Review of Literature
2.0. Review of Literature

Nowadays, the concerns regarding the products produced in an environmentally friendly and health friendly way are interestingly increasing among the people (Pelletier et al., 2013). The contaminant based "food scares" (antibiotics, hormones and pesticides) are of more concern to consumers than hygiene standards and food poisoning (Huang, 1993; Miles et al., 2004 cited in Fontes et al., 2013). These issues have been resulted in the demand for environmentally friendly products such as organic foods (Briz and Ward, 2009). The present research focuses on comparison of nutrients and bio-active compounds, pesticide residue level, consumer perception and sensory attributes of organic foods and conventional foods. The review of collected recent scientific literature is categorized into the following heads:

2.1. An overview on organic farming and organic food products

2.2. An overview on organic nutritive aspect of organic foods

2.3. An overview on organic synthetic pesticides and fertilizers

2.4. An overview on organic sensory attributes of organic foods

2.5. An overview on organic consumer knowledge, attitude and purchasing behaviour regarding organic foods

2.1. An overview on organic farming and organic food products:

Organic farming works in harmony with nature. This involves using techniques to achieve good crop without harming the natural environment or the people who live and work in it. This section is discussed in following subheads:

2.1.1. Sustainable development and organic farming:

Sustainable development focuses on giving high priority in meeting important human needs. Basically, the principle of sustainability not only emphasizes the needs of the present generation but also considers the needs of future generations. The objective of
sustainability is in the ability of present generations being able to pursue their own objectives without avoiding the ability of generations in the future to meet their needs (Langehelle, 2000). Environmental health, economic profitability, and social and economic equity are the three main goals of sustainable agriculture. To achieve these goals, many people from farmers to consumers, with a variety of attitudes, practices along with various policies have to contribute to it. Hence, role of natural and human resources become very essential to achieve sustainable outcomes (Gold, 2009).

2.1.2. Organic farming as sustainable agriculture:

Organic agricultural is often considered as true sustainable agriculture as the practices involved in organic farming supports the claim that it facilitates environmental conservation and animal welfare, increases soil “health,” enriches biodiversity, and supplies the demand of more nutritious foods (O‘Riordan and Cobb, 2001).

Discriminatory use of agrochemicals to yield more production, deteriorated the soil quality, water sources, environment, and resulted in non-sustainable outcome (Narayan, 2012). In this regards, organic farming is considered as a system that is designed and maintained to facilitate long term soil biological activity, ensure effective peak management and recycle wastes to return nutrients to the land. It also provides attentive care for farm animals and handles the agricultural products without the use of extraneous synthetic additives or processing in accordance with the act and the regulations in this part (Roychowdhury et al., 2013).

2.1.3. History of organic farming:

Sustainable and organic agriculture was traditionally practiced worldwide and in India since past centuries. Before 19th century, most food in the world was organically produced using organic manures as well as human and animal power (White, 1970). Organic farming was a part of the traditional Indian farming systems. The ancient repertoires of knowledge like the “Vrikshayurveda,” “Agnipurana,” “Brihat Smahitha” and “Arthasastra” (4th Century B.C.) contain separate sections on Indian agriculture. All these reveal that the ancient science of agriculture was nature friendly. Traditional farmers were well aware of optimal utilization of land and expert in
determining the nature of the soil (Vijaylakshmi, 1993 cited in Roy and Dhumal, 2011). Further, importance of organic manure, green manure, dungs of cow, goat, sheep and water in agricultural practices is also mentioned in Rig Veda 1, 161, 10, 2500-1500 BC, Atharva Veda II 8.3, (1000 BC), Sukra (IV, V, 94, 107-112). A reference of manure is also made in Vrksayurveda by surpala (manuscript, oxford, No 324 B, Six, 107-164) (Bhattacharyya and Chakraborty, 2005).

During the last 20th century, the rate of increase in world population was very high while agricultural land area was decreased. This lead to insecurity of food produced from the traditional agricultural practices. It resulted into the Green Revolution (Lal, 2000). As a part of Green Revolution, farmers started using various components namely, chemical fertilizer, pesticides and farm machinery and so on (HAU, 2003). As an outcome, India became self-sufficient in food production.

Later on, due to the introduction of pesticides and fertilizers, the tradition of natural or organic farming seems to be at great loss. By the beginning of the 20th century, the soil health was continuously deteriorated due to the offensive use of the agrochemicals. In addition, the ill effects of over-use of chemical fertilizer were also seen. These were nitrate enrichment of ground waters, river waters and release of ammonia and nitrous oxide to the atmosphere. Later on, the adverse effects on environment in the form of acid rain and damage in ozone layer were also noticed (Laegreid et al., 1999).

Hence, there was a necessity to reverse the problems of agriculture – erosion, soil depletion, decline of crop varieties, low quality food and livestock feed, and rural poverty (Kuepper, 2010). Instead of solving these problems with any new human resource venture, it was suggested that the farmers should go back to the arms of the nature and take up organic farming to restore the loss. Organic farming in India was given importance by all those farmers and consumers have given priority to organic farming, who are seriously and consciously trying to get rid of harmful chemicals and fertilizers for the benefit of a healthy and safe environment (Shivashankar, 1995 cited in Raghavan, 2010). Table-2.1 depicts key milestones on organic farming in current scenario.
Table 2.1: Key milestones on organic farming in current period

| **Sir Albert Howard**  
| (1900-1947) | father of modern organic Agriculture, developed organic composting process (mycorrhizal fungi) a Pusa, Samastipur, India and published document "an Agriculture Testament". |
| **Rudolph Steiner**  
| (1922) | a German spiritual Philosopher built biodynamic farm in Germany. |
| **J.I. Rodel**  
| (1950), | USA popularized the term sustainable agriculture and method of organic arowina. |
| **IFOAM**  
| (1972) | Establishment of "International Federation of Organic Agriculture Movement" |
| **EU Regulation**  
| (1991) | EU Regulation on Organic Food |
| **Codex**  
| (1999) | Codex guidelines on organic standard |

(Source: Bhattacharyya and Chakraborty, 2005)
2.1.4. Principles (Concept) and definitions of organic farming:

A fundamental principle in organic farming is to reduce its environmental impact as much as possible while sustaining the farming system. The main principles are based on sustainable development. It considers that nature is the best role model for farming, since it does not use any inputs nor demand unreasonable quantities of water. The entire system is based on intimate understanding of nature's ways. The system does not believe in mining of the soil of its nutrients and do not degrade it. The soil in this system is a living entity. The soil's living population of microbes and other organisms are significant contributors to its fertility on a sustained basis and must be protected and nurtured at all cost. The total environment of the soil, from soil structure to soil cover is more important (Yadav, 2012).

The various definitions of organic farming are discussed below:

Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives to the maximum extent feasible. Organic farming systems rely on crop rotation, crop residues, off-farm organic wastes, mechanical cultivation, mineral bearing rocks and aspects of biological pest control to maintain soil productivity and tilth to supply plant nutrients and to control insects, weeds and other pests.

Beharrell and MacFie, 1991

Organic farming is basically a holistic management system, which promotes and improves the health of the agro-ecosystem related to biodiversity, nutrient biocycles, soil microbial and biochemical activities. Organic and bio-dynamic farming emphasizes management practices involving substantial use of organic manures, green manuring, organic pest management practices and so on. It has also come to mean that it is a system of farming that prohibits the use of artificial fertilizers and synthetic pesticides.

GOI, 2001
In philosophical terms organic farming means "farming in spirits of organic relationship. In this system, the agricultural compounds are interconnected. Since organic farming means placing farming on integral relationship such as the relationship between the soil, water and plants, between soil-soil microbes and waste products, between the vegetable kingdom and the animal kingdom of which the apex animal is the human being, between agriculture and forestry, between soil, water and atmosphere etc. It is the totality of these relationships that is the bed rock of organic farming.

Yadav, 2012,

2.1.5. Comparison of organic and conventional farming:

The major differences between organic and conventional farming are use of chemicals in the form of chemical fertilizers and pesticides. The other differences are crop yield, soil quality, biodiversity, product quality in the form of nutritional and sensory attributes. Cost of the product is also a major concern.

Conventional agriculture is characterized by using an immense amount of chemical fertilizers, synthetic pesticides, and growth regulators which resulted in to polluted water resources, soil degradation, reduced biodiversity and contaminated food with various chemicals (Matson et al.,1997; Drinkwater et al., 1998; Tilman, 1999; Zhu et al., 2000; Reganold et al., 2001; Biao et al.,2003 cited in Alfano et al., 2009). Few studies suggest that repeated applications of inorganic fertilizer nutrients can suppress production of certain soil enzymes that are involved in cycling of a given nutrient. The decline in crop productivity during conversion from chemical input to substitute systems (more noteworthy dependence on natural assets) may be because of initial biological potentials of conventionally managed soils to maintain natural supplement sources (Dick,1992).

Under organic agriculture, soil must be soft, porous, and humid which can be maintained by use of bio-fertilizers and bio-pesticide as well as thorough crop rotation, multi cropping or cover crop, mulching and many other ecofriendly principles. A major objective of organic farming is to encourage a higher level of
biological activity in the soil, in order to sustain its quality and thereby promote metabolic interactions between the soil and plants (Stolze et al., 2000).

Organic farming can play an important role in increasing biodiversity. Organic farming practices are considered to be benefited to a wide range of taxa, including birds and mammals, invertebrates and arable flora, through increases in plenty and/or species richness. Organic farming has the potential to help in achieving this balance (Hole et al., 2005). Organic agriculture comprises of various agricultural practices that can help farmers to mitigate with climate change through strengthening agro-ecosystems. Carbon sequestration, lower-input of fossil fuel dependent resources and use of renewable energy all represent opportunities for organic agriculture to lead the way in reducing energy consumption and mitigating the negative effects of energy emissions. As per FAO, organic agriculture is an alternative approach that maximizes the performance of renewable resources and optimizes nutrient and energy flows in agro ecosystems. Life cycle assessments show that emissions in organic production systems are always lower as compared to conventional systems and soil emissions of nitrous oxides and methane can be avoided from arable or dried peat lands by organic management practices. Moreover, Many studies have reported that soil under organic fertilization and management systems has higher soil carbon as compared to chemical fertilized soil (Reganold et al., 2010). Organic fertilizers are also helpful to maintain soil organic carbon and in sequestering large quantity of carbon dioxide to soil. Hence it is considered as environment friendly practices which have potential to mitigate and adopt the climate changes. It lowers greenhouse gas emissions for the production of crop, increase carbon sequestration and also serves other benefits of biodiversity (FAO, 2013).

Under organic farming, soil had significantly higher organic matter content, thicker topsoil depth, higher polysaccharide content, lower modulus of rupture and less soil erosion than soil in conventional farming. Organic farming practices helps to reduce soil erosion and to maintain soil productivity as compared to conventional ones on long term (Reganold et al., 1987). The superior quality of soil under organic agriculture is due to cover crop, crop rotation, manure, mulching.
A cover crop is a crop planted primarily to manage soil fertility, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an agro ecosystem (Lu et al. 2000). One of the primary uses of cover crops is to increase soil fertility. These types of cover crops are referred to as green manure. Usually, green manure crops are developed for a particular time period and before they reach full maturity they are plowed under the soil to improve soil fertility and quality. They are utilized to deal with a range of soil macronutrients and micronutrients (Thiessen-Martens et al, 2005). It can likewise enhance soil quality by increasing soil organic matter levels through the input of cover crop biomass over the long term. Increased soil organic matter upgrades soil structure, and the water and nutrient holding and buffering capacity of soil.

Cover crops have been promoted as a technique to help counterbalance the rise in carbon dioxide levels as it increase soil carbon sequestration (Sainju et al. 2002, Jarecki and Lal 2003). Hence, by reducing soil erosion, cover crops regularly diminish both the rate and amount of water that drains off the field, which would pose natural dangers to waterways and ecosystems downstream (Dabney et al. 2001).

As per National Organic Program (NOP) crop rotation is defined as “alternating annual crops grown on a specific field in a planned pattern or sequence in successive crop years so that crops of the same species or family are not grown repeatedly without interruption on the same field. Perennial cropping systems employ means such as alley cropping, intercropping, and hedgerows to introduce biological diversity in lieu of crop (USDA, 2009). Crop rotation helps to control pest and diseases, maintains soil fertility, soil organic matter levels and soil structure and it also ensures that enough nutrients are available to different crops (Soil association, 2013).

Mulching is one of the simplest and most beneficial practices. Mulch is simply a protective layer of a material that is spread on top of the soil. Mulches can either be organic such as grass clippings, straw, bark chips, and similar materials or inorganic such as stones, brick chips, and plastic. Both organic and inorganic mulches have numerous benefits. It protects the soil from erosion, conserves moisture, reducing the
need for frequent watering, maintains a more even soil temperature, prevents weed growth (USDA, 2014).

Organic yields are comparative lower than conventional yields. But these yield differences are highly contextual, depending on system and site characteristics. However, under certain conditions, with good management practices, particular crop types and growing conditions, organic systems can nearly match conventional yields (Seufert et al., 2012). Similarly, Cooper et al. (2011) have also mentioned that grain yields were highest under conventional fertility management and crop protection practices, but a type of previous crop also affected by the yield of specific crop under organic farming. They observed that: growing wheat after a previous crop of grass/clover was shown to partially compensate for yield reductions in organic fertility management.

