Centuries of use of chemical pesticides has caused irreparable damage to the earth. For the past few decades we are searching for ecofriendly alternatives to rectify past mistakes. Twenty years after synthetic insecticides were overzealously entrenched in ‘modern’ agricultural production; they induce widespread environmental contamination, toxicity to non-target organisms, development of resistance against insecticides, and negative effects on animal and human health (Pretty and Hine, 2009). Uses of Biopesticidial approaches and integrated pest management have begun to show positive results. But there is a need and study the mode of action that the used molecule follows.

Growth and development of insects are regulated by hormones: prothoracicotrophic hormones (PTTH) (brain hormone), ecdysteroids, and juvenile hormones (JH). PTTH controls the secretion of the molting hormone (ecdysone) from the prothoracic gland (Eto, 1990). Ecdysone and juvenile hormone (JH) control majority of the growth and developmental activities of the insects. Ecdysone is responsible for cellular programming and together with JH, initiating for the molting process. JH has been considered to be an exclusive insect hormone and thus has attracted much attention also in plant and grain protection oriented research (Hartfelder, 2000). It also regulates diverse traits in insects such as the synthesis of yolk protein, uptake of the molecule into the developing egg, diapause, flight, development, reproductive features and dispersal polymorphisms (Denlinger, 1985; Nijhout, 1999; Wyatt and Davey, 1996; Era and Cisper, 2001; Wheeler and Nijhout, 2003).
Scientist thought of synthesizing the insect hormone agonist so that to control insect pest and compounds that adversely interfere with the growth and development of insects have been synthesized, and have been collectively referred to as “insect growth regulators (IGRs)”. They don’t directly kill insects, but interfere with the normal mechanisms of development, resulting in insects dying before they reach adulthood. IGRs are classified into two general categories based on mode of action: chitin synthesis inhibitors and substances interfering with the action of insect hormones (Siddall, 1976). Insecticides with growth regulating properties (IGR) may adversely affect insects by regulating or inhibiting specific biochemical pathways or processes essential for insect growth and development (Tunaz and Uygun, 2004). They generally have selective effect on the target insects and have practically no apparent side effect on non-target organisms especially vertebrates. Hence, insect growth regulators could be a suitable choice to control pests in stored products (Ghasemi et al., 2010).

On the last few decades insecticides with improved chemistries have been developed, including tebufenozide, pyriproxyfen, lufenuron, teflubenzuron, and novaluron that are best known insect growth regulators. Lufenuron, teflubenzuron, and novaluron are benzoylphenylureas, also known as chitin synthesis inhibitors (CSIs), and they exert their action by inhibiting the production of chitin, a major component of the insect exoskeleton (Dhadialla et al., 2005; Retnakaran and Wright, 1987). Tebufenozide interacts with the insect molting hormone receptor, especially in Lepidoptera, which induces a premature and incomplete molting (Smagghe and Degheele 1994; Smagghe et al., 2013). The juvenile hormone mimic pyriproxyfen interferes with the hormonal balance and provokes a strong suppression of embryogenesis, metamorphosis and adult formation (Dhadialla et al., 2005). Chlorantraniliprole (IGR), acts by activating insects’ ryanodine receptors and is
categorized as a ryonadine receptor modulator and it was proved safe on birds and fishes (Lahm et al., 2007). IGRs are often considered safer for beneficial insects than neurotoxic broad-spectrum insecticides (Darvas and Polgar, 1998) however, their supposed safety and compatibility for beneficial insects in IPM programs have become an issue for further consideration for chrysopid predators (Bueno and Freitas, 2004; Medina et al., 2003; Rumpf et al., 1997).

The action of ecdysteroids and non-steroidal ecdysone agonists like tebufenozide, methoxyfenozide were found to be activating EcR based gene switches in insects (Kumar et al., 2002; Smagghe et al., 2002). The insect molting steroidal hormone, 20E, also manifests its actions via interaction with the EcR proteins. The presence of EcR complexes is very unique to all insects and many arthropods. No vertebrates or plants are known to have the EcR gene or protein, even though all vertebrates have multiple forms of steroid hormones and specific hormone receptors (e.g. estrogen and estrogen receptor, testosterone and testosterone receptor, retinoic acid and retinoic acid receptor, etc.). Based on this, it would be safe to assume that methoxyfenozide would not have any effects on aquatic or terrestrial plants (Smagghe et al., 2013).

Chitin synthesis inhibitors (CSIs) affect the ability of insects to produce new exoskeletons when molting. They act on the larval stages by inhibiting or blocking the synthesis of chitin which represent 30-60% of the insect exoskeleton structure. They also increase egg mortality. CSIs include conventional benzoyleureas, triazine / pyrimidine derivatives, and buprofezin. They are harmless or exert little adverse effect on bees, predators, or parasitoids (Tomlin, 2000) which renders them acceptable for inclusion in IPM programs.
Ecdysteroids, which are widespread in the animal and plant kingdoms (Lafont et al., 2002), are signaling molecules that fulfil diverse functions in the life of an insect by virtue of their roles as hormones, pheromones, or insect deterrents (Nijhout, 1994). Interestingly, they do not occur naturally in vertebrates, which are the feature that makes mimics of this important hormone suitable as ligand-dependent gene-switch ligands in different applications in agriculture and medicine due to the reduced likelihood of pleiotropic effects (Smagghe et al., 2013).

