

REVIEW ARTICLE

Is eating organic a healthy or safer option? Health claims for organic food consumption, food quality and safety – A systematic review

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Abstract	Introduction	Methodology	Results	Conclusion	References	Citation	Tables / Figures
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Citation

Ghai S; Sharma A, Dasgupta P. Is eating organic a healthy or safer option? Health claims for organic food consumption, food quality and safety –a systematic review. Indian J Comm Health. 2017; 29, 4: 340 - 349.

Source of Funding: Nil **Conflict of Interest:** None declared

Article Cycle

Received: 10/11/2017; **Revision:** 02/12/2017; **Accepted:** 05/12/2017; **Published:** 31/12/2017

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Abstract

Universally, there has been an increased awareness about the harmful effects of chemical inputs used for production of food on soil composition, environment and human health. This has triggered the consumption level of organic food products. India has witnessed a tremendous growth in domestic as well as export market. The demand is mainly driven by consumer perceptions that organic farming is more sustainable, produces healthy food, pesticide-free and safeguards the environment & biodiversity. Organic food producers also manifests the quality and safety of food. These claims which are perceived and professed as beneficial can only be accepted if they are tested and validated. Therefore, the foremost objective of this review paper is to provide an update on set of studies related to scientific evidence for nutritional composition marking the quality of organic foods vis-à-vis conventional foods and its impact on human health. Secondly, the paper examines the comparison of the sensory quality of the organic food, and thirdly the food safety aspect of organically as compared with conventionally grown foods. Past few controlled studies have proved that there is no such evidence of differences in concentration of various nutrients amongst organic and conventional foods. Furthermore, there are certain issues related to the impact and assessment of these nutrients in organic food which requires some future directives. Owing to the heterogeneity in results observed related to nutritional quality and safety of organic foods, technological aspects together with sensory parameters are the best for future comparative studies. To safeguard the public health and to avoid the difference in sampling and sample results, testing laboratories should also be adhering to uniform standards. Organic food business in India lack standard guidelines for quality, policy framework for domestic and export market. Also, traceability is another factor which should be given prime importance to ensure removal of fraudulent practices.

Keywords

Food; Organic; Food Quality; Food Safety; Nutritional Composition; Sensory Quality; Nutrients; Standards

Introduction

International Federation of Organic Agriculture Movements (IFOAM) defines the term 'Organic

Agriculture' as a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with

adverse effects (1). Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. This definition is also followed by The Codex Alimentarius Commission, a joint body of WHO and FAO. According to a research conducted by Grand view Research, the organic food market is expected to grow at Compounded Annual Growth Rate (CAGR) of 15.7 percent from 2014-2020 and will reach 211.44 billion by 2020. The highest growth rate is expected for the products like Organic Tea and Coffee at CAGR over 20 percent followed by Organic Frozen and processed foods with CAGR of over 11 percent. Consumers associate consumption of organic foods with well-being (2). Consumers' have a strong belief towards organic foods and they consistently associate them with 'Healthiness'. (3-5). Consumer studies based upon relating organic foods with the highest degree of quality and positive health effects are one of the strongest motives to buy organic foods. However, these expectations of being healthy lack some scientific evidence. Different kinds of study has been conducted and published confirming to the health value of organically produced food compared with their counterparts. Empirical studies and researches have been reviewed in this paper comparing the post-harvest quality of organically and conventionally grown foods. The parameters taken into consideration of post-harvest quality are physico-chemical properties, microbiological, sensory and nutritional properties of organic foods as compared to its conventional counterparts. Many a times organic farming has been related to the production method with an absence of pesticides, but however it is possible to find traces of such chemical inputs from some external or indirect source such as contaminated soil history, through water or air (6,7).

Aims & Objectives

1. To review the literature comparing the nutritional value, sensory qualities and food safety of organically and conventionally produced foods.
2. To study the effects of organic v/s conventional foods on Public Health.