Cost of organic foods is affected by many factors. The first factor is requirement of “organic” certification which is very costly. The other reason is organic production is labour intensive as compared to conventional production as no chemical inputs are allowed in organic farming. Another reason for readymade food products is preservatives are not permitted for use in organic products so due to lower shelf life as compared to non-organic products. Further, in many countries organically produced do not have any subsidy that helps to keep the market price low (Mainville and Mundy, 2006).

The global organic food sector has grown substantially within a fairly static total food market over the last decade (Baker et al., 2004). The World organic food production has taken a leap from US $ 23 billion (2002) to US $ 40 billion (2006) (organic monitor, 2006). The increasing importance of the organic food business is probably a result of greater interest in both a healthier and safer diet and a better environment (Squires et al., 2001; Zanoli, 2004; Knudson, 2007). Some reports stated that organic foods are available in nearly 3 of 4 conventional grocery stores (USDA, 2009).

In US and global marketplace, organic industry is one of the fastest growing business segment. The total sales of organic food products and beverages worldwide is
about $23 billion in 2002, with North America and Western Europe grossing the most revenue in retail markets (Wilier & Yussefi, 2006). Organic food sales have increased about 17-21% each year since 1997 in U.S. in comparison with total food market with growth of 2 to 4% per year during the same period in U.S. (Makatouni, 2002; Organic Trade Association, 2006).

2.1.6. **Organic food certification:**

As per USDA, for certification of any farm as organic farm the major criteria are no use of pesticides, chemical fertilizers, sewage sludge or human waste, no genetically modified inputs, as well as minimum three years of transition phase and a distinct distance (7.5m-15m) from adjoining conventional farm.

Organic Certification is necessary to prove that your produce is organic in nature. Demand for Certified Organic Products is increasing worldwide. Certification is an important tool for building trust between Consumer and Organic Producers. Certification is link between farmer, processor and consumer. Organic labels and certification marks help the consumer to identify the organic products easily. Achieve better price as compared to conventional products. Certified organic products meet stringent standards which connect small farmers to global market. Small Farmers can bargain and get premium price on certified organic products, like cumin, basmati rice etc.

Certified organic food and other products are those which are produced according to recognized standards. Various organic certifying agencies around the world that establish their own production standards and certification processes. From these, a small number of agencies were accredited from the International Federation of Organic Agricultural Movements (IFOAM), based on verification that the agencies are operating in accordance with the IFOAM Basic Standards. Moreover, some certification agencies have ISO accreditation (e.g., ISO 65 for certifiers). While, some agencies are unaudited by government agencies giving the certifiers another level of independent certification of their standards and operating systems (Bourn & Prescott, 2002).
Various International organic certification bodies are USDA ORGANIC, EU, JAS, Australian Quarantine and Inspection Services, etc. The conditions for certification are different for crop farms, livestock operations and processing operation units (Riddle, 2012).

In India, the Government of India has implemented the National Programme for Organic Production (NPOP). The national programme involves the accreditation programme for Certification Bodies, standards for organic production, promotion of organic farming etc. The NPOP standards for production and accreditation system have been recognized by European Commission and Switzerland as equivalent to their country standards. Similarly, USDA has recognized NPOP conformity assessment procedures of accreditation as equivalent to that of US. With these recognitions, Indian organic products duly certified by the accredited Certification Bodies of India are accepted by the importing countries (APEDA, 2014).

Under NPOP, various certification bodies are Eco-Cert, One Cert, Food Cert, Biocert, INDOCERT, SGS, USOCA, AOCA, ROCA, NOCA, etc. In Gujarat, GOPCA (Gujarat Organic products Certification Agency) carries out impartial third party inspection & certification in organic production and handling. GOPCA works in accordance with the criteria derived under the NPOP (National Program for Organic Production) 2005 programme.

According to USDA, 100% organic means completely made up of organic, other standards categorized such as category-1 : if 95% or more organic ingredients are used, the product may be labeled “organic” in the title, category -2 : if between 70 to 95% of the ingredients used are organic then the term “organic” may only be used in the ingredient list and if less than 70% of the organic then the term “organic” may not be used anywhere on product packaging (Mainville and Mundy, 2006).

2.1.7. Growing area under organic agriculture:

On a global level, the organic agricultural land area increased in all regions. 35 million hectares of agricultural land are managed organically by almost 1.4 million producers. At present an increase in total by almost three million hectares (9%) as compared to
the data from 2007. The regions with the largest areas of organically managed agricultural land are Oceania (12.1 million hectares), Europe (8.2 million hectares) and Latin America (8.1 million hectares). The countries with the most organic agricultural land are Australia, Argentina and China. About one-third of the world’s organically managed agricultural land (12 million hectares) is located in developing countries. Most of this land is in Latin America, Asia and Africa. Twenty-six percent (1.65 million hectares) more land under organic management was reported for Latin America, mainly due to strong growth in Argentina. In Europe the organic land increased by more than half a million hectares, in Asia by 0.4 million. The countries with the largest area under organic management are Argentina, China and Brazil.

As per BioFach, 2010, the total organic agricultural area in Asia is nearly 3.3 million hectares which constitutes nine percent of the world’s organic agricultural land. The leading countries by area are China (1.9 million hectares) and India (1 million hectares). Organic wild collection areas play a major role in India and China, while Aquaculture is important in China, Bangladesh and Thailand (Yadav, 2012).

2.1.8. Organic agriculture in India:

Since January 1994 “Sevagram Declaration” for promotion of organic agriculture in India and certain initiatives taken by Government and Non-Government organization, organic farming has grown many folds in India. At present, India is considered as one of the top ten countries which has maximum land under organic cultivation. Indian government is actively playing a role in promotion of organic agriculture but still it needs to motivate Indian farmers farming by combating their economic and social unwillingness towards organic farming (Roy and Dhumal, 2011).

In 2003-04, it was estimated that approximately 42,000 ha of cultivated land were certified organic. By 2009, India had brought more than 9.2 million ha of land under certification. Out of this, approximately 1.2 million ha was cultivable land while remaining 8 million ha area was forest land for wild collection. The government of India has also played an important role to motivate organic farming across the nation by implementing NPOP, RCOF in 2000 (Devarajaiah and Natraju, 2009 cited in Roy
Table – 2.2: Growth of area under organic management in India

<table>
<thead>
<tr>
<th>Years</th>
<th>Area under Organic management (in Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-04</td>
<td>42,000</td>
</tr>
<tr>
<td>2004-05</td>
<td>1,73,000</td>
</tr>
<tr>
<td>2005-06</td>
<td>5,38,000</td>
</tr>
<tr>
<td>2006-07</td>
<td>8,65,000</td>
</tr>
<tr>
<td>2008-09</td>
<td>12,07,000</td>
</tr>
<tr>
<td>2009-10</td>
<td>10,85,648</td>
</tr>
<tr>
<td>2010-11</td>
<td>7,77,517</td>
</tr>
<tr>
<td>2013-14</td>
<td>47,20,000</td>
</tr>
</tbody>
</table>

(Source: Yadav, 2012; APEDA, 2014)
and Dhumal, 2011; Roy and Dhumal, 2011). One of the examples of this, all 4000 farmers in the Karuapuram village of Kerala district attained 100% organic farming. Beyond this, Uttaranchal, Sikkim, Nagaland and Meghalaya have declared themselves as organic farming states. (Usha, 2006 cited in Roy and Dhumal, 2011).

By March 2010, India has brought more than 4.48 million ha area under organic certification process. Out of this cultivated area accounts for 1.08 million ha while remaining 3.4 million ha is wild forest harvest collection area (Yadav, 2010). The total organic agricultural area in Asia is nearly 3.3 million hectares. This constitutes nine percent of the world’s organic agricultural land. 400'000 producers were reported. The leading countries by area are China (1.9 million hectares) and India (1.0 million hectares) in Asia. Due to the above benefits, World organic food production has taken a leap from US $ 23 billion (2002) to US $ 40 billion (2006) (Organic Monitor, 2006).

2.2. An overview on nutrients and non-nutritive bioactive compounds of organically and conventionally grown foods:

At present, there is uncertainty about the degree of difference in nutrient composition between conventionally and organically produced foodstuffs. Some reviews and studies have reported that organically produced foodstuffs have higher nutrient content than conventionally produced foodstuffs (Magkos et al., 2003). While some reviews have concluded that there were no consistent differences in nutrient content between production methods (Bourn and Prescott, 2002; Woese et al., 1997).

Nutrient variability in crops depends on numbers of factors (Figure-2.1) like soil characteristics, soil history, seed input such as cultivar, genetic modification, crop input such as irrigation, time of planting and harvesting, length of crop and crop handling including the use of fertilizers and pesticides (Dangour et al., 2009).

Apart from nutrients, agricultural practices also affect phenolic compounds which are secondary metabolites and generally known as antioxidants. Antioxidants scavenge
reactive oxygen species (ROS) which can damage the cells in plant tissues. ROS are produced during various metabolic processes as by products (Mittler, 2002).

Nowadays, antioxidants are getting popular as they are helpful in prevention of various chronic diseases. The free radicals are considered as etiological factors in the development of non-communicable diseases such as cancer, diabetes, cardiovascular diseases, autoimmune disorders, neurodegenerative disorders, ageing, and so on (Bandyopadhyay et al., 1999; Mittler, 2002). Antioxidants are polyphenols, classified into flavonoid and non-flavonoid compounds. Organically grown foods have higher polyphenol and flavanoid content which are needed for the maintenance of good health and to prevent cell damages.

The phenolic compound and flavonoid content of organically and conventionally grown plants is influenced by several factors such as cultivar, seasonal variation, time of harvest, light, climate, maturity stage, degree of ripeness, storage conditions, food preparation and processing (Dangour et al., 2009). Along with these factors, plant nutrient availability (Fritz et al., 2006) also affects the content of nutrients and secondary plant metabolites in crops. The microorganisms and insect pressure also alters phytochemical synthesis by plants (Lattanzio et al., 2006). Hence, the differential use of pesticides and fungicides may influence phenolic compound and flavonoid content. Lattanzio et al. (2006) have mentioned that flavonoids, such as quercetin and kaempferol can be synthesized by plants as a response to the attack of pathogens. Moreover, the distribution of this compounds may be carried out at different levels in the same plant (Lima et al., 2008). Together with biological and environmental stresses, water-stress and wounding also affect the composition of fresh produce by triggering responses that could induce the accumulation of phenolic compounds or other secondary metabolites (Kays, 1997; Saltveit, 1996 cited in Reyes et al., 2007).

Absence of pesticides and chemical fertilizers may put greater stresses on plants and this affect plants to contribute greater resources to develop their own chemical defence mechanisms. The majority of plant phenolics are synthesized via the
Figure-2.1: Factors affecting nutrients variability in foods

(Source: Dangour et al, 2009)
shikimate/arogenate pathway. The shikimate pathway is restricted to plants, fungi and bacteria, making aromatic amino acids essential in the diets of animal. The exceed use of herbicides, insecticides, antibiotics affect shikimate pathway in plant (Herrmann, 1995).

The shikimate pathway has seven metabolic steps beginning with the condensation of phosphoenol pyruvate (PEP) and erythrose 4-phosphate (Ery4P) and ending with the synthesis of chorismate. This pathway is mainly synthesis three aromatic amino acids, L-phenylalanine, L-tyrosine, and L-tryptophan. Apart for using these amino acids for protein synthesis, higher plants also use these amino acids as precursors for a large number of secondary metabolites (Herrmann, 1995).

The pathway bifurcates at chrosimate. The prephenate branch yields tyrosine and phenylalanine. These compounds enter into phenylpropanoid pathway. The interface between phenylalanine and the secondary phenylpropanoid metabolism is controlled by the enzyme phenylalanine ammonia-lyase (PAL). This enzyme catalyzes a non-oxidative deamination of phenylalanine to form cinnamic acid and benzoic acid. Cinnamic acid produces P-coumaroyl coA and coumaric acid. Various secondary metabolites such as flavonoids, isoflavonoids, lignin, catechins, proanthocyanidin etc are produced from P-coumaroyl coA and caffeic acid from coumaric acid (Vogt, 2010; Fraser and Chappie, 2011). Generally, any kind of stress factors modulate PAL activities which affect the synthesis of secondary plant metabolites.

Moreover, in organic farming various kinds of composts and mulching, are practised as well as soil microbial diversity is also higher which can also increase polyphenol contents in food. Polyphenols enter the soil mainly by two pathways: (1) as leachates from above and below ground plant parts, and (2) within above and belowground plant litter. Plant litter generally contains more proanthocynadin (PA) in comparision with low molecular weight polyphenols. The insoluble part of phenylalanine enters the soil as litter which may predominate over soluble polyphenols. Hence, soluble products are released slowly by microbial decomposition of insoluble fraction. Along with this, polyphenol pool of soil can be increased with lignin breakdown and microbial synthesis from nonphenolic compounds. Organic farm soil also contains
large number of fauna, from which some can digest polyphenol and mostly ingested polyphenols are mixed with other litter components (Figure-2.3).