Bisacetylhydrazine (BAH), a class of IGRs, is ecdysone agonists or disruptors with molting hormone activity (Wing et al., 1988). BAHs include chromafenozide (Virtu ®), Tebufenozide (Mimic ®, Confirm®), Halofenozide (Mach-2 ®), and Methoxyfenozide (Intrepid ®). Methoxyfenozide and halofenozide are currently owned by Dow AgroSciences LLC and tebufenozide was purchased by Nippon Soda Co., Ltd. from Dow AgroSciences LLC, in 2010. Four of the BAH compounds (methoxyfenozide, tebufenozide, chromafenozide, and fufenozide) have a spectrum of control largely specific for lepidopteran larvae, while halofenozide has a broader spectrum of control that includes coleopteran and lepidopteran larvae, showing special utility as a soil insecticide and marketed for control of turf pests. To date, methoxyfenozide is the most widely registered and used BAH insecticide, with registrations in more than 50 countries for use on a variety of crops ranging from vegetables to specialty uses such as in forestry and tea production (Smagghe et al., 2013).

Wing et al. (1988) were the first to use D. melanogaster embryonic Kc cells to demonstrate that like 20E, RH-5849 also induced aggregation and clumping of otherwise confluent cultures of Kc cells. Morphological effects of four of the
commercialized BAH compounds, tebufenozide, methoxyfenozide, halofenozide, and chromafenozide, have also been demonstrated for cell lines derived from embryos or tissues of *D. melanogaster* (Mosallanejad *et al*., 2010) the mosquitoes, *Aedes* sp., *Anopheles* sp., and *Culex* sp. (Beckage *et al*., 2004; Smagghe *et al*., 2002), the midge, *Chironomus tentans* Fabricius (Smagghe *et al*., 2003), the cotton boll weevil, *Anthonomus grandis* (Boheman) (Soin *et al*., 2009), the beet armyworm, *S. exigua*, and the silk moth, *Bombyx mori* (Linnaeus) (Mosallanejad *et al*., 2008).

They have a greater metabolic stability than the insect steroid molting hormone 20-hydroxyecdysone (20E) *In vivo* (Retnakaran *et al*., 1995). They are toxic after ingestion or exposure to higher doses of topical application. Ingestion of BAH creates hyper ecdysonism in susceptible insect, including molting events. The effect starts with feeding inhibition within 3-14h (Retnakaran *et al*., 1997), which is very important for preventing further crop damage. In the mean while, larvae become moribund, slip their head capsule, and the hind gut may be extruded in extreme cases. The new cuticle is not sclerotized or tanned. Consequently, the food intake by larva is prevented as the mouthparts become soft and mushy. Larval death is due to incomplete molting, starvation, and desiccation due to hemorrhage. Both Tebufenozide and methoxyfenozide, selectively toxic to Lepidopteran pests, have been classified by US EPA as reduced risk pesticides (Retnakaran *et al*., 1997).

Methoxyfenozide have been shown to have lethal and sublethal effects (Riedl and Brunner, 1996; Sun *et al*., 2000). Both tebufenozide and methoxyfenozide are active primarily by ingestion, but also exhibit selective contact and ovicidal activity (Trisyono and Chippendale, 1997; Sun and Barrett, 1999; Sun *et al*., 2000). The effectiveness of tebufenozide against larvae of the codling moth, *Cydia pomonella* (L), (Pons *et al*., 1999; Knight, 2000; Pons *et al*., 1999) was studied and found that it has

Tebufenozide used to control caterpillar pests in vegetables, fruits, ornamentals, and forest, and has no or little adverse effects on various predators and beneficial like honeybees (Heller *et al*., 1992; Dhadialla *et al*., 1998; Carlson, 2000). Fifth instar larvae of *B. mori* showed delay or inhibition of spinning, alteration of the feeding behavior, decrease of the nutritional parameters, impairment of the growth of the silk glands, and an increased mortality during larval-pupal transformation due to fenoxycarb treatment (Leonardi *et al*., 1998).

The lethal and sublethal toxicity of methoxyfenozide affected the ovary development, vitellogenin incorporation and egg production in isolated pupal abdomen in silk moth *B. mori* (Rajathi *et al*., 2010). Pyriproxyfen caused significant defects in the legs and wings of some adults and severe morphological changes in the ovaries of emerged adults of *Plodia interpunctella* (Hübner) (Ghasemi *et al*., 2010). Methoprene was highly effective against *Rhyzopertha dominica* Fab, but less active on *Sarocladium Oryzae* Sawada. RH-5849 could achieve almost complete control of adults of *T. castaneum* and *R. dominica* but was less potent on *S. Oryzae* and tebufenozide appeared to be much less active on these three species compared with methoprene and pyriproxyfen (Kostyukovsky *et al*., 2000) and pyriproxyfen can be used with low side effects to humans (Ghasemi *et al*., 2010).

The disturbance of adult eclosion by fenoxycarb in *B. mori* pupa is due in part to the inability of the formation of the rectum in the pharate adult stage (Dedos and
Accumulation of IGRs in the reproductive system of females and males of mealworm *Tenebrio molitor* L was relatively high, which may explain the strong reproductive effects of the IGRs tested. In addition the rate of clearance of insecticide from the insect body via the excrements, with the chitin synthesis inhibitors exhibiting higher rates than halofenozide (Chebira *et al*., 2006).

