, presence of which in conventional food was found to be high [17-19]. Biological plausibility for good health due to organic food is convincing. But its effectiveness in reality is yet to be proved. The evidence available till date on beneficial effects of organic food on health is not convincing enough to recommend it in a large scale. None of the studies looked into dose response relationship of the effects.

Studies done on microbiological aspects of organic food showed increase prevalence of microorganisms and increased susceptibility to antibiotics. The problem of antibiotic resistance in crops can be reduced greatly with usage of organic food. Many studies have shown that infections on organic food can be reduced with washing and maintenance of cleanliness.

Studies done on quality aspects of organic food samples showed that besides absence of pesticides and fertilizers, organic food is superior to conventional food in various parameters such as increased antioxidants, presence of healthy fatty acids etc. Flies raised on diets made from organically grown products had greater fertility and longevity.

Before recommending organic food in large scale we have to consider the following factors such as decreased production, increased pest attack etc. without the use of fertilizers and pesticides. The decreased production of food will have a negative impact both economically and adversely on health triggering the diseases related to malnutrition. The appearance of conventional food is better than organic food. Increasing price of food with organic tag and false labeling of organic food are next hurdles in implementation of organic food in large scale. So, we recommend more follow up studies on humans exploring different health aspects of organic food and further solid evidence can be generated for implementation in large scale.

Limitation

The articles are selected only from PubMed database and are not screened by any quality guidelines. But, considering the fact that PubMed database is a standard database, consisting of standard, peer-reviewed studies, the articles included in this study cannot be underestimated for their quality. Only free full texts are included in this study.

Conclusion

The current knowledge of health impact on organic food based on the available research studies is still primitive and not convincing enough to recommend organic food for the community. Before implementing organic food on a large scale apart from health aspects, other factors like economic, social, cultural factors, sensory attributes, food safety, and environmental friendly, nutritional factors have to be considered.

Recommendations

We recommend more follow up studies in humans on different health aspects of organic food thereby generating evidence will help in better understanding the benefits of organic food.

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