Review of collected research papers on comparison of nutrients and antioxidants in organically and conventionally grown foods are discussed in table. The studies conducted in the research papers were classified by two different study types. The first is Field trials which compare the samples originating from organic and conventional agricultural practices on adjacent land as well as the samples from organic and conventional farms which may be matched for selected variables and the second type is Market basket study which compare the samples of organically and conventionally produced food as available to the consumer from retail outlets.
Figure-2.2: Synthesis of polyphenol through shikimate and phenylpropanoid pathway
(Source: Hättenschwiler and Vitousek, 2000)

Figure-2.3: The biosynthesis and fate of polyphenols

[(a) represents any living plant tissues], release into the environment and fate of polyphenols in the soil (b).

LMP-Low molecular weight phenolics
PA- Proanthocyanidins

\[\text{CXI indicates regulation}\]

\[\text{Leaching (part of dissolved organic C in groundwater or streams)}\]

[(Source: Hättenschwiler and Vitousek, 2000)]
<table>
<thead>
<tr>
<th>No.</th>
<th>Foods</th>
<th>Chemical compounds studied</th>
<th>Major findings</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tomatoes</td>
<td>Ascorbic acid, carotenoids, polyphenols</td>
<td>Organic tomatoes had higher levels of Vitamin C, carotenoids, and polyphenols than conventional on fresh weight basis.</td>
<td>Caris-Veyrat et al., 2004 (Field study)</td>
</tr>
<tr>
<td>2.</td>
<td>Tomato (cv. Carmem and Débora)</td>
<td>Physical, chemical and sensorial characteristics</td>
<td>Carmem and Debora cultivar did not show significant differences between the organic and conventionally grown tomatoes in relation to the tonality of red. The values of pH, total soluble solids and titratable acidity exhibit differences for organic and conventional tomatoes.</td>
<td>Borguini and Silva, 2005 (Field study)</td>
</tr>
<tr>
<td>3.</td>
<td>Tomato (cv. California Wonder and Excalibur) and bell pepper</td>
<td>Total phenolics, soluble solids, ascorbic acid, and the flavonoid (aglycones quercetin, kaempferol, and luteolin)</td>
<td>Significantly higher levels of soluble solids (17%), quercetin (30%), kaempferol (17%), and ascorbic acid (26%) were found in Burbank tomatoes (FWB), whereas only levels of soluble solids (10%) and kaempferol (20%) were significantly higher in organic Ropreco tomatoes (FWB). Year-to-year variability was significant. Bell peppers were influenced less by environment and did not display cropping system differences.</td>
<td>Chassy et al., 2006 (Field study)</td>
</tr>
<tr>
<td>4.</td>
<td>Tomatoes (cv. Carmem and Debora)</td>
<td>Ascorbic acid, lycopene, β-carotene and minerals (P,K,Ca,S,Cu and Fe)</td>
<td>Conventionally produced Debora tomatoes had higher ascorbic acid contents than other samples (28.9 vs. 21.9-24.9 mg/100g), whereas lycopene and carotene contents did not differ significantly between organically and conventionally grown samples. Organic Carmem and Debora tomatoes had lower contents of Ca and higher contents of S than their conventionally grown counterparts.</td>
<td>Borguini and Silva, 2007 (Field study)</td>
</tr>
</tbody>
</table>
5. Tomato fruits  | Ascorbic acid, β-carotene, flavonols and phenolic acids  | Organic tomatoes contained more total sugar and reducing sugars and more organic acids. Moreover, in the organic fruits, significantly more bioactive compounds such as ascorbic acid, β-carotene, flavonols and phenolic acids were found. Only the content of lycopene was higher in the conventional fruits.  | Hallmann and Rembialkowska, 2007 (Field study) |

6. Dried tomatoes  | Quercetin and kaempferol aglycones (10 years comparison)  | Significant higher levels (P < 0.05) of quercetin and kaempferol aglycones in organic tomatoes. Ten-year mean levels of quercetin and kaempferol in organic tomatoes [115.5 and 63.3 mg g of dry matter (DM)] were 79 and 97% higher than those in conventional tomatoes (64.6 and 32.06 mg g of DM), respectively. The levels of flavonoids increased over time in samples from organic treatments, whereas the levels of flavonoids did not vary significantly in conventional treatments.  | Mitchell et al., 2007 (Field study) |

7. Tomatoes  | pH, soluble solids, acidity, and colour, β-carotene, lycopene, ascorbic acid, and total phenolics  | No significant differences between organic and conventional farming systems for all tomato fruit parameters measured, including quality (pH, soluble solids, acidity, and colour), content of bioactive compounds with antioxidant activity (β-carotene, lycopene, ascorbic acid, and total phenolics), and antioxidant activity. No consistent effect of the farming system on tomato fruit parameters.  | Juroszek et al., 2009 (Field study) |
| Flavonoid aglycones, hydroxycinnamic acids, carotenoids and the total antioxidant activity and bioactivity of polyphenol extracts from tomato | Tomato | 8. | Systematic differences in the concentrations of certain elements such as manganese, calcium, copper, and zinc may occur between crops cultivated under organic and conventional regimes possibly due to the presence of elevated levels of arbuscular mycorrhizal fungi in soils cultivated organically. Statistically higher levels ($P < 0.05$) of phenolic compounds in organic tomato juices. This increase corresponds not only with increasing amounts of soil organic matter accumulating in organic plots but also with reduced manure application rates once soils in the organic systems had reached equilibrium levels of organic matter. | Fjelkner-Modig et al., 2000 (Field study) | Crop yield, nutrients, trace elements and trace element concentrations. | Carrot, cabbage, onion, pea and potato | 11. | However, significant differences of molybdenum, nickel, silicon and copper were observed for tomato, lettuce and tomato juices. Overall, no significant differences in the other three substances than integrated grown. | Fjelkner-Modig et al., 2000 (Field study) |

Comparatively low level of quercetin, chlorogenic acid and caffeic acid were noticed for organic tomato as compared to conventional ones. No difference in biological effect was observed using cell models. Flavonoid aglycones, hydroxycinnamic acids, carotenoids and the total antioxidant activity and bioactivity of polyphenol extracts from tomato

| | | | | Durazzo et al., 2010 (Field study) | | Durazzo et al., 2010 | | Kelly and Bateman, 2010 (Market Basket study) | | Vallverdu-Queralt et al., 2011 (Market basket survey) | | Kelly and Bateman, 2010 | | Vallverdu-Queralt et al., 2011 | | Kelly and Bateman, 2010 | | Vallverdu-Queralt et al., 2011 |
Polyphenol content and antioxidant capacity varied among organic and conventional vegetables with no prevalence from either agricultural type. Organic potato (peel and pulp), broccoli (leaf and stem), carrot (peel and pulp), cabbage (outer and inner leaves) and tomato (peel and pulp) showed higher soluble phenol contents. Potato peel and pulp, broccoli leaves, onion, carrot peel, tomato peel and pulp from organic cultivation showed higher radical scavenging activity.

Soltoft et al., 2010 (Field study)
Lombardo et al., 2012 (Field study)
Brazinskienė et al., 2014 (Field study)

No significant differences in the content of flavonoids and phenolic acids between the conventional and the two organic growth systems were found. In the organically grown potatoes fertilized with cover crops, a significantly higher content of 5-O-caffeoylquinic acid was found as compared to the conventional system.

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The organic potato was found with higher dry matter, total phenols and lower nitrate content than conventional ones. Organic potatoes are also noticed for better sensory performance after frying (strong taste and crisp flesh).

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No significant effect (p > 0.05) on the content of phenolic acids. No significant effect (p > 0.05) of farming type on dry matter and starch content, or sensory properties was found. No significant relation (p > 0.05) was found between the content of phenolic acids.

Potato, carrot, onion, broccoli, and white cabbage

Onions, carrots, and potatoes

Potato (Cv. Arinda, Ditta and Nicola)

Potato (five Lithuanian varieties)
The mean levels of ascorbic acid and flavonoids were significantly (p < 0.001) higher in the organically grown spinach as compared to the conventionally grown spinach. Conversely, the mean levels of nitrate were significantly (p < 0.001) higher in the conventionally grown spinach as compared to the organically grown spinach. No significant effects were observed in the oxalate content of spinach from either production system.

Organically grown pumpkins were found with higher dry matter, soluble solid, β-carotene, vitamin-E and ascorbic acid content as compared to conventionally-grown pumpkins. Organic red pepper contained more carotenoids, vitamin C, dry matter and flavonoids as compared to conventional red pepper. Peroxidase activity in organic sweet peppers was higher than in conventional ones, in both maturity stages studied. The level of total phenolic compounds was also higher in organic than in conventional sweet peppers. Capsidiol activity (expressed as inhibition of fungus growth) was not affected by the cultivation method at the green mature stage. However, at the red mature stage, organic sweet peppers showed higher capsidiol activity than those grown under the conventional system.