Material & Methods

A systematic review and update of literature was consulted for the present paper from the period of 2001-2017. The mesh terms searched (which

includes all the headings, subheading and the abstracts) were-organic food, health, conventional foods, organic agriculture, nutrition, diet, food consumption, food quality, and food safety etc. These terms were identified and used to find a relation with the terms like human health and nutritional diseases and ultimately the choice motive to buy organic foods. English abstracts with comparisons of organic and conventional foods and its influence on food quality and human health were included. Any conference abstract or unpublished data is excluded for the study. A systematic and critical search has been made through the journals and international databases like SCOPUS, PubMed, ISI Web of Science, CAB Abstracts, between the period of 2001 and 2017; included peer-reviewed articles from Emerald, Springer, Taylor & Francis etc., and hand-searched bibliographies on health claims for organic food consumption, food quality and safety finding the relevant references and bibliography using the keywords like Health benefits, nutritional composition, food safety of organic foods and benefits of organic foods, food quality and safety of organic foods, physicochemical characteristics of organic foods. The papers were selected from more than 4000 available studies. Research conducted for plant based and animal based organic foods from various authors from the period of 2001 to 2017 and the results from the meta-analysis and multi-variate analysis have been tried to be compiled for an extensive review on the topic.

One criteria was clear for to write this paper is that the studies taken into consideration are not funded by any industry. As industries are already been benefitted by the perception that organic foods are more nutritious than comparable conventional foods.

Literature Review

Physicochemical Characteristics & Composition-Comparative studies

a) Plant Foods

The fundamental features of organic agriculture are asserted to be sustainability, cropping techniques, non-chemical-based fertilizers & pesticide usage but a methodical and explorative assessment of the so-called high nutritional value of organic foods and its benefits on human health is still lacking. Researchers have found lower levels of nitrates and comparatively higher amount of vitamin-C in organic

foods but this doesn't hold well for all the species as it was studied on Spinach (*Spinacia oleracea*) crop (8-10). Nutritional quality of Broccoli (*Brassica oleracea* var. *italica*) taking Vitamin-C as a marker was assayed and it was found that there were no significant differences pertaining to the nutritional content in organic v/s conventional broccoli however the differences were observed related to the differences due to crop being grown in different seasonal conditions rather than being labelled as organic or conventional varieties (11). Reduced Nitrogen content owing to absence of chemical fertilizer application is the cause which strongly influence the levels on N content and together with Nitrate content (8,9). No such significant effect of organic farming is found on phenolic acids and starch content in potatoes (*Solanum tuberosum*), however they found growth spread of *P. infestans* to be faster in organically grown potatoes (12).

Studies for the content of calcium for tomatoes (*Lycopersicon esculentum*) grown organically were compared and it is depicted to be highest (377.53 mg/100g) reported by as compared to conventional tomatoes (181.60 mg/100 gm) (13). These results can be compared to the 15.97–23.13 mg/100g (14) and least 8-9mg/100g for organic tomatoes (15). Vitamin-C content in their study was found to be low (26 mg/100g) in comparison with conventional tomatoes (28mg/100g). These, results were gathered from the various studies have been considered as a reference for micronutrient composition from organically and conventionally grown tomatoes. Zinc as proclaimed by the studies of was found to be 0.14–0.33 mg/100g (14). However, Zn and Mg content was not influenced by the growing method organic or conventional as reported (16). Significant concentration of Mg (953.27 mg/100g) was found in organically grown tomatoes in comparison to conventional tomatoes (426.96 mg/100g) (13). Whereas, others have discussed significant effect with greater concentrations of Zn and Mg (17.36-22.22 mg/100g) found in organic tomatoes (17) as compared to 10.30–11.88 mg/100g of Mg (14). On the other hand, Zinc was found to be same amount in both organic and conventionally produced tomatoes (13). However, they also reported that significant differences in these heavy metal composition could be attributed to the soil microflora such as higher level of arbuscular mycorrhizal fungi (AMF). The content of micronutrient Iron (Fe) was found to be

almost similar as 0.51-0.64 mg/100 g and 0.54–1.37 mg/100g (15,14) respectively. Several other studies compared the mineral & vitamin content, phytochemicals and dry matter in the plants, which seem to be more effected by the pre-harvest, harvest, environmental factors and some other physiological characteristics of the plant (10,18).

Recent studies have shown that organic crops have a higher antioxidant content but lower cadmium and pesticide levels. The increased cadmium level in conventional crop produce is contributed by the long term use of mineral phosphorus fertilizer in the soil. Also, organic meat and dairy products have found to have high omega-3 fatty acids. Omega-3 fatty acids play a vital role in the body as they help the heart beat at a steady rhythm, they also reduce the risk of cardiovascular disease, atherosclerosis, and lower blood pressure with an improved blood vessel function (19). The inference made by the studies undertaken by the researchers suggested an association of reduced risk of eczema in infants by consumption of organic foods (20). Majority of the studies conducted in past do not show any evidence of nutrition related health outcomes drawn out of organic food consumption. However, the only plausible biological difference in nutrient content is attributed to the difference in production methods (21). Consumers seems to be willing to pay a premium price for the products they consider safe and healthy like organic food products, functional foods etc. Organic semolina samples were compared with conventional samples for the detection of heavy metals, the latter ones were substantially found richer in Cd (82 $\mu\text{g kg}^{-1}$ vs. 18 $\mu\text{g kg}^{-1}$) and Cr (182 $\mu\text{g kg}^{-1}$ vs. 50 $\mu\text{g kg}^{-1}$), but organic samples had revealed higher concentrations of Ni (295 $\mu\text{g kg}^{-1}$ vs. 166 $\mu\text{g kg}^{-1}$) (22).