Other than the morphological disruptions the physiological and biochemical disturbances were also influenced by IGR. Penfluron caused a great reduction in haemocytes in both sexes of *Dysdercus koenig* Fab (Prakash *et al*., 2007). Methoxyfenozide caused a significant changes on the total haemocyte count (THC) as well as on the differential haemocytic count (DHC) in V instar larva of *B. mori* and a gender difference was also observed among the haemocytic populations (Jasmine *et al*., 2011).

Haemolymph are the fluid fraction that transport nutrition, hormones and metabolic waste and contains elements of the immune system while the cellular components are haemocytes (Gillot, 1995). The haemocytes, the insect blood cells, change in number and morphology accompanying metamorphosis (Trenczek *et al*., 1997; Gardiner and Strand, 1999, 2000; Beetz *et al*., 2004, 2008). With respects to metamorphosis, the haemocytes can synthesize, form nodules, phagocytose, store and transport various cellular and humoral components (Sorrentino *et al*., 2002; Ceraul *et al*., 2003; Ling *et al*., 2005; Figueiredo *et al*., 2006; Gandhe *et al*., 2007; Merchant *et al*., 2008; Singh *et al*., 2008; Pandey *et al*., 2010).
The identification and classification of insect hemocytes based on their ultrastructural features (Ratcliffe et al., 1985; Brehelin and Zachary, 1986) and immunochemical identification (Charalambidis et al., 1996; Ceraul et al., 2003; Ling et al., 2005; Merchant et al., 2008) have also been made and Jones (1962) classification which is still the most accepted one. Based on morphology, staining reaction and response towards stresses, six types of hemocytes were identified in various insects (Tiwari et al., 2002; Pandey, 2004; Tiwari et al., 2006; Pandey et al., 2003a,b, 2008a,b, 2010; Pandey and Tiwari, 2011). They are Prohemocytes (PRs), Plasmatocytes (PLs), Granulocytes (GRs), Spherulocytes (SPs), Oenocytoids (OEs) and Adipocytes (ADs). Besides, Vermicytes (VEs) and Podocytes (POs) were occasionally observed in specific stage of insect life (Tiwari et al., 2006; Pandey et al., 2010; Pandey and Tiwari, 2011).

Categorisation of hemocyte schemes based on morphology or a combination of morphological and functional typescripts, has been developed for various insects (Brehelin and Zachary, 1986; Lackie, 1988; Gillespie et al., 1997; Gardiner and Strand, 1999, 2000; Lanot et al., 2001; Lavine and Strand, 2002; Irving et al., 2005; Wertheim et al., 2005). Silkworm hemocytes are classified into five types based on their morphology and function: granulocytes, plasmatocytes, oenocytoids, prohemocytes and spherulocytes (Akai and Sato, 1976; Nakahara et al., 2009).

The number of reports describe changes in total and differential haemocytes count with respect to developmental changes for insects from a variety of orders (Brehelin et al., 1978) including the hemiptera (Bahadur and Pathak, 1971), Orthoptera (Hoffmann, 1970) and Blattodea (Patton and Flint, 1959; Wheeler, 1963), as well as in the holometabolous orders Diptera (Lanot et al., 2001) and Lepidoptera (Nittono, 1960;
Gardiner and Strand, 2000). Generally the cells present in the circulating blood of various adult species varied from 1000 per cubic mm to about 100 times of this number (Tauber and Yeager, 1936). Stem cells (prohemocytes) in hematopoietic organs differentiate primarily into plasmatocytes, whereas other hemocyte types differentiate after release into circulation (Gardiner and Strand, 2000; Yamashita and Iwabuchi, 2001; Lavine and Strand, 2002).

Effects of certain stresses on hemocyte profile like THC, DHC and cell contour have been observed by several investigators (Pandey et al., 2003b, 2010; Pandey and Tiwari, 2005; Tiwari et al., 2006; Singh et al., 2008). It is reported that cellular immune responses of different insects under various temperature regimes showed that the plasmatocytes and granulocytes are the cells which get affected with all types of temperature treatment (Pandey, 2004; Pandey et al., 2010). Pandey et al. (2010) showed that heat stress caused a significant variation in hemocytic immune responses of tropical tasar silkworm, *Antheraea mylitta* (Drury). Decline in the number of hemocytes in *Danaus chrysippus* (L) due to chilling (Pandey et al., 2008b) by Tiwari and Shukla (2000) was observed in *Papilio demoleus* (L).

A decrease in hemocyte number has been reported after starvation (Nittono, 1960; Tiwari et al., 1999a; Tiwari and Shukla, 2000). On the other hand, Sujatha and Gupta (1991) in *Corcyra cephalonica* Stainton, Tiwari et al. (1999b) and Pandey and Tiwari (2004) in *Papilio demoleus* reported an increase in THC following resumed feeding. The variation in hemocyte population is well known under different developmental and physiological conditions (Lackie, 1988). According to some reports, there is an enhancement in THC following starvation (Arvy et al., 1948; Rosenberger and Jones, 1960) but according to others, there is a decline (Nittono, 1960; More and
Sonawane, 1987; Sujatha and Gupta, 1991; Tiwari and Shukla, 2000). Likewise, different explanations have been given to these variations in hemocyte population. More and Sonawane (1987) suggested the decline in THC due to the degeneration of the cells.