<table>
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<th>Nitrate, ascorbic acid and 17 flavonoids (glucuronides and acylated di and tritylcosides of methylated and methylene-oxigenated flavonoids) LC/MS Nutritional and sensory characteristics</th>
<th>Spinach (27 varieties)</th>
<th>Pumpkins and pumpkin products</th>
<th>Red pepper (cv. Ozarowska and Roberta)</th>
<th>Sweet pepper fruit</th>
<th>Peroxidase activity, total phenolics content, and capsidiol activity</th>
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<td>Koh et al., 2012 (Field study)</td>
<td>Danilchenko, 2002 (Field study)</td>
<td>Hallmann and Rembialkowska, 2007</td>
<td>Del Amor, et al. 2008 (Field study)</td>
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<td>No.</td>
<td>Sample Type</td>
<td>Phenolic Content</td>
<td>Description</td>
<td>References</td>
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<td>20.</td>
<td>Eggplant (Cv Blackbell and Millionaire)</td>
<td>Phenolic content 5-caffeoylquinic acid content</td>
<td>The cv. Millionaire showed a higher total phenolic content as compared to the Blackbell cultivar. No significant consistent trend was noticed for the phenolic content of eggplant samples grown with organic and conventional farming practices with both eggplant cultivars.</td>
<td>Luthria et al., 2010 (Field study)</td>
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<td>21.</td>
<td>Onion (Cv. Wenta Sochaczewska, Wolska, Red aron and Sterling)</td>
<td>Dry matter, total and reducing sugars, flavonoids, ascorbic acid and anthocyanins</td>
<td>Organically grown onions obtained more flavonoids, ascorbic acid and anthocyanins as compared to conventionally grown ones.</td>
<td>Hallmann and Rembialkowska 2006 (field study)</td>
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<td>22.</td>
<td>Mint, lovage, thyme and sage</td>
<td>Total phenol, flavnoids</td>
<td>Organic herbal plants contained significant (p&lt;0.01) higher total phenol and flavonoid contents. Moreover, Gallic acid, Chlorogenic acid, Caffeic acid, P-coumarin acid and Ferulic acid were also found higher in organic herbal plants.</td>
<td>Kazimierczak et al., 2011 (Field study)</td>
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<td>23.</td>
<td>Chinese mustard, Chinese kale, lettuce, spinach and swamp cabbage</td>
<td>β-carotene, vitamin C and riboflavin (reverse-phase HPLC)</td>
<td>Swamp cabbage grown organically was highest in β-carotene, vitamin C and riboflavin contents among the entire samples studied. However, not all of the organically grown vegetables were higher in vitamins than that conventionally grown not</td>
<td>Ismail and Fun, 2003 (Market basket study)</td>
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<td>24.</td>
<td>Cabbage leaves</td>
<td>Glycosylated kaempferol using reversed-phase HPLC-DAD-MS/MS-ESI</td>
<td>Organic samples of leaves showed higher total phenolics content than those from conventional practices collected in the same period</td>
<td>Ferreres et al., 2005 (Field study)</td>
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<td></td>
<td>Phenolic compounds and phenolic acids (caffeic acid, gallic acid) and aglycone or glycoside flavonoids (apigenin, kaempferol, luteolin, and quercetin)</td>
<td>No significant difference in phenolic compounds in organic and conventional lettuce and collard samples. The total phenolic content of organic pac choi samples was significantly (p &lt; 0.01) higher than conventional samples.</td>
<td>Young et al., 2005 (Field study)</td>
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<td>25.</td>
<td>Lettuce, collards, and pac choi</td>
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<td>26.</td>
<td>Broccoli</td>
<td>Vitamin- C [2,6- dichloro phenol indophenol method]</td>
<td>The ascorbic acid content of organically and conventionally labeled broccoli was not significantly different. However, significant seasonal changes have been observed. The fall values for vitamin C were almost twice as high as those for spring for both varieties (P=0.021 for organic and P=0.012 for conventional). The seasonal changes in vitamin C content are larger than the differences between organically labelled and conventionally grown broccoli.</td>
<td>Wunderlich et al., 2007 (Market basket study)</td>
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<td>27.</td>
<td>Italian Cauliflower</td>
<td>Ascorbic acid and Polyphenols</td>
<td>Significant higher levels of ascorbic acid (p&lt;0.05) and phenols (p&lt;0.01) were observed in organically grown cauliflower. In addition, under organic management, the use of higher fertilisation levels significantly increased the phytochemical production of Magnifico, in particular ascorbic acid (P &lt; 0.05) and polyphenols (P &lt; 0.01). However, the same fertigation treatments decreased the phytochemical production of Emeraude, particularly glucosinolates and ascorbic acid. The addition of fertilisers to organic soil might be effective only with a cauliflower genotype suited to organic agriculture.</td>
<td>Picchi et al., 2012 (Field study)</td>
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<td>No.</td>
<td>Description</td>
<td>Polyamines and total phenols contents</td>
<td>Organic vs. Conventional Apples</td>
<td>Source(s)</td>
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<td>28.</td>
<td>Lima et al., 2008 <em>(Field study)</em></td>
<td>Higher polyamines and total phenols contents under organic cropping was observed for majority of the analysed vegetables.</td>
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<td>29.</td>
<td>Briviba et al., 2007 <em>(Field study)</em></td>
<td>Higher level of total phenol content was noticed for conventional apples. The average content of total identified and quantified polyphenols in the organically and conventionally produced apples was 308 and 321µg/g fresh weight, respectively.</td>
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<td>30.</td>
<td>Garnweidner, et al., 2007</td>
<td>Organically produced apple juices had higher values on the average than conventional ones. Organic apple juices showed higher antioxidant capacity than conventional ones. Additionally, the contents of single phenolic compounds were analysed by the HPLC-method were also found higher in organic juices. The contents of chlorogenic acid predominated quantitatively in both apple juices followed by phloridzin, epicatechin and catechin. Furthermore, organically produced apple juices had higher concentrations of ascorbic acid than conventional ones.</td>
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<td>31.</td>
<td>Valavanidis et al., 2009 <em>(Field study)</em></td>
<td>No significant difference was noticed for most important polyphenolics (chlorogenic acid, catechin, epicatechin, procyanidin B1 and B2, cyaniding 3-galactoside, phloridzin, quercetin 3-galactoside and quercetin 3-arabinoside) between the organic and conventional apples. Statistical significance of differences in antioxidant activities among the same cultivars was relatively small (flesh + peel or peel only) for both types of apples.</td>
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<td>32.</td>
<td>Apple (cv. Golden Delicious)</td>
<td>Phenols</td>
<td>Significantly higher polyphenol concentrations were found in the organically grown apples in year 2005. In 2004 and 2006 no significant differences were observed. (2004, 304 µg/g organic vs 284 µg/g conventional, p = 0.18; 2005, 302 µg/g organic vs 253 µg/g conventional, p = 0.002; 2006, 402 µg/g organic vs 365 µg/conventional, p = 0.17). Year-to-year variations in the antioxidant capacity and the polyphenol content of up to 20% were more significant than the production method found within one year.</td>
<td>Stracke et al., 2009 (Farm study)</td>
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<td>33.</td>
<td>Black currants (Ribes nigrum L.)</td>
<td>hydroxycinnamic acids, flavonols, and anthocyanins</td>
<td>Statistically significant differences between farms were found for almost all the compounds pertaining to total phenol contents, hydroxycinnamic acid derivatives, flavonols, and anthocyanins. The biochemical quality of organically grown black currant fruits does not differ from those grown conventionally.</td>
<td>Anttonen and Karjalainen, 2006 (Farm study)</td>
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<td>34.</td>
<td>Black and red currants</td>
<td>Phenolic profile, antioxidant capacity and antiproliferation activity</td>
<td>The mean value of total polyphenol content in organically grown currants was similar but statistically higher than conventional cultivation (11831.0 and 1543.0 mg/kg of d.m., respectively). Conventionally grown red currant had higher anthocyanin content than organically grown red currant (11.8%) but, organic fruits of red currant had 2.7 times higher content of oligomeric procyanidins than fruits coming from conventional cultivation. All currants from organic cultivation possess higher ferric reducing capacity than conventionally grown fruits.</td>
<td>Aneta et al., 2013 (Field study)</td>
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<td>No.</td>
<td>Sample Type</td>
<td>Measured Parameters</td>
<td>Description</td>
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<td>35.</td>
<td>Peach (cv. Regina bianca) and pear (cv. Williams)</td>
<td>Polyphenoloxidase (PPO) activity and total polyphenol</td>
<td>All organic peach samples were found with significant (P&lt;0.001) higher polyphenol content as compared with conventional peaches. While, organic pear samples grown with spontaneous weed cover and under tilled soil contained higher polyphenol content with respect to the conventionally grown sample (P&lt;0.05). Activity of PPO extracted in appropriate conditions and tested towards 1 mM chlorogenic and caffeic acid was significantly higher in most of the organic peach and pear samples than conventional ones.</td>
<td>Carbonaro et al., 2001 (Field/farm study)</td>
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<td>36.</td>
<td>Peach (cv. Regina bianca) and pear (cv. Williams)</td>
<td>Polyphenols and PPO activity, ascorbic acid, citric acid, and α and γ-tocopherol,</td>
<td>Higher polyphenol content and PPO activity were noticed in organic peach and pear as compared with conventional samples. Ascorbic and citric acids were found higher in organic peaches than conventional ones, whereas α-tocopherol was noticed higher in organic pear.</td>
<td>Carbonaro et al., 2002 (Field/farm study)</td>
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<td>37.</td>
<td>Yellow plums</td>
<td>Antioxidants, ascorbic acid, vitamin E, β-carotene and total polyphenols, phenolic acids, flavonols</td>
<td>Ascorbic acid, α and γ-tocopherols, and β-carotene were found higher in organic plums grown on soil covered with natural meadow. The highest phenolic acids content was detected in plums grown on soil covered with trifolium. Total polyphenols content was higher in conventional plums. Quercetin was higher in conventional plums, but myrecitin and kaempferol were higher inorganic plums.</td>
<td>Lombardi-Boccia et al., 2004 (Field study)</td>
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<td>Marionberries, strawberries, and corn</td>
<td>Total phenolic content</td>
<td>Significant higher total phenol content was found in organically and sustainably grown foods as compared to those produced by conventional agricultural practices. Moreover, in all samples, freeze-drying preserved higher levels of TPs in comparison with air-drying.</td>
<td>Asami, et al., 2003</td>
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<td>38.</td>
<td>Strawberries</td>
<td>Ascorbic acid and effect of extracts on the proliferation of colon cancer cells HT29 and breast cancer cells MCF-7</td>
<td>The ratio of ascorbate to dehydroascorbate was significantly higher in the organic strawberries. The extracts from organically grown strawberries had a higher antiproliferative activity for both cell types at the highest concentration than the conventionally grown, which reveals that organic strawberries contain higher content of secondary metabolites with anticarcinogenic properties.</td>
<td>Olsson et al. (2006) (Field study)</td>
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<td>39.</td>
<td>strawberry (Fragaria x ananassa Duch)</td>
<td>yield, quality and nutritional status</td>
<td>According to total yield of two years, there were significant differences between two growing systems, ranging from 21% (Camarosa) to 29% (Sweet Charlie). There were also significant differences in average fruit weight among cultivars in organic and conventional system. Total Soluble Solid (TSS) content and Titretable Acidity (TA) of fruit differed among the cultivars. Sweet Charlie and Festival cultivars had the highest TSS content under conventional system.</td>
<td>Macit et al. (2007) (Field study)</td>
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Organic blueberry fruit had significantly higher sugars (fructose and glucose), malic acid, total phenolics, total anthocyanins, and antioxidant activity (ORAC) than conventional blueberries. The organic blueberries were also found with higher contents of myricetin-3-arabinoside, quercetin 3-galactoside, delphinidin 3-galactoside, delphinidin 3-glucoside, delphinidin 3-arabinoside, and malvidin 3-arabinoside than conventional ones.

Not all the organic berries showed significantly higher TPC, TAC, and ORAC than the conventional berries. A subtle difference of bioactive phytochemicals were noticed between the organically and conventionally grown berries. The total anthocyanin content during ripening of the conventionally grown grapes was significantly higher as compared to organic ones. All samples of conventional grapes presented higher contents of delphinidin, petunidin, malvidin, and acylated malvidin glucosides as compared to grapes from organic agriculture.

Organic grape juices showed statistically different (p < 0.05) higher values of total polyphenols and resveratrol as compared to conventional grape juices. Purple juices presented higher total polyphenol content and antioxidant activity as compared to white juices, and this activity was positively correlated (r = 0.680; p < 0.01) with total polyphenol content.
<table>
<thead>
<tr>
<th>No.</th>
<th>Variety</th>
<th>Measurement</th>
<th>Description</th>
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<td>45.</td>
<td>Rio Red red-fruit red grapefruit</td>
<td>Fruit weight, specific gravity, peel thickness, and peel colour, % juice, and colour</td>
<td>Conventional fruit was better coloured, higher in lycopene and the juice was less tart, lower in the bitter compound naringin, and better accepted by the consumer panel than the organic fruit. Organic fruit had a commercially preferred thinner peel, and the juice was higher in ascorbic acid and sugars and lower in nitrate and the drug interactive furanocoumarins.</td>
<td>Lester, 2007 (Field study)</td>
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<td>46.</td>
<td>Grapefruit (cv. Rio Red)</td>
<td>Vitamin C, limonoids, and carotenoids using HPLC</td>
<td>Vitamin C levels were higher in organically grown grapefruits (41.8 mg/100 g) as compared to conventionally grown grapefruits (39.2 mg/100 g) at 0 days after harvest in the first experiment. During storage at room temperature, vitamin C degradation losses ranged from 0.5 to 7% for organically produced grapefruits and from 3 to 18% for conventional grapefruits. In the first experiment at harvest, organically produced grapefruits had 77% higher nomilin than conventionally produced grapefruits, whereas conventional grapefruits had 2-fold higher lycopene levels as compared to organic grapefruits. In the second experiment, both β-carotene and lycopene levels were significantly higher in conventionally produced grapefruits than in organic grapefruits.</td>
<td>Chebrolu et al., 2012 (Field study)</td>
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<td>47.</td>
<td>Mandarin (India)</td>
<td>Nutritional and sensory qualities.</td>
<td>Organic and conventional mandarins contained moisture (87.51% and 86.75%), fibre (0.31% and 0.39%), ash (0.40% and 0.31%), total sugar (9.23% and 8.15%), vitamin C (57.33 mg% and 39.92 mg%), calcium (33.02 mg% and 24.15 mg%), magnesium (19.07 mg% and 8.19 mg%), sodium (8.07 mg% and 3.56 mg%) and potassium (11.13 mg% and 7.93 mg%), respectively. Organic mandarins were superior and have better commercial quality as compared to conventional mandarins.</td>
<td>Acharya and Bhatnagar, 2007 (Field study)</td>
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<td>Study</td>
<td>Analyzed Sample</td>
<td>Analyzed Parameters</td>
<td>Findings</td>
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<td>48.</td>
<td>Kiwi fruit (cv. Hayward and Bidan)</td>
<td>Total phenol, flavonoids, flavanols, tannins, DPPH, FRAP, ABTS and CUPRAC</td>
<td>Total phenol content was found higher in organic kiwifruit (cv.Hayward ) but did not significantly vary. Moreover, flavonoids, flavanols and tannins also differed as per cultivar. Similarly antioxidant capacity was also varied as per the cultivar. Overall no significant effect of cultivation practices was observed on phytonutrient compounds of kiwifruit.</td>
<td>Park et al., 2012 (Field study)</td>
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<td>49.</td>
<td>Winter wheat (cv.Ludwig and Sulamit)</td>
<td>Grain yield and protein content</td>
<td>Grains from organic farming had lower protein content than those from conventional farming when grown under 125 mm inter-row distance. However, when the distance between rows was increased from 125 to 375mm in organic farming, the grain protein content increased by0.5-1.3% depending on the cultivar. Widening the row spaces did not decrease grain yield.</td>
<td>Bicanová, et al., 2006 (Field study)</td>
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<td>50.</td>
<td>Wheat</td>
<td>52 different metabolites including amino acids, organic acids, sugars, sugar alcohols, sugar phosphates, and nucleotides</td>
<td>The statistical analysis of the data shows that the metabolite status of the wheat grain from organic and mineralized farming did not differ in concentrations of 44 metabolites. Little or no impact of the different farming systems on the nutritional value of their products.</td>
<td>Zorb et al., 2006 (Field study)</td>
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<td>51.</td>
<td>Wheat ears and matured grain</td>
<td>Lipids, cations, starch and protein concentrations, DPPH radical scavenging activity</td>
<td>Protein content was found in lower in organic wheat ears and grains as compared to conventional and mineralic fertilized wheat ears and grains. Total antioxidant capacity was found higher in organic wheat but no significant difference was observed as compared to conventional ones. Differences in 62 metabolite concentrations become marginal or disappear in the matured grains.</td>
<td>Zorb et al., 2009 (Field study)</td>
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No significant differences were found between the two farming systems. Sum of carotenoids (μg/g) for 2003 (0.91 organic vs 0.96 conventional), for 2005 (1.61 organic vs 1.33 conventional), for 2006 (0.87 organic vs 0.83 conventional); sum of phenolic acids (μg/g) for 2003 (448.4 organic vs 327.3 conventional), for 2005 (502.8 organic vs 484.4 conventional), for 2006 (659.1 organic vs 945.9 conventional). However, statistically significant year-to-year differences up to 55% were observed. Altogether, the results indicate that climate factors have a greater impact on the phytochemical concentrations in whole wheat than the production method (organic/conventional).