b) Animal Foods

The organic foods tend to show a lower level of nitrates and a higher levels of vitamin -C and a high level of PUFA and Omega-3 & 6 fatty acids especially in organic fruits, vegetables and dairy products (23). A higher PUFA content is beneficial for the healthy heart and linked with the prevention of heart diseases, the ratio of PUFA to MUFA specifically n-6: n-3 FA was found to be consistently lower in case of organic milk as compared to conventional milk so we can conclude that organic milk is a better choice if all other factors like breed, effect of seasons etc. are not taken into consideration (19). PUFA, also includes linoleic acid (Omega-6 FA found in meat) and alpha-

linoleic acid (omega-3 FA found in dairy products are found to be in greater concentrations in organic foods) but this amount is unlikely significant for nutrition aspect in light of other dietary sources available. They also have shown an increased levels of phytochemicals but the profound effect of these metabolites on the public health doesn't seem to show consistent results. Also, it is more of a production process of the food which seems to show significant differences within studies for a particular nutrient content. Omega-3's are supposed to reduce the chances of cardiovascular diseases and improves the neurological functioning.

Indeed few studies have shown a remarkably higher amounts of α -tocopherol and β -carotene in organic milk in comparison to conventional milk ($p < 0.001$) which helps in prevention of spontaneous milk oxidation (24-29). With a reduced use of fungicide and antibiotics and increased application of farm yard manure, it might cause frequent contamination by micro-organisms like fungi, moulds and sometimes mycotoxins (30, 31).

Studies in the past have tried to compare the compositional quality of organic and conventional milk but they have lacked the sound interpretation because the quality is dependent upon several other factors like feed to the animal, breed of the animal, lactation stage, seasonal variation, management of the farm etc. (32-33,25,26,28).

Sensory Quality

Sensory related product characteristics plays a vital role for the first time buyers in purchasing organic foods (34). The consumer preferences for the organic vegetables for its overall acceptability was assessed with the help of Likert scale measuring the liking for organic and conventional vegetables like tomatoes, spinach, cucumber etc. (35). The results indicated that 28% of the consumer found the taste of organic spinach better. This consumer perceived sensory quality was found to showcase no difference in the sensory properties of the vegetables taken for the test however there was a prominent difference in flavor intensity and ripeness among the organically and conventionally grown tomatoes. This clearly indicates that these type of consumer tests should also be supported by the consumer descriptive analysis to represent a better interpretation. It was intervened in a study that the production method has a less effect on sensory quality for organic produce (36). Taste of organic

food which is perceived to better is only due to the 'Halo Effect' and nothing more. A similar kind of study was undertaken to assess the hedonic rating based upon the sensory properties of organic wine (37). The experiment revealed that the organic labelling increases the hedonic evaluation and purchase intention which itself is mediated by increased sensory ratings and perceived healthiness of organic wine when all the consumers tasted the same wine. This influence of organic labelling on the sensory perception of wine is explained by the Organic Halo Effect. One of the studies undertaken have substantiated the claim put forward by the consumers for better taste that each product type is different contributing to the taste perception (38). While doing sensory analysis to many consumer, the taste of organic orange juice was perceived to be better than conventional, however there was no significant difference in taste of organic milk as compared to conventional milk.

Another dimension of sensory quality can be given by the concept of sustainability labelling which is an important tool for consumer's perception towards organic food hedonic rating and quality. The results demonstrated in a research marks the influence of quality and sustainability labelling (organic certificates etc.) on the overall sensory acceptance of the product based upon a blind test for the flavor rating of six dark chocolate samples with varying percentage of cocoa (39).