In a number of insects treated with chemicals including insecticides, the haemocytes are pathologically affected (Feir, 1979). The female total haemolymph cell count tends to exceed the male blood cell count (Tauber, 1935). When Penfluron was applied topically on *Chrysocoris purpureus* the THC count showed a lower rate in males than females (Pugazhvendon and Soundararajan, 2009). And in *Schistocerca gergaria* Forsskal and *P.americana* application of genistein showed an increase in haemocytes for 24 h and no change was observed earlier. The count was found to be decreased significantly later on (Berger *et al*., 2003).

Different type of haemocytes respond differently to stress conditions as evident by observations on different insect’s species exposed to different conditions and compounds they are as follows:
Table 1: Influence of different stress factors on differential haemocytic counts on various insects.

<table>
<thead>
<tr>
<th>Compound used</th>
<th>Insect</th>
<th>Changes in the differential count</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>β - ecdysone</td>
<td><em>Spodoptera litura</em></td>
<td>Increase prohaemocytes, plasmocytes and granulocytes</td>
<td>Gupta and Sutherland, 1968)</td>
</tr>
<tr>
<td>Neem gold</td>
<td><em>S. litura</em></td>
<td>Decrease Prohaemocytes, plasmocytes and spherule cells</td>
<td>Sharma <em>et al.</em>, 2003</td>
</tr>
<tr>
<td>Genistein</td>
<td><em>P. americana</em></td>
<td>Increase prohaemocytes</td>
<td>Berger <em>et al.</em>, 2003</td>
</tr>
<tr>
<td>Organophosphorous insecticides</td>
<td><em>Rhynocoris kumarii</em></td>
<td>Increase prohaemocytes plasmocytes and granulocytes</td>
<td>(George and Ambrose, 2004)</td>
</tr>
<tr>
<td>Nicotinyl insecticides</td>
<td><em>Dysdercus konigi</em></td>
<td>Increase prohaemocytes plasmocytes and granulocytes</td>
<td>Haq, 2005</td>
</tr>
<tr>
<td>Starvation</td>
<td><em>Tenebrio larvae</em></td>
<td>Increase prohaemocytes</td>
<td>Jones and Tauber, 1952</td>
</tr>
<tr>
<td></td>
<td><em>Anagasta larvae</em></td>
<td>Increase prohaemocytes</td>
<td>Arnold, 1952</td>
</tr>
<tr>
<td></td>
<td><em>Galleria larvae</em></td>
<td>Increase prohaemocytes</td>
<td>Shapiro, 1966</td>
</tr>
<tr>
<td></td>
<td><em>D. koenigii</em></td>
<td>Increase prohaemocytes</td>
<td>Mishra, 1999</td>
</tr>
<tr>
<td>Leaf extract of <em>Ageratum conyzoides</em></td>
<td><em>D. chrysippus</em></td>
<td>Increase prohaemocytes</td>
<td>Pandey, 2004</td>
</tr>
<tr>
<td>organophosphorus</td>
<td><em>D. cingulatus</em></td>
<td>Increase prohaemocytes</td>
<td>Qamar and Jamal, 2009</td>
</tr>
</tbody>
</table>

Some of the plant extracts were also found to be acting like an IGR. The bioactivities of plant extracts *Artemisia annua* on adults *Eurygaster interfriceps* (Zibae and Bandani, 2010) and the marjoram essential oil against potato tuber moth *Phthorimaea operculella* Zeller (El-Aziz, 2011) were studied and founded the increase
in the total protein and tryacylglycerol content it also proved that the compound inhibited ovary development. Marked decrease in total lipids, total protein and glucose contents were observed on the IV larval instar of the cotton leaf worm, *Spodoptera littoralis* (Biosd) under laboratory condition treated with extracts of *Azadirachta indica*, *Citrullus colocynthis*, *Ammi majus* and *Mentha microphylla* (Rawi et al., 2011). Proteins as well as the activities of mid gut protease and amylase were increased by 21.444 to 83.706 percent and 14.54 to 52.257 percent respectively due to aqueous solution of herbal drug kho-go in V instar larvae *B. mori* (Vithalrao and Sucheta, 2012).

The carbohydrate content in the haemolymph is an important indicator of the level of metabolism in insects, and a dynamic balance of the absorption, metabolism, and utilization by different tissues (Zhu et al., 2012). Protein synthesis is necessary for the maintenance of body growth and reproduction. Many factors had been implicated in the control of protein synthesis (Carlisle et al., 1987). Proteins enter in various reactions such as the hormonal regulation and they integrated in the cell as a structural element at the same time as the carbohydrates and the lipids (Cohen, 2010; Sugumaran, 2010). Quantity of lipids available for the reserves seems to be the result of a balance between the catch of food and the requests for reserves by processes such as maintenance, growth and reproduction, and this balance is disturbed by any toxic product (Canavoso et al., 2001).

During the development of holometabolous insects, processes such as the destruction of certain larval tissues, rejuvenation, and remolding of various tissues into adult ones lead to the synthesis and utilization of various macromolecules (Hyrs1 and Simek, 2005) including the proteins. Hemolymph proteins are synthesized by fat body
cells and then secreted into the hemolymph in a time-dependent situation during post embryonic development and metamorphosis (Tojo et al., 1980; Tomino, 1985; Kishimoto et al., 1999). Several classes of abundant insect haemolymph proteins have been identified of which productions are regulated by hormones (Tojo et al., 1980; Goodman et al., 1985; Cole et al., 1990). Quantitative assays of various biomolecules of haemolymph and fat bodies of Papilio demoleus and Papilio polytes during the larva to pupa to adult transformation revealed that the protein contents were higher while carbohydrate contents were lower in the haemolymph of P. polytes than P. demoleus during all the stages of development. Similarly lipid contents were more in haemolymph of P. polytes than P. demoleus. While in larval fat bodies of both the species it was at par (Kishori and Vrushali, 2011).