A little influence of the farming system was observed. The differences are mainly caused by different kernel sizes (thousand-kernel weight), which are found to be correlated to the lutein content.

Spring wheat was observed to have significantly higher values for B, Cu, Fe, Zn, Ca, S and K as compared to winter wheat. A very high mineral concentration, close to daily requirements, can be produced by growing specific primitive wheat genotypes in an organic farming system.

All metals except for Pb were significantly affected by crop management practices and the year that the wheat was grown. Grains contained higher levels of Cd and Cu under conventional fertility management practices. Higher levels of Al and Cu were noticed when conventional crop protection practices were used.
<table>
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<th>Wheat flours</th>
<th>Protein, minerals and heavy metals</th>
<th>Organic samples had significantly lower protein content and lower levels of Ca, Mn and Fe as compared to conventional samples. Protein digestibility and levels of K, Zn and Mo were significantly higher in organic than in conventional wheat flours. Regarding undesirable metals, significantly higher levels of As and Cd were found in conventional in comparison with organic wheat flours.</th>
<th>Vrc’ek et al., 2014 (farm/market basket study)</th>
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<tr>
<td>56.</td>
<td>Oat grains</td>
<td>Avenanthramides (AVAs), hydroxyl cinnamic acids (HCAs), a sucrose-linked truxinic acid (TASE)</td>
<td>Significant differences were noticed between years, cultivars, and N rate for AVA concentration in the grains, but there were no differences in concentration as a consequence of the conventional or organic cropping system used. The HCAs showed cultivar and year differences, but were not influenced by N rates or the cropping system.</td>
<td>Dimberg et al., 2005 (Field study)</td>
</tr>
<tr>
<td>57.</td>
<td>Vegetable soups</td>
<td>Salicylic acid was determined by using HPLC with electrochemical detection</td>
<td>The median contents of salicylic acid in the organic and non-organic vegetable soups were 117 (range: 8-1040) ng/g and 20 (range: 0-248) ng/g respectively. The organic soups had a significantly higher content of salicylic acid (p=0.0032), with a median difference of 59 ng/g (range: 18-117 ng/g).</td>
<td>Baxter et al., 2001 (Market basket study)</td>
</tr>
<tr>
<td>58.</td>
<td>Milk and dairy products</td>
<td>Fatty acid composition and fat-soluble vitamin</td>
<td>Significantly higher cis-9 trans-11 C-18:2 (CLA), linolenic acid (LNA), trans-11 C-18:1 (TVA) and alpha- tocopherol (TH) concentrations were measured in organic buffalo milk and mozzarella cheese. For heat-treated cow’s milk and dairy products, all organic samples contained significantly higher CLA, TVA, LNA, TH and beta-carotene concentrations than conventional dairy foods.</td>
<td>Bergamo et al., 2003</td>
</tr>
<tr>
<td>Edible oils</td>
<td>Fatty acid composition</td>
<td>Saturated, monounsaturated and polyunsaturated fatty acids were all significantly different between types of oil ($P&lt;0.001$) and each had significant interaction between type and production method demonstrating that organic and conventional oils differed in these components in an inconsistent fashion. Although, there were large differences particularly between MUFA and PUFA components in specific pairs of oils, especially in sunflower and mustard seed oils, no consistent overall trend of difference was noticed in the fatty acid composition between organic and conventional oils.</td>
<td>Samman et al., 2008 (Market basket study)</td>
<td></td>
</tr>
<tr>
<td>Groundnuts, cashew nuts and almonds, dry grapes, sugar and jaggery</td>
<td>carbohydrate, protein and minerals</td>
<td>Organically grown groundnuts, cashew nuts and almonds were found with higher calcium, iron, sodium, potassium as compared to conventional ones. However, protein, fat and carbohydrate varied as per variation in cultivation practices. Organically grown sugar and jaggery contained higher protein content than their conventional counterparts.</td>
<td>Venkatasubramanian, 2011 (Market basket study)</td>
<td></td>
</tr>
<tr>
<td>Cinnamon and peppermint</td>
<td>Total phenol, DPPH radical scavenging activity</td>
<td>Conventional cinnamon extracts had slightly higher total phenolics and radical scavenging capacities against hydroxyl, peroxyl and DPPH radicals than their organic counterparts, but no significant difference was observed. For peppermint extracts, the relative scavenging activity (RDSC) value of the conventional peppermint was significantly higher than organic one. Organic peppermint extract had slightly higher Hydroxyl scavenging activity and ORAC values than the conventional extracts, but not at a statistically significant level. Organic cinnamon and peppermint had stronger anti-proliferative ability than the conventionally grown samples and both conventional</td>
<td>Lv et al., 2012 (Market basket study)</td>
<td></td>
</tr>
</tbody>
</table>
Vallverdu-Queralt et al., 2011 and organic peppermint and cinnamon extracts exhibited strong anti-inflammatory properties.

<table>
<thead>
<tr>
<th></th>
<th>Tomato ketchup</th>
<th>Antioxidants and related compounds</th>
<th>Organic ketchup contained higher total phenol, individual phenolic compounds, individual flavonoids, DPPHRSA and ABTSRSA as compared to conventional ketchup. Organic tomatoes and tomato-derived products with a significantly higher content of antioxidant micro constituents.</th>
<th>Vallverdu-Queralt et al., 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>63.</td>
<td></td>
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</table>
2.3. An overview on pesticide residues in organically and conventionally grown foods:

India is an agrarian country. Modern agricultural practices require application of pesticides to combat pests and diseases and to increase productivity but their use must be restricted and farmers must be aware of possible undesirable effects on human health and the natural environment. Incorrect use of pesticides not only reduces agricultural sustainability by causing environmental problems, but it can also cause harmful effects on the health of both farmers and consumers (Isin and Yildirim, 2007). The prime reason among consumers for moving towards organic foods is to avoid the use of agrochemicals such as synthetic pesticides and chemical fertilizers. Selecting organic products help to reduce the risk of exposure to pesticides in food and chemical contamination in the environment (CCOF, 2012).

2.3.1. An overview on pesticide:

During the mid-sixties, the use of pesticides, herbicides and fungicides was introduced in India which are now being used on a large scale. It is now considered as a common feature of Indian agriculture. The main intention behind introducing pesticides was to prevent and control insects, pests and diseases in the field crops. As intended, the application of pesticide reduced pest attack and paved way for increasing the crop yield. However, increased use of chemical pesticides found to be a reason for contamination of environment and has also caused many long-term effects on the society (Bhanti and Taneja, 2007).

Pesticide means any substance intended for preventing, attracting, repelling or controlling any pest including unwanted species of plants or animals during production, storage, transport, distribution and processing of food, agricultural commodities, or animal feeds. These may be administered to the animals for the control of ectoparasites. It includes substances intended for use as a plant growth regulator, defoliant, desiccant, fruit thinning agent or sprouting inhibitor and substances applied to the crops either before or after harvest to protect the commodity from deterioration during storage and transport (FAO/WHO, 2013).

Pesticide residues mean any specified substances in food, agricultural commodities, or animal feed resulting from the use of a pesticide. The term includes any derivatives of
a pesticide, such as conversion products, metabolites, reaction products, and impurities considered to be of toxicological significance. It also includes residues from unknown or unavoidable sources such as environmental as well as known uses of the chemicals (FAO/WHO, 2013).

Figure – 2.3 shows the classification of pesticides. Pesticides are basically classified into three major groups namely, microbicide, zoocide and herbicide. Insecticide is a part of zoocide. The four major classes of synthetic insecticides are organochlorines, organophosphates synthetic pyrethroids and carbamates. The characteristics of each of this class are discussed in table no.-2..4.

For toxicity of any compound two aspects are important. One is LD$_{50}$ and another is half life time. LD$_{50}$ is a standard measurement of acute toxicity that is stated in milligrams (mg) of pesticide per kilogram (kg) of body weight. It represents the individual dose required to kill 50 percent of a population of test animals (e.g., rats, fish, mice, cockroaches). Because LD$_{50}$ values are standard measurements, it is possible to compare relative toxicities among pesticides. The lower the LD$_{50}$ dose reveals higher toxicity for the pesticide. Often the inhalation LD$_{50}$ is lower (more toxic) than the oral LD$_{50}$, which is in turn lower (more toxic) than the dermal LD$_{50}$ (EPA, 2014).

Pesticides are degraded in many ways after their use. Insecticides vanish in a variety of ways. Pesticides applied to crops, agricultural lands, and water bodies can move into the soil, surface water, and groundwater. They may be washed off, evaporate or decompose. Decomposition can be caused by light (photo-decomposition), chemical reactions, or other factors. After decomposition, the pesticides are broken down to smaller compounds which are known as breakdown products. These end products may be either more or less toxic as compared to original insecticide. Methamidophos, a breakdown product of acephate is 50 times more toxic to mammals (by oral exposure) than is acephate. Some elemental insecticides (sulfur, lead, arsenate) are persistent in nature as they cannot be further broken down. However, they can be combined with other chemicals; such molecules may have different toxicity characteristics from the elements themselves (Mahr, 2013).
Figure 2.4.: Classification of Pesticides

(Source: Patel, 2010)
### Table-2.4: Characteristics of different insecticide groups

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Organochlorins (Chlorinated insecticides)</th>
<th>Organophosphates</th>
<th>Carbamates</th>
<th>Synthetic Pyrethroids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition</td>
<td>• Presence of C, H, Cl, sometimes O &amp; S atoms including a number of C-Cl bonds</td>
<td>Organophosphates are the neutral ester or amide derivatives of phosphorus acids carrying a phosphoryl (P-O) or thiophosphoryl (P-S) group.</td>
<td>Carbamic acids are unstable &amp; produce CO₂ + NH₃</td>
<td>• synthetic compounds based on pyrethrins as models to improve photo stability and insecticidal activity</td>
</tr>
<tr>
<td></td>
<td>• Presence of cyclic carbon chains including benzene rings Lack of any particular active intramolecular sites like ester bond, keto / hydroxy group or ether group non polar and lipophilic in nature</td>
<td></td>
<td>Esters of carbamic acid are carbamates.</td>
<td>• Lipophilic in nature, almost insoluble in water</td>
</tr>
<tr>
<td>Stability to environment</td>
<td>Stable to environment</td>
<td>Biodegradable and get degraded to non-toxic metabolites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persistency</td>
<td>• Highly persistent</td>
<td>• Usually not persistent in the environment.</td>
<td>• Not persistent</td>
<td>• Not persistent</td>
</tr>
<tr>
<td></td>
<td>• Half life time is in years</td>
<td>• Short half life time, varies from 1 day to 4-5 months</td>
<td>• Half-life in Soil is 7-28 days; plant surface residues last less than 14 days</td>
<td>• Half life time is in hours</td>
</tr>
<tr>
<td></td>
<td>• The half-life of DDT is 2-15 years; for chlordane 4 years.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree of Health hazards</td>
<td>Mostly affect lipid metabolism in the adipose tissues and change glucose pathway in other cells.</td>
<td>• Highly hazardous,</td>
<td>Affect the nervous system</td>
<td>Some synthetic pyrethroids are toxic to the nervous system. (EPA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Affects nervous system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• LD50 is very low</td>
<td></td>
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</tbody>
</table>

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Figure-2.5 depicts that the pattern of pesticide usage in India is different from that for the world in general. In India 76% of the pesticide used is insecticide, as against 44% globally (Mathur, 1999). The use of herbicides and fungicides is correspondingly less in India (Aktar et al., 2009).

Bhushan (2006) reported that India is using 75% of insecticide as compared to 32% usage of insecticide worldwide. While the use of herbicide, fungicide was lower in India in comparison with the world. He further reported that Organophosphates and organochlorine (50% and 16% respectively) use in India as compared to (37% and 6% respectively) worldwide. Use of carbamates and synthetic pyrethorid was lesser in India compared to world. Biopesticides are used only at 1 % compared to 12% of the same of world. Currently 400 members of three groups of pesticides namely chlorinated hydrocarbon compounds (CHC), organophosphates (OP) and synthetic pyrethroids (SP), which work by different mechanism, are being used in India. The use of CHC, OP and SP constitutes 40%, 30% and 30%, respectively (Garg et al., 2004). At present 256 pesticides have been registered and this number increases every year. It is also noted that 28 pesticides are banned for manufacture, import and use, 18 pesticides are refused registration and 13 pesticides are restricted for use in India under insecticide Act 1968 (CIBRC, 2014).

2.3.2. Effect of pesticide on Environment and Health

During the last 50 years, many wild plant and animal species have been destroyed due to agricultural intensification. This has intensely damaged the agro-ecosystems performance. The adverse effects of agricultural intensification were observed on wild plant, carabid and bird species diversity and also affected natural biological cycle that it has affected predators that attack on numbers of aphids. The use of insecticides and fungicides had consistent negative effects on biodiversity. Organic farming and other ecological agricultural practices are helpful in overcoming the negative effects of intensive farming on biodiversity and also helpful to increase the diversity of wild plant and carabid species (Geiger et al., 2010).