Organic Food Safety

Organic foods must meet the food safety requirements unlike its conventional counterpart (40). Also, to meet this objective it must have an organic label which ensures the production under the specific regulations by law (41,42). However, the labelling only indicates and signifies that the produce has been prepared as per the specific regulations and standard guidelines and has nothing to do with the final product characteristics (43). Pre-dominance of health claims is attributed to non-availability of quality standards for organic foods or not adhering strictly to quality requirements. Further there is a mixing up or organic with the inorganic products. FSSAI is not able to address the quality issues such as label, logo and other specific organic standards as 'organic food' is not considered as a matter of food safety or health hazard. In total there are 112 laboratories accredited by the National Accreditation Board for Testing and Calibration

Laboratories (NABL) also approved by Food Safety and Standards Authority of India (FSSAI) for assessing the products to be certified as 'Organic' (44).

In other countries samples of fruits and vegetables were analyzed to assess the bacteriological quality of the produce. Manures have been used both in organic as well as conventional type of farming which becomes a direct source of microorganisms. The organic vegetables were found to have a higher bacterial and mould count but the results however were statistically insignificant but the results for *E.coli*, *Listeria monocytogenes*, *Salmonella* was found to be negative. Hence, we may conclude that although the organic food exhibiting immunity for microorganisms is still debatable, yet both the organic and conventional foods have a chance of presence of foodborne pathogens but under a controlled limit (45-47). In general organic animal production system restricts the use of veterinary drugs and antibiotics (48,49). But the available literature doesn't support this fact and is contradictory as majority of the reports indicate a significant level of pathogens in organic animal production. Studies have shown the presence of *Campylobacter* spp. in organic broiler carcasses (208 organic broilers and 228 conventional broilers) at slaughterhouse, *Salmonella* spp. in organic eggs taken from 228 raw poultry samples. This bacterium was reported in 78.6% of organic poultry and surprisingly in 53.3% of conventionally grown poultry at farm with 20% of the positive samples of organic eggs for *Salmonella* & only 5.3% of conventional eggs. Also, mastitis-causing bacteria, such as *Staphylococcus aureus*, *Streptococcus* spp., and *Corynebacterium* spp. in organic milk samples (50-54). The prevalence of these pathogens were significantly higher ($p = 0.01$) as compared to the conventional ones produced with antibiotics and other related drugs.

Effects of organic v/s conventional foods on Public Health – concerns & claims

Many a times the premium prices being charged by the organic food manufacturers justify with numerous claims and arguments but the validity of those is still not clear (55). However, food safety is the most commonly and loosely argument being used (56). These results found from a research conducted declares that the food safety concerns and health consciousness are the major triggering

factor for occasional consumers in framing their attitude and purchase intention towards organic foods (57).

The misconception and consumer anticipation of organic food superiority have given birth to these unsubstantiated claims which are often conflicting with the scientific evidences. Organic foods having an effect on environment and society has no significant grounds hence they are not considered as a part of health claim regulation. Hence it becomes difficult to validate the health claims of organic foods (58). It is argued in various studies that organic foods are triggered with fungal and mould infections like *Aspergillus*, *Penicilium* and *Fusarium* due to non-application of pesticide and fungicide. These fungi can produce mycotoxins that are reported allegedly to cause cancer, nephrotoxicity and intestinal & renal carcinogenicity (59-63). Yet, findings are contradictory when it comes to biological and microbiological safety. After reviewing plethora of available literature, we can contribute that there are few differences between organic and conventionally grown products but if the detected contaminants in any form are under the legal maximum limits, have not shown any results representing any major health concern or issue to the consumers. However, there studies also uncovered another concern which is microbial contamination which is due to the farm manure and compost being used. Hence keeping quality of organic fruits and vegetables is another area of research to be looked at.

In a prospective cohort study conducted during the period of 2002-2008 measured the associations between organic food consumption during pregnancy and the risk of pre-eclampsia among nulliparous Norwegian women (64). The author found a lower risk associated of pre-eclampsia who consumed organic vegetables principally. Another birth cohort study was warranted with $n=2764$ determining the effect of organic diet on eczema and wheeze in infants until age 2 years and Multivariate logistic regression models were fitted to assess the potential factors. The diet was segregated as conventional (less than 50% organic), moderately organic (50-90% organic) and strictly organic (more than 90% organic). It was found that consumption of organic dairy products was related to lower eczema risk (OR 0.64 (95 % CI 0.44, 0.93)), however was no association of organic meat, fruit, vegetables or eggs

and was independent of the percentage of organic diet been consumed (65).