The abundant hemolymph proteins of B. mori are lipophorins, female specific protein vitellogenin, storage proteins, 30K proteins, and some undetermined proteins (Gamo, 1978; Tojo et al., 1980; Tomino, 1985; Hyrsl and Simek, 2005). 30K proteins are major hemolymph proteins that include the storage proteins (Kishimoto et al., 1999). 30 kDa proteins amounts increase sharply during the fifth instar and they are concentrated in fat bodies (Ogawa et al., 2005). Studies suggest that some of them may be involved in inhibiting apoptosis (Kim et al., 2003; Park et al., 2003) and or play a role in self-defense (Ujita et al., 2005). The major hemolymph proteins are grouped as follows: storage proteins (72 kDa-76 kDa), 30kDa proteins, lipophorin (230 kDa), and vitellogenins (178 kDa and 42 kDa) (Uranli et al., 2011).

Insect hexamerins called storage proteins, circulate as oligomers of approximately 450 kDa and their subunits of about 75-80 kDa (Telfer and Kunkel, 1991; Terwilliger, 1999). Silkworms have 2 kinds of storage protein (SP): SP1, which
is methionine rich, and SP2, which is arylphorin. Storage proteins exist in hemolymph from I to V instar of *B. mori* larvae (Nagata and Kobayashi, 1990). Just before pupation, storage proteins are taken up by fat body and used to form new structures such as somatic tissues and female reproductive products (Nagata and Kobayashi, 1990; Terwilliger, 1999). Vitellogenin is a tetramer with molecular weight of 440 kDa, composed of each two molecules of non-identical subunits termed ‘heavy chain’ and ‘light chain’ (Izumi *et al*., 1980). In *B. mori*, vitellogenin is synthesized by the fat body cells of females at larval-pupal ecdysis and released into the hemolymph before being taken up by the developing oocytes (Yano *et al*., 1994).

Such biochemical components are found to be affected among insects due to exposure to IGRs. Abdel-Hafez *et al*., (1988) found out that there was a reduction in the level of proteins and free amino acids in laboratory and resistant strains of *S. littoralis* as a result of IGR (diflubenzuron and triflumuron) treatments. Proteins, being the key organic constituents, could be expected to play a role in the compensatory mechanisms of silkworm during stress. It was reported that pyriproxyfen did not affect the protein band pattern in treated insects, although it affected the amount of protein concentrations (Aribi *et al*., 2006). JH and the JHA fenoxycarb and pyriproxyfen induced an inhibition of larval haemolymph protein synthesis in *Locusta migratoria* (De Kort and Koopmanshap, 1991) and *B. mori* (Monconduit and Mauchamp, 1998). A significant decrease in total protein was observed in fifth instar larva of silkworm when exposed to pyriproxyfen residue (Etebari *et al*., 2007).

Protein content was determined in the haemolymph and fat body of nymphs and adults after treatment of the newly moulted last (V) instar nymphs of the desert locust *S. gregaria* with the insect growth regulators pyriproxyfen (juvenoid), tebafenozone
(ecdysone agonist) and lufenuron (chitin synthesis inhibitor) (Ghoneim et al., 2012) and another chitin synthesis inhibitor, cyromazine against the IV larval instar of *Culex pipiens* increased the protein content (Assar et al., 2012).

The electrophoretic patterns of the hemolymph protein showed 10 different bands of which six showed great variation in the control and the treated samples Aboul-Ela et al. (1991). Comparative 2D gel electrophoresis of proteins extracted from the midgut revealed 388 protein spots, of which 7% of the proteins were significantly affected in their levels by DFB (diflubenzuron) treatment in *Tribolium castaneum* as determined by laser densitometry. Mass spectrometric identification revealed that UDP-N-acetyl glucosamine pyrophosphorylase and glutathione synthetase were up-regulated (Merzendorfer et al., 2012).

The proteins were found to be increased due to aqueous solution of herbal drug kho-go treated in mulberry and fed to the fifth instar larvae of polyvoltine, crossbreed silkworm, *B.mori* (Vittalrao and Sucheta, 2012). Pyriproxyfen was comparatively the strongest IGR for preventing the mid and late-aged nymphs to gain the normal protein content. In connection with the disturbed protein content in the fat body of nymphs, IGRs exhibited various degrees of reducing action with an exception of pyriproxyfen which slightly promoted the one day old nymphs to gain more proteins in fat body. All the adult females showed inhibitory action of IGRs on the haemolymph protein content. Also the adult females were deprived to gain proteins in their fat bodies like control congeners (Ghoneim et al., 2012). Total protein in *Plodia interpunctella* in whole larva was similarly reduced by 20-hydroxyecdysone and azadirachtin (Rharrabe et al., 2008, 2009).
Diazinon spraying on the three populations of rice striped stem borer *Chilo suppressalis* showed a significant difference in protein amount in different populations (Zibaee *et al*., 2008). The lowest dose of Lufenuron or diofenolan caused a gradual decrease in protein content in *Rynchophorus ferrugineus*, the total body protein content of the newly formed treated pupae was more significantly depleted than that of their control (Ghoneim *et al*., 2003).