Chronic exposure to pesticides has been suspected of being linked to a wide range of medical problems such as cancer, neurotoxic effects, and reproductive harm and
Figure -2.5: Pattern of pesticide use worldwide and in India

(Source: Aktar et al., 2009)
endocrine disruption (Menegaux et al., 2006; Weselak et al., 2007; Elbaz et al., 2009 cited in Nougadere et al., 2011). Pesticides are toxic in nature and do not differentiate between targeted and non-targeted species and hence should essentially be subject to safe and judicious use. Due to injudicious and indiscriminate use of pesticides, many hazardous incidents have occurred in different parts of world (FAO/WHO, 2005 cited in Lama, 2009).

Chronic exposure to low levels of pesticides can cause mutations and/ or carcinogenicity (Bull et al. 2006, IARC 1991, Karabay & Gunnehir 2005 cited in Asita and Makhalemele,2008). Acute pesticide poisoning is a significant cause of morbidity and mortality worldwide. Moreover, the collective toxicological effects a pesticides mixture with similar chemical structure may produce different toxic effects. The contribution of secondary chemicals changes the toxico-kinetics of the pesticide which can increase toxicity activation or decreased detoxification. For an instance, the cumulative toxicity of organophosphates and organochlorines may result in estrogenic effects and the promotion of organophosphate-induced delayed polyneuropathy (Hernandez et al., 2013).

Organophosphate pesticide has been associated with acute health problems such as dizziness, headache, abdominal pain nausea, vomiting and dermatological problems related to skin and eye (Arcury et al.,2003). Long term low levels exposure to pesticides affects immune suppression, leukemia, Parkinson’s disease, low birth weight, neurological problems, reproductive disorder, birth deformities including cleft lip/palate, limb reduction defects and neural tube defects, miscarriages and wide variety of cancers like lymphoma, leukemia, Wilm’s tumor, bone cancer, breast cancer, brain cancer, ovarian cancer, pancreatic cancer and stomach cancer (Charlier et al.,2003, Kamel et al., 2003, Kamel and Hoppkin, 2004).

Various researchers have observed that school children fed on diet consisting primarily of organic foods had lower levels of metabolized organophosphorus pesticide byproducts in their bodies than in children who had taken diets of industrially grown foods (Ecobichon,1996; Lu et al.,2006). Garg et al (2004) reported that the chronic exposure of chicks to small amount of SP, OP and CH pesticide leads to deleterious effects on metabolism and immune system of birds. Blood glucose, serum globulin and acetyl cholinesterase (AChE) activity level were decreased (P<0.01) in all treated groups as compared to control. The total ATPase activity was enhanced (p<0.01) in fenvlerate and
monocrotophos than birds in control group. Total leucocytes and T-lymphocyte count was lower (P<0.01) in all treated groups as compared to control group. Microscopic examination of these organs further revealed atrophy/hypoplasia, decrease in the size of follicles with depletion of lymphocytes and haemorrhages in thymus.

Chronic inhalation of certain toxic pesticides which are generally used for domestic and industrial purposes can result into hematotoxicity and bone marrow degenerative disease. The decreased proliferation and functional maturation of marrow stromal cells and hematopoietic progenitors with subsequent increase in marrow cellular apoptosis following pesticide toxicity provided the base necessary for explaining the increased incidence of hypoplastic bone marrow failure in to moderate to high concentrations of pesticides (Chatterjee et al., 2013).

Mainly, the adverse effects of the pesticide toxicity depend on human physiological system and metabolic detoxification capacity of an individual. This can be explained by xenobiotic metabolism. Xenobiotic is a compound that is foreign to body. It can be any chemical compound. Xenobiotic are often ranked for hazard in accordance with the route of exposure. A substance may be categorized as relatively non-toxic by one route like and highly toxic via another route.

Xenobiotic biotransformation is the process by which lipophilic foreign compounds are metabolized through enzymatic catalysis to hydrophilic metabolites that are eliminated directly or after conjugation with endogenous cofactors via renal or biliary excretion. This metabolism takes place in two phases (Murray, 2011) (Figure 1).

The major reaction in Phase I is hydroxylation reaction. Certain other reactions also occur in Phase-I. These reactions are mediated primarily by the cytochrome P450 family of enzymes, but other enzymes (e.g. flavinmonooxygenases, peroxidases, amine oxidases, dehydrogenases, xanthine oxidases). These enzymes catalyse a wide range of reactions involving deamination, dehalogenation, desulfuration, epoxidation, peroxxygenation and reduction. The reactive metabolite produced at the end of phase-I, get enter to phase-II. These products are converted by specific enzymes into various polar metabolites by conjugation with glucuronic acid, sulfuric acid, acetic
acid, or an amino acid combines with the newly established functional group to form a highly polar conjugate to make them more easily excreted.

However, the end products of Phase-I can also bind with macro molecules and result in to majorly three kinds of toxic effects. The first is cell injury (cytotoxicity), which can result in cell death. There are many mechanisms by which xenobiotics injure cells. The second effect in which, the reactive species of a xenobiotic may bind to a protein, altering its antigenicity. This acts like hapten which does not stimulate antibody synthesis but it will combine with antibody and the resultant antibodies can damage the cell by several immunologic mechanism. The last, chemical carcinogenesis which is a result of reactions of activated species of chemical carcinogens with DNA.

2.3.3. Pesticide residue level in various food commodities:

The presence of organochlorines, organophosphates, synthetic pyrethroids, carbamates, herbicide as well as fungicides residues in different foods were studied by various authors.

Lozowicka et al., (2012) have studied total 130 pesticides of different chemical classes in broccoli, Brussels sprouts, cauliflower, head and Chinese cabbage (N=350). Fifteen different pesticides (insecticides mainly) were detected in 118 samples (32%), while multiple pesticides (more than one pesticide residue) in about 4% samples. Chlorpyrifos (27.4%, .005 to 1.51 ppm) and cypermethrin (3.3% , at 0.02 to 0.19 ppm) were the most commonly detected pesticides. Thirty-three (9%) samples exceeded the maximum residue levels (MRLs). A similar study in Ghana reported that organochlorine residues were found in 71.9 % of all the market vegetable samples out of that 31.48 % samples were above the maximum residue levels (MRLs). The most frequently found and abundant pesticides were the metabolites of DDT (o,p'-DDE, p,p'-DDE and o,p'-DDD), followed by lindane and then o,p'-DDT ( Bempah et al., 2012).

Zawiyah et al. (2007) have also reported the presence of cypermethrin (synthetic pyrethroid) in 38 of 302 vegetable samples. The mean value of cypermethrin for tomato, chinese parsley, chinese celery, chilli, brinjal, french beans, green mustard and capsicum ranged from 0.16 to 1.48 mg/kg. However, none of the sample crossed
Figure 2.6: Xenobiotic Metabolism

(Source: Murray et al., 2011)
Moreover, none of the 206 fruit samples was found to be contaminated with any pesticide residue. Hussain et al. (2002) have also studied cypermethrin, methamidophos, monocrotophos, cyfluthrin, diazinon and methyl parathion in three varieties of Mango. The samples were detected with a varied level of pesticide residues however the values were within permissible limit. In a study from China has evaluated the organophosphorus (OP) pesticide residues in market foods (cereals, vegetables, and fruits). In 18 of 200 samples, five OP pesticides, including dichlorvos, dimethoate, parathion-methyl, pirimiphos-methyl and parathion, were found in concentrations ranging from 0.004 to 0.257 mg/kg. The mean levels of dimethoate in fruits and parathion in vegetables exceeded the maximum residue limits (Bai et al., 2006). A total of 75 green and leafy vegetables were studied for 23 fungicide and insecticide residues by Gonzalez-Rodriguez et al. (2008). The highest concentrations of fungicides were found in lettuce (procymidone, 12 mg/kg) and the highest concentrations of insecticides were found in Swiss chard (cypermethrin, 6 mg/kg).

2.3.4. Pesticide studies in India:

Pesticide residues in fruits, vegetables and cereals samples were also reported by various Indian authors. However, a very few comparative researches were conducted about pesticide residue analysis of organic and conventional foods.

Sinha et al. (2012) reported the presence of various organophosphate residues especially chlorpyrifos, triazophos, acephat, fenitrothiona nd phosalone in vegetables samples namely eggplant, cabbage, cauliflower, tomato and lady finger from Hyderabad. Most of the samples were found to be contaminated with chlorpyrphos and triazophos residues. A similar trend was observed for acephate, fenitrothion and phosalone. Dethe et al. (1995) have also reported pesticide residue in tomato (33.3%), brinjal (73.3%), okra (14.3%), cabbage (88.9%) and 100% cauliflower samples. Yet, the levels of concentrated pesticide residues were lower than the MRLs prescribed. Reddy (1998) studied the pesticide residue in vegetable samples from farms around Hyderabad and Guntur. The residues of HCH were above MRL (0.25 ppm). Residues of DDT and Cypermethrin were found to be below MRL (3.5 & 0.2 ppm respectively) and Mancozeb residues were above MRL (2 ppm) in bittergourd. Residues of HCH, DDT, aldrin (including dieldrin), endosulfan and methyl parathion in vegetables were found below MRL. The same author in their another study reported that market
samples of grapes were contaminated with the residues of acephate (2.6743 ppm), methamidophos (0.1383 ppm), chlorpyriphos (0.8341 ppm), monocrotophos (1.3648 ppm) and quinalphos (0.4132 ppm) (Reddy et al., 2000).

Bakore et al., (2002) have studied organochlorine insecticide residue levels in locally marketed vegetables of Jaipur. Maximum pesticide residues were detected from cabbage (21.24 ppm), cauliflower (1.685 ppm) and tomato (17.046 ppm) collected at the end of season and okra (17.84 ppm) and potato (20.60) collected at the middle of season. OCP residue levels in majority of samples were above the maximum acceptable daily intake. Mukherjee (2003) has also reported the all the vegetables samples in their study were contaminated with pesticides, only 31% of the samples contained pesticides above the prescribed tolerance limit. Bhanti and Taneja (2007) have evaluated the residual concentration of selected organophosphorous pesticides (methyl parathion, chlorpyriphos and malathion) in vegetables grown in different seasons (summer, rainy and winter). The concentration of the various pesticides was well below the established tolerances limit.

2.3.5. Comparison of pesticide residue in organic and conventional foods:

Many studies revealed lower pesticide residues in organic crops as compared to conventional ones. Collins and Nassif (1993) found 12% of organic samples and 30% of conventional samples containing pesticide residues. Baker et al. (2002) evaluated pesticide residues in fruits and vegetables from organic, conventional and IPM growth system. They found that 23% of organic samples contained pesticide residues, while 73% of conventional samples contained pesticide residues. Organically grown foods contain fewer pesticide residues than conventional or IPM-grown foods. They also noticed if pesticide residue is present it is lower in organic foods.

The occurrence and distribution of highly hydrophobic organochlorine pesticide (OCP) in vegetables cultivated under organic and conventional conditions were evaluated by Gonzalez et al. (2005). OCP residues were analysed from the aerial and subterranean tissues of two varieties of lettuce and chard along with the soil where they were grown. The distribution pattern of pesticide residue was DDT followed by chlordane, helptachlor and aldrins for all the samples. Conventional soils had higher OCP residues than organic one. Vegetables accumulated OCP efficiently with residue
levels 4 to 45 fold greater than those of soils. Lettuce showed a high variability in pesticide uptake regarding varieties and tillage practices. Moreover, the authors reported that environmental conditions like presence or absence of trees, hedgerows or nearby to conventional farms influence on OCP occurrence and levels in organically grown vegetables. Knezevic and Serdar (2009) have reported that out of 240 fruit and vegetable samples, 62 (25.8%) samples contained pesticide residues at or below MRL and 18 samples (7.5%) contained pesticide residues above MRL. Total samples contained two fungicides and one insecticide which were found in oranges. MRL values were exceeded most often in oranges. Fresh fruits and vegetables and other processed food products namely fruit juices, grains, and meats which were purchased at supermarkets and grocery stores across the US from were detected with chlorpyrifos and permethrin residues (Katz and Winter, 2009; FDA, 2013). One study has evaluated the pesticide residue levels in conventionally-grown and organic produce available in New Zealand. 42% of conventionally grown and 9% of organically fruits and vegetables were contaminated with pesticide residues. No pesticide residues were detected in organic potato, broccoli, banana or wine samples.

Rekha et al. (2006) have evaluated pesticide residues in organic and conventional wheat and rice sample from all over the India. They reported that wheat was contaminated with endosulfan, phroate and permethrin while rice was also contaminated with these three residues along with carbofuran. Organic samples contained traces of pesticide residues. Moore et al. (2000) carried out organochlorine and botanical pesticide residue analysis of organic and conventional baby food. None of the sample showed detectable pesticide residues.

### 2.3.6. An overview on fertilizers used in organic and conventional farming practices:

The other difference between organic and conventional farming is the use of chemical fertilizers. Fertilizers are chemical compounds applied to promote plant growth. Typically, fertilizers are applied either to the soil or by foliar feeding. Fertilizers can be placed into the categories of organic and inorganic fertilizers (composed of simple chemicals and minerals). Organic fertilizers are 'naturally' occurring compounds manufactured through natural processes. Inorganic fertilizers are manufactured through chemical processes which generally contain N, P, K and micronutrients.
Chemical fertilizers which are used in conventional farming may have long-term adverse impact on the organisms living in soil and a detrimental long-term effect on soil productivity of the soil.