Conclusion

Based upon the review of recent literature the authors shall conclude that the concept of organic foods seems to be full of contradictions seeing the current scenario of consumer behavior and the health benefits tested and validated. Secondly, there lacks an outcome of the impact of these nutrients on consumer health. There could only be possible assumptions made which are precise however magnitude of the effects are absent. Also, at times it is seen that factors like time of harvesting the produce, method of harvesting, storage, transportation and handling techniques are crucial for the differential nutritional and sensorial quality of the produce. Hence, only the production or cultivation practices should not solely be taken as a driver for the food safety and quality of the organic foods. After considering numerous studies depicting the increased level of omega-3 Fatty acids have an established impact on human health as these fatty acids are linked to improved foetal brain development, reduced risk of dementia, delayed decline in cognitive function etc. therefore it poses serious health concerns. There are numerous studies indicating a lower level of toxic metals like nickel, cadmium, chromium due to potential difference in soil organic matter, fertilizer application, Physiological characteristics of the plant etc. These findings taken together may suggest an increased propensity of consumers' switching from conventional grown foods to organic foods.

Findings based upon the systematic review suggests that no clinical studies on humans have been found to have a direct influence of organic foods on human health. The reason perhaps is that studies and trials tend to have a long-term effect and needs to be conducted in a proper sequence. It is also sometimes difficult to perform these studies because of expense and chances of dietary interventions.

From another aspect of hedonic evaluation, we may conclude that consumer perception of sustainability, quality and ultimately the purchase intention is mediated by the labelling and certification. These sustainability labels and the quality characteristics drives the overall sensory acceptance for a product. Hence, this understanding can support and contribute to the value added approach to the food

chain. It can be concluded that some evidence on organic food consumption and its effect on human health is still lacking. The results also vary significantly due to differences observed in the methodology & practices of organic farming.

Recommendation

Focusing on the current scenario, there is still a room for more in-depth research confirming the food safety aspect of organic foods. As far as the sensory quality of the organic foods are concerned, proper segmentation and profiling of consumers shall be done to substantiate the differences in their liking and preferences. There has been estimated inadequate assessment of the consumer perception towards organic foods potentially based upon cultivar, environmental effects and the growing conditions.

There could be more number of intervention studies in future to be undertaken for assessing the impact of organic foods on human health. Also, observation methods are also very useful in substantiating the results. The published literature lacks a strong evidence of a direct effect of organic food on human health. However, they indicate that organic food consumption may reduce the risks of allergies, issues like obesity, ill-development of foetus but these evidences are not conclusive. There are various other confounding factors playing a vital role defining an overall healthy dietary pattern.

Limitation of the study

Studies related to the comparisons between organic and conventional foods are limited in number, and publication bias could also be present. After thorough selection of the relevant studies, however, the results are still insufficient and heterogeneous to present the explicit conclusions.

Relevance of the study

Human health is considered to be the most important parameter when it comes to the consumption of raw or processed foods. Growing demands of organic foods makes it necessary to evaluate the benefits of these foods over human health or it is just a labelled 'claim' that it is enjoying. The present study relies on the scientific studies and evidences related to the physio-chemical, nutritional and sensory qualities of the organic foods and to check whether it has any impact on human health.

Authors Contribution

Both the authors have contributed to the design and implementation of the research, to the analysis of the results etc. Authors together have discussed the results and contributed to the final manuscript.

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- (Is eating organic a healthy or safer option...) | Ghai S et al
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Tables

TABLE 1 COMPARISON OF STUDIES INCLUDED FOR MICRONUTRIENT ANALYSIS

Nutrient	Studies included for the analysis
Potassium	Ilić S. Z et al.,2013; Hernandez Suarez et al.,2007
Magnesium	Ordonez-Santos et al.,2011; Yadav.P
Zinc	Kelly and Bateman 2010; Rodr�ygu�ez et al.,2001; Ordonez-Santos et al.,2011; Yadav.P, 2017
Calcium	Rodr�ygu�ez et al.,2001; Yadav.P, 2017; Ilić S. Z et al.,2013; Ordonez-Santos et al.,2011
Iron	Hernandez Suarez et al.,2007; Ilić S. Z et al.,2013; Ordonez-Santos et al.,2011
Cadmium, Chromium and Nickel	Zacconne et al., 2013
Vitamin-C	Wunderlich et al., 2008; Yadav.P, 2017
Omega-3 & 6 fatty acids (Animal Foods)	Ellis, K. et al.,2006
�-tocopherol and �-carotene	Butler et al., 2008; Schwendel, Wester et al., 2015 ; Stergiadis et al., 2014,2015 ; Slots et al.,2008
Phenolic acids	Brazinskiene et al.,2014
Nitrogen	Herencia et al., 2011; Hoefkens et al., 2009
Nitrates	Herencia et al., 2011; Hoefkens et al., 2009