The bioactivities of marjoram essential oil against immature stages and adults of potato tuber moth *Phthorimaea operculella* Zeller showed increases in the total protein and triacylglycerol content of most post-treatment days (El-Aziz, 2011). Novaluron affected significantly the amount of proteins in mosquito larvae and it decreased during fourth instars larvae starting from the day three following treatment and as compared with control series (Bouaziz *et al*., 2011). For the same treated series a significant decrease was also recorded in the body weight with a decrease in development time.

Hamadah *et al*. (2012) investigated the metabolic effects of pyriproxyfen, tebufenozide or lufenuron on the lipid content in two different tissues like hemolymph and fat body of the desert locust *S. Gregaria* with the age of nymphs, all IGRs could significantly or non-significantly reduce the lipid content of hemolymph. Concerning the lipid content in fat bodies of nymphs, a predominant inhibitory effect of all IGRs was detected. With regard to the adults, nymph treatments led to remarkable or slightly decreased lipids in the haemolymph. Lufenuron and diofenolan treatments resulted in decreasing lipids at the start and end days of pupae of the red palm weevil *R. ferrugineus* but increasing lipids were estimated for mid-aged pupae (Ghoneim *et al*., 2003).
Rharrabe et al. (2009) showed a reduction in lipid contents in the larva of *Plodia interpunctell* due to 20-hydroxyecdysone. Novaluron affected significantly the fourth instars larvae starting from the day three following treatment, the lipid amounts increased significantly in *Culiseta longiareolata* compared with control (Bouaziz et al., 2011).

Carbohydrates are of vital importance since they can be utilized by the insects’ body for production of energy or conversion to lipids or proteins. Metabolism of carbohydrates is controlled mainly by carbohydrate hydrolyzing enzymes. The final product of carbohydrates metabolism is glucose, the increase of these enzymes during the larval stage suggested that these enzymes degrade carbohydrates to glucose for chitin build-up (Wyatt, 1967).

Glucose showed a significant difference due to diazion spraying the populations of rice striped stem borer *Chilo suppressalis* (Zibaee et al., 2008). Carbohydrate content was found to decrease gradually even at lowest dose of lufenuron or diofenolan content in *R. ferrugineus* (Ghoneim et al., 2003). Cyromazine as chitin synthesis inhibitor (CSI) against the IV larval instar of *Culex pipiens* decreased the glucose (Assar et al., 2012). Carbohydrates were found to be affected due to novaluron in *Culiseta longiareolata* (Bouaziz et al., 2011).

Fahmy (2012) studied the occurrence of lipid peroxidation due to IGRs treatment in the larval tissues in *S.littoralis* larvae which enhanced different antioxidant defensive system to overcome its effect. The Reactive Oxygen Species (ROS), such as superoxide anion radicals, hydroxyl radicals and hydrogen peroxide, generated during normal oxidative processes in cells and extracellular fluids and a balance exists between production and elimination of ROS. They interact with essential
macromolecules, such as DNA, proteins and lipids specially those in cell membrane, leading to the disturbance of physiological processes (Cnubben et al., 2001).

One of the main reasons for reduction in ovarian size in treated insects by JH, JHA, or growth regulator of plant origin, is the lack of materials supplied through hemolymph to the growing ovaries (Telfer et al., 1981) or due to the lack of materials made by the ovaries themselves (Indrasith et al., 1988). The lack of compounds like proteins, lipids, and carbohydrates may lead to abnormal oogenesis (Kunkel and Nordin, 1985; Kanost et al., 1990). The decrease of two major biochemical compounds: lipid and protein, in the ovaries of the present insect may confirm this assumption. Shaaya et al. (1993) reported that the growth of ovaries in P. interpunctella in early pupa is under the influence of high titer of ecdysone in hemolymph but vitellogenesis is under the influence of low titer of ecdysone. Hence, another reason for the low rate of growth in the ovaries of the present insect may be due to a discrepancy in ecdysone production in the presence of excess JHA after larval treatment. Perveen and Miyata, (2000) found that the protein content in treated S. litura by Chlorfluazuron in ovaries was reduced. They speculated that the reduction of protein in the ovaries may be due to interruption of the compound with controlling mechanisms in yolk incorporation.

Different studies showed that IGRs have a direct effect on nutritional indices of treated larvae (Miranda et al., 2003) Thus, the biochemical changes in some metabolites related to feeding was obvious after major alteration in nutritional indices. These changes in different compounds may be the main reason for reduction in economical parameters of silkworm after topical application of JHA (Miranda et al., 2002). Whereas the most important reason for non-spinning syndrome is interruption in concentration of ecdysone and juvenile hormone. It has been reported that high doses of
the fenoxycarb affects important nutritional parameters, suggesting a reduced efficiency in the utilization of ingested food (Assal, 1994).