In organic farming, organic fertilizers are used which contain essential nutrients to improve the health and productivity of soil and encourage plant growth. Organic nutrients increase the abundance of soil organisms by providing organic matter and micronutrients for organisms such as fungal mycorrhiza, which assists plants in absorbing nutrients. Moreover, biofertilizers and manures are also used in organic agriculture. Cow dung compost is traditional compost in which cow dung is kept on soil along with vegetable and plant waste. After 6 to 8 months it becomes excellent manure which increases nutrient content of soil. The second is vermicompost which is prepared with earthworms and considered as the best compost which makes the soil soft and more porous hence increases water retention capacity of soil. The third biofertilizers is green manure is a kind of cover crop which is prepared basically to add nutrients and organic matter to the soil. It increases the water holding capacity of soil, soil fertility, it supplies nutrient requirement of crops as well as add fresh matter to the soil and avail more oxygen to the plant. Mostly leguminous plants are more preferred and used for green manuring due to their nitrogen fixing capacity. (Upadhyay, 2012). The other substances like limestone, rock phosphate and sodium nitrate are also approved for the use in organic farming to increase soil mineral content.

The use of soluble chemical fertilizers has resulted in higher yield of crops but on other hand, it also stimulates the high nitrate concentrations in many conventionally farmed foods, especially in fruits and vegetables. Leafy vegetables can have the highest concentrations. Nitrates are a matter of concern for public health due to their easy transformation into nitrites. Nitrate and nitrite are found naturally in the environment, and form part of the nitrogen cycle. Nitrate is formed from oxidation of organic wastes by the action of nitrogen-fixing bacteria. The presence of these compounds in food and drinking water get converted into nitrosamines that are carcinogens. When this nitrite is absorbed into the bloodstream, it oxidizes iron in the hemoglobin of red blood cells to form methemoglobin, which lacks hemoglobin's oxygen-carrying ability. In severe cases this can be one of the causes of Blue Baby
syndrome, however in most cases the symptoms would be tiredness, lethargy and a general feeling of being unwell.

Many studies revealed that nitrate content of organically grown crops is usually significantly lower than in conventionally grown products (FAO, 2000). Lairon (2010) reviewed various comparative studies on nitrate content of organically and conventionally grown foods. He observed that significantly lower nitrate contents (about -28% to -85%) in organic potato, leek, turnip, carrots, lettuce, potato, carrot, turnip, leek, beetroot and spinach sand salad but no significant difference was observed in kale, spinach, tomato. Organic vegetables can overall contain at least 30–50% less nitrates than conventional ones. The level of nitrate in vegetables can be affected by nitrogen availability for roots, temperature, light exposure and cultivars and species.

Worthington (2001) summarized the results of 18 studies comparing nitrate levels of organic and conventional foods. He found 127 cases where nitrate levels were higher in conventional foods, 43 cases where nitrate levels were higher in organic foods, and 6 cases where no difference was observed. A review by Woese et al.,(1997) also concluded that conventionally cultivated or mineral fertilized vegetables normally have quite higher nitrate content than organically produced or fertilized vegetables. Similarly, Guadagnin et al. (2005) have also reported significant (p<0.05) higher nitrate level in conventional leafy vegetables namely watercress, lettuce and arugula as compared to the leaves grown in organic and hydroponic agricultural practices. Matallana Gonzalez et al. (2010) reported that the vegetable samples taken directly from the organic farm except eggplant showed higher or slightly higher average nitrate values than samples purchased in the organic food stores. A few studies have reported no significant difference or higher nitrate levels in organically grown foods. Malmauret et al. (2002) have reported no significant difference in organically and conventionally grown carrots and lettuce. Contradictory, DeMartin and Restani (2003) have reported significant higher nitrate content in organically grown green salad and rocket leaves than their conventional counterparts.
2.4. An overview on sensory attributes of organic foods:

Organoleptic quality plays an important role in acceptance of any food product. Organoleptic quality includes the typical sensory properties of a food: its taste, appearance and colour, aroma, size and firmness, and even sound (e.g., the “snap” or “crack” when biting into a crisp apple). But organoleptic measures also include mouth feel and any other sensations related to eating a food. The organoleptic quality of produce is key property at the point of sale and consumption.

Kazimierczak and Swietlikowska (2006) confirmed a few attributes for food acceptance and its consumption. The most important criteria are taste, appearance and freshness of the product while choosing it.

Various studies on sensory attributes of organically and conventionally grown foods vary in their conclusion. Conventionally grown carrots were sweeter, crunchier while ecologically grown carrots were harder and had a more pronounced aftertaste (Haglund et al., 1999). In other study by Gilsenan et al (2010), no significant difference between the organic and conventional baked potato samples for the sensory attributes of appearance, colour, aroma, texture and taste acceptability. However, authors have noticed that the conventional potatoes had a lower dry matter content (p< 0.05) and a slightly softer texture (p< 0.05) than the organic potatoes in raw and baked form. Moreover, conventional baked potato to be slightly softer, less adhesive and wetter than the organic baked potato (p <0.05).

Wszelaki et al (2005) have used triangle tests to check whether panelist could differentiate cooked wedges of potatoes grown organically (with and without compost) and conventionally. They reported that panellists were able to differentiate conventional potatoes and organic potatoes, irrespective of soil treatment when potatoes are presented with peels. However, they did not distinguish between organic treatments ( with or without compost).

Taiwo et al. (2002) evaluated the quality of okra grown in the green house with organic fertilizer (composted sawdust and decayed chicken manure) or chemical fertilizer. Soups produced from the harvested okro fruits were subjected to sensory evaluation tests. Soups made with organically fertilized okro were judged more acceptable.
Crecente-Campo et al. (2012) concluded that the cultivation system affected significantly on all of the CIE surface colour parameters of strawberries. The colour of the organic fruits was darker, less bright and frequently redder (lower L*, C* and H values). These differences were consistent with the higher scores given by panellists in the external colour evaluation for organically grown strawberry. This is further justified by significant higher levels anthocyanins in organic strawberries as compared to conventional produce. Moreover, Andrews and Reganold (2006) have also reported the positive sensory attributes for organic strawberry. Organic strawberries grown in California were slightly smaller but sweeter, better-looking, and preferred by consumers than conventionally grown strawberries. Moreover, in another study by Reganold et al (2010), they reported that strawberries from organic farms were significantly smaller than those from conventional farms, but had significantly greater dry matter content. Fruit firmness and external colour intensity were similar between conventional and organic berries, but organic berries were darker red than conventional berries. Moreover, consumer-sensory panels found organic strawberries to be sweeter and have preferable flavour, appearance, and overall acceptance as compared to conventional berries.

Organic apples showed a significant increase in firmness, acidity, soluble solid content. Moreover, organic apples were brighter and more yellow based on the readings from a Hunters Lab Colourmeter. Organic management may delay on-tree fruit ripening and also improve fruit eating quality (Reig et al., 2006). Moreover, Organic management yielded sweeter and less tart Golden Delicious apples as compared with conventional and integrated systems (Reganold et al., 2001). Peck (2004) studied Gala apples grown during the different growing seasons under organic, integrated, or conventional management. Organic apples had 610 Newton units higher flesh firmness than conventional apples and 4-7 N units higher firmness than integrated apples. Furthermore, consumers consistently rated organic apples to be firmer and to have better textural properties. The higher score for fruit flavour was justified by higher values for soluble solids concentration or titratable acidity. These Gala apples were slightly smaller in some years but were as firmer and had consistently superior storability as compared to conventionally grown apples. In another study by Succop and Newman (2004), effect of agricultural practices showed an effect on sensory attributes of basil leaves. Two-thirds of trained tasters could
differentiate between the organically fertilized basil and the conventionally fertilized basil, but they had no taste preference.

Tobin et al (2013) studied sensory attributes of organic and conventional fruits and vegetables available to Irish consumers. A panel of nine trained panel members evaluated carrots, cherry tomatoes, onions and broccoli for various sensory attributes like specific aroma, texture, moistness, sweetness, bitterness, after taste and so on. Organic broccoli samples scored slightly higher for cabbage-like aroma, overall firmness, tenderness, savoury taste and cabbage taste while Organic samples scored just slightly higher in juiciness and savoury taste. Conventional samples scored higher for all other attributes of which colour was calculated to be significantly higher at the P < 0.05 significance level. Although the score is higher in cherry tomatoes, none of sensory attribute of all other vegetable showed any significant difference according to type of agricultural method.

Olivera and Salvadori (2006) concluded that the organic product not only has a good acceptability along with the benefit of high dietary fibre content. The textural characterization of lasagna made from organic whole wheat revealed significant differences in view of all the texture parameters, except for the cohesiveness. These differences indicated a possible interaction between the fibre and the gluten network. Organic dough had higher value of hardness and consistence, which were considered as unwanted characteristics. On the other hand, the pasta is slightly firmer and less adhesive, which are good attributes for the cooked pasta.

Gilsenan et al. (2008) found no significant difference for the sensory attributes of appearance, aroma, texture and taste between organic and conventional carrots. Sensory evaluations conducted for organic and conventional mushrooms also found no significant differences for cap colour, firmness, and appearance, aroma and texture acceptability values. However, the sensory data indicated that the organic mushroom samples had darker gills (P<0.05) and a stronger mushroom aroma (P<0.05). Similarly, Roth et al. (2007) observed no significant difference in sensory attributes of apples coming from different regions and different production systems.

McCollum et al., (2005) reported conventional tomatoes had significantly higher soluble solids and were firmer than organic fruit. Panelists perceived a difference
between conventional and organic tomatoes by smell or taste with high reliability (P<0.001). Organic tomatoes were perceived as softer and were preferred because of their taste, flavour, texture and juiciness. Alternatively, conventional tomatoes were described as "not as ripe", "dry", and having "less aroma". Ishida and Chapman, (2004) reported darker red colour due to significantly higher contents of lycopene as compared to conventional catsup while comparing the deepness of the catsups' red colour.

2.5. Consumers' knowledge, attitude and purchasing behaviour pattern about organic foods:

The market of organic food is considered as one of the major growing markets in the food industry which attracts attention of researchers as an interesting subject of research. This growth is mainly affected by the consumers' knowledge, attitudes, intentions towards organic produce and purchasing behaviour for the same. The increasing consumer demand for higher quality food products, where quality consists of different dimensions (taste and appearance, health, convenience and process) (Brunso et al.,2002), makes organic food products an interesting consumption option because they satisfy three different desires at the same time.

Food choice evolves from cultural practice, tradition, ideology, values, preferences, resources, and the fundamental place of food behaviour in daily life and family structure, and in accordance with education, age, and income. Understanding these complex food attitudes and preferences can be helpful for developing both relevant public food policy and appropriate private sector marketing strategies (Bellows et al.,2010).

The consumer behaviour is complex pattern of psychological and social intentions towards any aspect. Consumer behaviour consists of ideas, feelings, experience and actions for any aspect. Some internal factors like knowledge, attitude, self-motivation, value and some external factors like socio economic status, culture, group or social influence and advertisements may affect the purchasing behaviour of consumers for any product (Mutlu, 2007).
2.5.1. Socio–Economic factors and organic food consumption:

The reviewed literature reveals that differences in socio-demographic background may also differ in relation to attitude, intentions or behaviour (Lea and Worsley, 2005; Gracia and de Magistris, 2008, Bartels and Reinders, 2010). Mutlu (2007) has mentioned that some internal factors like knowledge, attitude, self-motivation, value and some external factors like socio economic status, culture, group or social influence and advertisements may affect the purchasing behaviour of consumers for any produce (Finch ,2006).

A study by Stobbelaar et al. (2007) and Gotschi et al. (2009) have reported that adolescent girls have strong positive attitude towards organic foods as compared to adolescent boys. Lockie et al. (2004) and Magnusson et al. (2001) have observed that more numbers of women had positive attitudes towards organic food than men and a higher percentage of women are purchasers or consumers of organic food (Storstad and Bjorkhaug, 2003; Radman, 2005, Bellows et al., 2010). As per Davies et al (1995) female aged 30-45, with children and having a higher level of disposable income is a profile of organic food consumer. Further, Bellow et al., (2010) have stated that women with positive association was found between natural oriented foods with women who were less likely to be partnered and live with children than men. Nearly half (49%) of young adults placed moderate or high importance on alternative production practices. Higher importance on alternative production practices was reported by women, those aged 25 years and older, vegetarians, and those living outside their parent/family home (Pelletier et al., 2013).

Regarding age, some authors have reported a significant and positive association between age and preferences towards organic foods. Bellow et al (2010), Lockie et al (2004), that majority of the consumers are from middle age group. In a study by Geen and Firth, (2005), 80 per cent of respondents were over 40 years and 1/3 of the respondents were above 60 years among committed organic food consumers. On the other hand, Magnusson et al. (2001) reported that young respondents belonging to 18 to 25 years age group had more positive attitude towards organic foods as compared to older respondents. Although, stronger interest in organic foods, young consumers do not buy organic foods more frequently than elderly. Stobbelaar et al (2007) has also concluded that adolescents (15-16 years) had positive attitudes towards organic.
foods. The respondents who have bought organic vegetables tend to be older, have a higher education level and a higher family income than those who have not bought them (Roitner Schobesberger et al., 2008) Pugliese et al. (2013) have concluded that younger and wealthier organic food consumer have more accepted organic and traditional foods.