Figures

FIGURE 1 QUOROM DIAGRAM

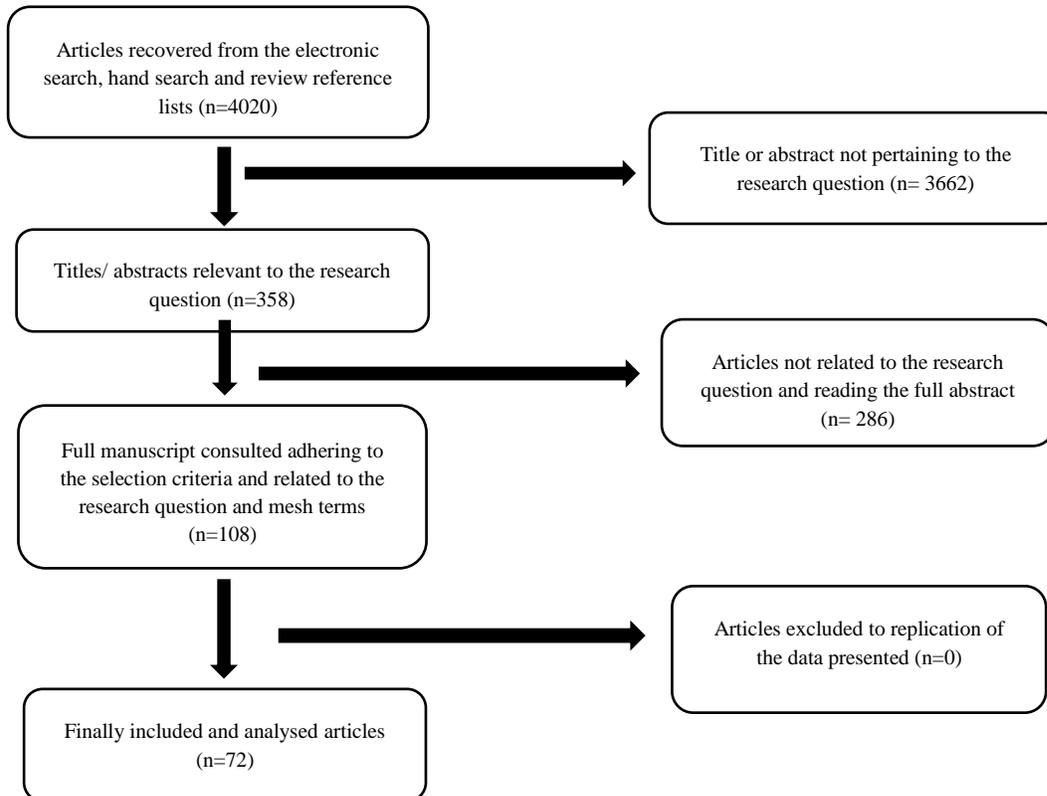
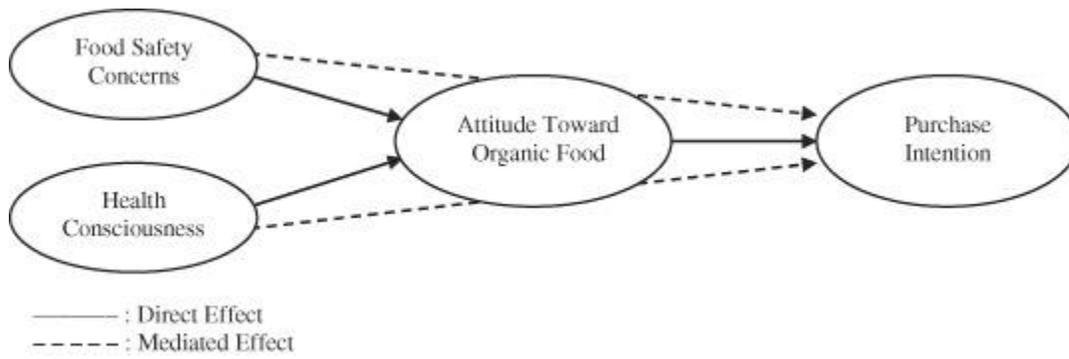


FIGURE 2 MEDIATING ROLE OF FOOD SAFETY CONCERNS AND HEALTH CONSCIOUSNESS ON PURCHASE INTENTION



Source: Mehra S. & Ratna P.A (2014)