Macromolecular components present in the foods are catalyzed by three major digestive enzymes in the gut viz. amylases, proteases, and lipases. Amylases catalyze the hydrolysis of α-D-(1, 4)-glucan linkage in starch, glycogen and other carbohydrates, which serve as energy sources for insect larvae (Johnston et al., 1991; Purcell et al., 1992; Pereir et al., 1999; Franco et al., 2000). The proteinases are a major group of hydrolytic enzymes in insects and are involved in digestive processes, proenzyme activation, liberation of physiologically active peptides, complement activation, and inflammation processes amongst others (Neurath, 1984). The two major proteinase classes in the digestive systems of photophagous insects are the serine and cysteine proteinases (Haq et al., 2004). Murdock et al. (1987) carried out an elaborate study of the midgut enzymes of various pests belonging to coleoptera, while (Srinivasan et al., 2008) have reported on the midgut enzymes of various pests belonging to Lepidoptera. Serine proteases are known to dominate the larval gut environment and contribute to about 95% of the promoters.

Protease activity levels recorded a continuous increase throughout the fifth instar development. Greater enzyme activity was observed in muscle. Protease activity has been reported in silkworm and other insects (Bharathi and Miao, 2003). The presence of non-intestinal proteases activity in silkworm tissues is attributed to its role in proteolysis, characterizing insect metamorphosis (Chen, 1971).
Disease, starvation, aging, stress and environmental factors are known to influence physiological and biochemical state of animals, by exhibiting marked changes in the activities of several enzymes (Knox and Greengard, 1965). Currently some of the major aspects in pest control are to achieve the selective inhibition of the digestive enzymes of many insect pests (Ryan, 1981). UDP-N-acetyl|glucosamine pyrophosphorylase and glutathione synthetase were up regulated by the treatment of diflubenzuron in the red flour beetle Tribolium castaneum (Merzendorfer et al., 2012).

Genistein a synthetic estrogen agonist influenced different cells in a different manner. Through tyrosine phosphorylation or the control NADPH oxidase mediated by tyrosine kinase inhibition (Lee et al., 2003). Mamatha et al. (2008) studied the impact of low doses methoprene and fenoxycarb on B. mori larval muscle and silkgland protease, aspartate aminotransaminase (AAT) and alanine aminotransaminase (ALAT), adenosine triphosphate synthase (ATPase) and cytochrome-c-oxidase (CCO) activity levels, indicating an upsurge in the overall oxidative metabolism of the B.mori larval tissues. Chlorfluazuron and pyriproxyfen caused highly significant increases in the activity of chitinase enzyme activity (Al-shannaf et al., 2012).

Amylase is one of the key enzymes involved in digestion and carbohydrate metabolism in insects (Daone et al., 1975; Buonocore et al., 1976; Horie and Watanabe, 1980). In the silkworm, B.mori Yokoyama (1959) reported the presence of two types of amylase activities in digestive fluid and haemolymph. α-Amylase is a common enzyme for hydrolyzing starch. It was suggested that the increased enzyme activity of the polyvoltine races might be an adaptation to survive better in the tropical conditions (Abraham et al. 1992). Moreover, the activity of the α-amylase in digestive fluid was higher than that in the hemolymph (Abraham et al., 1992; Promboon et al.,
Helicoverpa armigera (Hüb) Chlorfluazuron, pyriproxyfen and Dipel DF gave the lowest significant decrease in the activity of amylase, invertase and trehalase enzymes and it also caused increases in the activity of chitinase (Al-shannaf et al., 2012).

Larval peptidolytic enzymes and their inhibitors are now involved in development of new strategies and approaches for enhancing of resistance of agricultural crops and forest trees to insect herbivores (Terra and Ferriera, 1994). Protein digesting enzymes may also be involved in activation and degradation of some insecticidal proteins of bacterial origin (de Maagd et al., 2001) and are presumed to participate in major part is events joined with the use of larvae in clinical practice (Sherman, 2002; Blahovoc et al., 2005). Diflubenzuron reduced amylase activity in vivo in S. littoralis, the reduction in activity being positively correlated with concentration, but invertase, trehalase and protease (proteinase) were not affected. In the VI instar larvae, diflubenzuron probably inhibits amylase indirectly by acting on the physiological system affecting amylase activity or secretion (Radwan et al., 1984; El-Saidy et al., 1990).

Acid and alkaline phosphatases have been shown to be associated with insect development, especially in relation to nutrition and egg maturation (Tsumuki and Kanehisa, 1984). Acid phosphatase has received considerable attention in developmental studies because of its association with histolysis. It is known that acid phosphatase hydrolyzes a variety of orthophosphorylation reactions (Hollander, 1971). Ecdysone is responsible for increase in the number of lysosomes (Radford and Misch, 1971) and of the activity of acid phosphatase (Van Pelt-Verkuil, 1979).
Abdel-Hafez et al. (1993) stated that the IGR/insecticide mixtures or their residues induced a variable decrease in the activity of alkaline phosphatase, much lower than in the control, while acid phosphatase enzyme showed a higher increase in its activity in the field strain larvae of *S. littoralis*. Cyromazine decreased the activity of, alkaline phosphatase (ALP) and phenoloxidase, while the activity of acid phosphatase increased in mosquito larvae (Assar et al., 2012).