**Economic factors**, such as household income and prices, have some effects on organic food demand. A finding by Gracia and de Magistris, (2008) has also revealed that consumers with lower income were less likely to purchase organic food products. In a study by Raab and Grobe (2005), 26.6% of the subjects were from higher income group. In one study, non-buyer group of organic foods have claimed that organic foods are mainly purchased by wealthy, highly educated and health conscious people (Finch, 2006).

**Education level** has a significant influence on preference and purchasing behaviour of organic foods (Gracia and de Magistris, 2008; Lockie et al., 2004; Tsakiridou et al., 2006). Further, stobbelaar et al (2007) Bellows et al., 2010 discussed that educational level of students and knowledge regarding organic food were positively correlated. Pelletier et al. (2013) has also reported that students with college degree or higher education have more positive attitude than students with less than college degree. Contradictory, there is minimal or negligible effect of education was observed on the belief of organic foods as well as on organic food purchasing behaviour (Lea and Worsley, 2005). Moreover, higher level of education and age more than 36 years are typical profile characteristics of organic food consumers in the study by du Toit et al. (2003).

**The size of family**, condition of family member and number of children in family affect the preference towards organic foods. Some authors have reported that families with children were more likely to buy organic produce (Tsakiridou et al., 2006 and Freyer and Haberkorn, 2008). Finch (2006) concluded in his study that both buyer and non-buyer groups were more likely to purchase organic foods if a family member became pregnant. Conversely, each group indicated that they would reduce their consumption of organic foods if the family faced a significant decline in household income. Similar conclusion was drawn by Torjusen et al. (2012). They stated that pregnant female frequently consumes organically grown foods due to the consideration of healthy and sustainable diets during pregnancy. Freyer and
Haberkorn (2008) have also reported that the desire to purchase organic products was influenced by children. Following a child-birth experience, mothers changed their food consumption patterns, using more organic products in their daily menu. In addition, those who had children younger than 10 years old, elderly, or people with family members having special disease were significantly willing to pay a higher premium price for these products (Haghjou et al., 2013).

Reflexive shopping practices can be sparked by life events (e.g. having children), "shocking" news about conventional food products and similar events, and news capable of creating a "cognitive dissonance" among consumers. The Danish case illustrates that the government needs to actively implement reforms and promote activities which make organic products a convenient choice for the pragmatic oriented consumer if their market share is to increase substantially (Hjelmar, 2011).

2.5.2. Perception of organic food:

Consumers generally perceived organic foods as natural foods. All organic foods are natural but all natural foods are not organic. The other perceptions regarding organic foods are chemical-free, home grown, healthier, more nutritious, eco-friendly, pure, fresh, animal-friendly and so on. (Raab and Grobe, 2005; Harper and Makatouni, 2002). However, Consumer perceptions about organic food are highly subjective. It is also worth noting that such perceptions may or may not be their actual behaviour in purchasing (Shafie and Rennie, 2012).

Organic food is perceived by its composition (no harmful, modified ingredients are used), method of production (food is grown only in natural conditions with minimal impact to the environment), represented values (safe and healthy) and even social class (upper and medium) (Michaelidou and Hassan, 2008; Davis et al., 1995). Consumer have also considered organic farming is good for environment as no pesticide or herbicides are used and it is natural or traditional farming. They also believed that organic products are healthy as they don't carry pesticides residues and chemical fertilizers. (Roitner-Schobesberger et al., 2008). The majority of respondents believed that organically produced food contained no artificial additives, had fewer pesticide residues, contained more nutrients, were healthier and had more flavour than conventional foods (Du Toit et al., 2003).
Consumers' preference for organic foods and purchasing behaviour pattern is mainly affected by the following concerns such as food safety concerns, health consciousness, quality, trust and ethical value, and cost of organic foods.

2.5.3. Consumer concerns regarding various aspects of organic foods:

Food safety and health:

Health consciousness is defined as concerns and awareness about individual's health and well-being. The health conscious people are constantly trying to improve the quality of life by adapting healthy behaviour. Some authors have reported that health is the primary reason for purchase of organic food (Zanoli and Naspetti, 2002, Wier et al., 2008; Canavari et al., 2002).

Concern for human health and safety is a key factor that influences consumer preference for organic food. It is consistent with observed deterioration in human health over time and, therefore, motivates consumers to buy organic food as insurance and/or investment in health (Yiridoe et al., 2005).

The respondents in one study, believed health concern as a prime most reason for buying organic food. The respondents stated that “organic foods helps to prevent breast cancers” and they try to avoid conventional apples as they contain lot of pesticides” (Hjelmar, 2011). In one study, the consumers who hold values for health and food safety are active buyers of organic foods (Nie and Zepeda, 2011). Frequent consumption of organic food was significantly (p < 0.001) associated with increased scores on the 'health and sustainability component'(Torjusen et al., 2012).

Along with health aspect, food safety is also an important criterion for selecting a food. In recent years food safety has been attaining a growing importance (Saba and Messina, 2003; Baker et al., 2004; Zanoli and Naspetti, 2006, Fontes et al., 2013). Among the consumers, the most important preference for organic is “chemical free”. This perception is mainly due to the principles associated with organic food production. Organic farming is a production system that avoids or largely excludes the use of agrochemicals. Hence, consumers would like to avoid the chemical residues in the form of pesticide residues, chemical fertilizers, artificial additives as well as GMOs. Hence, it can be an important influencing factor and main motive for attitude
and purchasing behavior of organic food (Michaelidou et al., 2008; Larue et al., 2004; Roitner-Schobesberger et al., 2008).

Saheb et al. (2006) have reported that the respondents in their study claimed that they find organic food as a much safer alternative and it is required for well-being of his/her self as well as the well-being of their family members. This is also agreed by Padel et al. (2005). Howlett et al. (2002) has also reported that health benefits associated with organic yoghurt were important, as respondents believed that organic yoghurt was free of many hazardous ingredients. Saba and Messina (2003) have stated that organic consumers were more aware of adverse effects of pesticide on health as well as on environment. Organic food consumers also believed that risks associated with pesticide are still underrated. On the contrary, they disagreed that food stuffs would be more expensive without the use of pesticides.

In a study by Saba and Messina (2003), the subjects tended to hold positive attitudes towards eating fruits and vegetables produced by organic agriculture. A significant relationship was found among perceived benefits and risks associated with pesticides. The results of the cluster analysis indicated the presence of a group of subjects who had less positive attitudes towards organic fruits and vegetables, perceived less risks and more benefits associated with pesticides.

In one study, adolescents who held supportive attitudes about locally grown, organic, nongenetically engineered, and nonprocessed food appeared to have a more healthful diet quality and care more about their personal health and eating healthfully (Robinson-O'Brien et al., 2009). Furthermore, organic food consumer believed health motive as an important driver of their choice. Hence, nutrition and health claims can be beneficial in the marketing of organic products especially for occasional consumers and non-consumers (Aschemann-Witzel et al., 2013).

Quality:

Quality of any food comprises nutritional quality and sensory attributes including its shelf life and storage stability. Quality, however, is not a well-defined attribute but comprises many other properties such as sensory attributes (appearance, texture, taste and aroma), nutritive values, safety determinants, chemical constituents, mechanical properties, functional properties and defects (Abbott, 1999; Mizrach, 2008). Taste will
continue to become a prime consideration in consumer food choice especially after
the experience of consuming the food (Fillion and Arazi, 2002; Dahm et al. 2009;
Roitner-Schobesberger et al., 2008). Quality of organic food plays an important role in
frequent consumption (Padel et al., 2005; Magnusson et al., 2001).

Saba and Messina (2003) have concluded that organic food buyers had higher
positive score for taste and nutrition of organic foods. The organic food consumer
believed that organic fruits and vegetables are tastier and contain more nutrients as
compared to conventional fruits and vegetables. Freshness, taste, health benefits are
primary motives for purchase decision for organic foods (Wier et al., 2008).

Taste, nutrition, health, freshness, ethnic concerns and enjoyment of cooking can be
implications for marketing and public policy strategies to promote organic and local
foods (Torjusen et al., 2001; Nie and Zepeda, 2011; Shafie and Rennie, 2012).
Further, concern with the naturalness of food, sensory attributes and emotional
experience of eating were the major determinants of increasing levels of organic
consumption (Lockie et al., 2004). The majority of consumers considered that organic
food tastes better than conventional and that consumption of organic bread should
increase (Kihlberg and Risvik, 2007).

Trust and Ethical Value:

Consumers are often confused for identification of organic food products. Hence, trust
becomes an important criterion for selecting organic produce (Saba and Messina,
2003).

The main barrier to increasing the market share of organic vegetables is that
consumers do not clearly differentiate between the various 'pesticide safe' labels and
the organic labels (Roitner-Schobesberger et al., 2008; Jensen et al., 2011)

Product labeling with organic certification logos plays a significant role for building
trust of the consumers towards organic foods. Authors concluded that it is advisable
to label organic products with well-known organic certification logos that consumers
trust. Moreover, it is important to label organic products with well-known organic
certification logos than generic organic certification logos (Janssen and Hamm,
2012). Informing consumers about unique characteristics of organic production
methods, the strict inspection and required third party certification might be a promising strategy to develop the market for organic vegetables in Roitner-Schobesberger et al., 2008). In one study, majority of consumers (42.21%) have recognized eco foods from food labels, 33.17% consumer trust organic produce while 23.62% consumers identified organic foods by its appearance and smell (Stoleru et al., 2012).

The ethical attributes, ‘animal welfare’, ‘regional production’ and ‘fair prices to farmers’ turned out to be the most important (Zander and Hamm, 2010). Higher consumption or organic food is also related to ‘green consumption’ behaviours (Lockie et al., 2004).Moral values affect the purchase intentions of organic food (Arvola et al, 2008). The main reasons for purchasing organic products are that consumers expect them to be healthier, that organic products are environmentally friendly (Roitner-Schobesberger et al., 2008). Moreover, Hjelmar (2011) has stated from his analysis that politically/ethically minded consumers have reflexive practices when purchasing organic food products. Health considerations, ethical considerations (animal welfare), political considerations (environmentalism) and quality considerations (taste) play an important part for these consumers.

The majority of respondents indicated that they recognized the external benefits of organic agriculture and believed that organic farming protected the environment, treated animals humanely and was suitable for small-scale farming. (Du Toit and Crafford, 2003). While in another study, respondents displayed high levels of environmental consciousness, but few linked the product attribute 'organic' to improving the environment. Animal welfare was rarely mentioned as a motivating factor in the purchase of organic yoghurt (Howlett et al., 2002) The findings indicate that humane motives are the major factors affecting consumer attitude and purchasing behaviour, making socio-demographic variables appear less important (Padilla Bravo et al., 2013).

**Cost and willingness to pay extra premium:**

Some studies have revealed that consumers are willing to pay premium prices for organic foods. Consumers are ready to pay premium even for the products containing less than 100% organic ingredients (Batte et al., 2007). The vast majority of
consumers of organic food was willing to pay higher prices for organic products with additional ethical attributes (Zander and Hamm, 2010). For the produce from the farm under conversion, consumers were willing to pay half of the premium than organic produce. Further, consumers are ready to pay higher premium for vegetables as compared to meat (Tranter et al., 2009).

Stolz et al. (2011) have considered price sensitivity as an important issue. They have identified two groups of occasional organic consumers. One group of consumers strongly preferred organic products and were less price sensitive. The other group of consumers who were significantly more price sensitive and preferred conventional-plus (the products between organic and conventional which are free from artificial additives) and conventional products rather than organic products.

However, socio economic profile and personal values also affect the willingness to pay extra premiums for organic foods. Haghjou et al. (2013) have reported that individual’s income, family size, environmental concerns and wholesome diet, significantly increased consumers’ willingness to pay a premium. According to the results, married respondents, females, family with children younger than 10 years, elderly, family member having special disease were significantly willing to pay a higher premium price for these products.

In a study by Aryal et al. (2009), all respondents are willing to pay price premium, but the level of acceptability varied considerably. Around 39% of the respondents have considered that extra cost for organic products is reasonable, while 27% considered it too high. The average premium was estimated about 30%.

The positive effects of organic labeling are also supported for consumers' purchase intentions and their willingness to pay a price premium (Bauer et al., 2013, Lee et al., 2013). the WTP differed considerably between the tested logos. The highest price premiums were recorded for logos that were well-known and trusted with perceived strict organic standards and a strict control system (Janssen and Hamm, 2012). As an instance, one study reported that consumers were willing to pay a positive price premium of some 33 eurocent per kilogram for labeled organic apples. Furthermore, after communicating the actual health and environmental effects of organic apples,
consumers were willing to pay 72% extra premium per kilogram of apples (Rousseau and Vranken, 2013)

On the other hand, Premium price continues to suppress organic food consumption (Gracia and de Magistris, 2003; Shafie and Rennie, 2012). About 50% declared that they would not buy an organic food product that was appreciably higher in price than a corresponding conventional food product (Kihlberg and Risvik, 2007). As well as many consumers also mentioned that absence of certifications and organic labels, lack of advertisement, lack of availability, lack of variety and higher prices as their most important problems in purchasing organic food products (Jensen et al., 2011; Haghjou et al., 2013). Moreover, consumers would buy more organic foods if price is similar to conventional foods (Crandall et al., 2010).