The activity of acid phosphatase (ACP) in insect fat bodies is stimulated by the steroid hormone 20-hydroxyecdysone (20E) in vivo (Arif et al., 2004). On *Spodoptera litura* larvae the activity level of ACP decreased dramatically in all tissues examined due to Azadirachtin (Senthil Nathan, 2005b). Increase in ACP activity was reported by different IGRs, such as, JHA and ecdysterone on *Chrysocoris stollii* (Saha et al., 1986); 20-HE on *Manduca sexta* (Caglayan, 1990), pyriproxyfen on *Culex pipiens* (El-Bassal, 1993), pyriproxyfen on *Pectinophora gossypiella* and *Earias insulana* (Anan et al., 1993), pyriproxyfen on *S. littoralis* (Abdel- Aal, 2004) and pyriproxyfen on *A. ipsilon* (El-Sheikh, 2002).

The combination three IGRs Chlorfluazuron, hydroprene and hexaflumuron caused a two-fold decrease in enzyme activity even at reduced concentration. The activities of the digestive enzymes protease, amylase and lipase in *Callosobruchus maculatus* larvae were affected by IGRs individually and in combination (Khatter and Abuldahb, 2011). JHA treatments increased the ACP in all tissues but 20E did not increase activity in any tissue. Allatotropin tended to mimic the effects of JHA treatment (Yi and Adams, 2001).
The activities of alkaline phosphatase, acid phosphatase and acetylcholinesterase in insect body decreased significantly and inhibition was higher along with increasing concentrations of plant extract. Isozyme electrophoresis profiles indicated that responses of isozymes (esterase and glutathione S-transferase) to plant extract were decreased after 48 h exposure to extract so that some enzymes bands disappeared (Zibaee and Bandani, 2010). In UDP-N-acetylglucosamine pyrophosphorylase and glutathione synthetase were up-regulated by the treatment of diflubenzuron in the red flour beetle *Tribolium castaneum* (Merzendorfer *et al.*, 2012). The activity of both alanine amino transferase and aspartate amino transferase are also being highly affected (Rawi *et al.*, 2011).

Dehydrogenases are very important tools for the investigation of insect metabolic activities during the course of development. The relative activities of the insect dehydrogenases may be related to the function and energy yielding demands of the tissues (Dickinson and Sullivan, 1975). Lactate dehydrogenase (LDH) is an important glycolytic enzyme that is present in virtually all tissues (Kaplan and Pesce, 1996). It is involved in carbohydrate metabolism and has been used as an indicative criterion of exposure to chemical stress (Diamantino *et al.*, 2001). LDH is, also, a parameter widely used in toxicology and in clinical chemistry to diagnose cell, tissue, and organ damage. However, the potential of this enzyme as an indicative criterion in the invertebrate toxicity tests has been scarcely explored (Ribeiro *et al.*, 1999; Senthil Nathan *et al.*, 2006).

The disturbed LDH activities in haemolymph and fat body indicate that the toxic components contained in the present plant extracts might be affecting the synthesis or functional levels of LDH, directly or indirectly, by altering the
cytomorphology of the cells (Nath, 2000). An increase and decrease, or induction and inhibition, of the LDH activities, was recorded in the on S. gregaria, where LDH were found to cause depression or mutations of the regulating genes responsible for biosynthesis of polypeptide chains building this enzyme (Hassanien et al., 1996). Fagonia bruguieri extracts caused some alterations in the LDH activity in haemolymph and fat body of S. Gregaria (Hamadah et al., 2010). Enhaced LDH activity was found S.littoralis at 24 h post treatment with 30 microgram/larva precocene I treatment (Abdel-Ghaffar and Basiouny, 2007). Diazinon treatment decreased activity levels of several enzymes, ATPases, LDH and α-amylase that had a significant effect on metabolism of nutrients in insect's body (Zibaee et al., 2008).

The midgut of insects comprises the longest and functionally most important part of the digestive tract, dealing primarily with the digestion of food stuffs and the absorption of nutrients (Ranjini and Mohamed, 1999) which is the longest part of the alimentary canal and differentiated into five morphologically and histologically distinct regions the first, second, third, fourth and fifth ventriculi. The midgut wall is formed of an outer longitudinal and inner circular muscle layers, basement membrane and epithelium. In the first ventriculus, the anterior and posterior regions are histologically different. In the middle and posterior region, ventricular wall is formed of broader and narrower epithelial regions. The epithelium consists of mainly columnar cells, few cuboidal cells and regenerative cells. The histological features indicate that the first ventriculus and the anterior region of the second ventriculus are mainly secretory in function. The third ventriculus is both secretory and absorptive in function. The forth ventriculus is mainly absorptive in function. The fifth ventriculus has no role in digestion and absorption (Ranjini and Mohamed, 1999; Habibi et al., 2008; Lucarotti, 2011; Mehrabadia et al., 2012).
Numerous well-developed microvilli occur at the basal region of the epithelium (Zhang et al., 2012). The regenerative cells present electron-dense cytoplasm and few organelles. The endocrine cells are characterized by electron-dense secretory granules, usually concentrated in the cytoplasm basal region (Levy et al., 2004). Columnar cells have many long, apical microvilli, which point toward the midgut lumen and basal invaginations that comprise a basal labyrinth, which is involved in the secretion of digestive enzymes. Goblet cells have a large, goblet-shaped central cavity with a role in regulating the electrogenic K+ secretion (Zeiske et al., 2002 and Levy et al., 2004).

A reduction in absorption of leucine by midgut and a large alteration of a number of midgut enzyme activities as a result of treatments with a high dose of fenoxycarb in B. mori, and lower dose increased leucine uptake by the midgut, an increased weight of the cocoon shell and a modification of some midgut enzyme activities was observed (Leonardi et al., 1998). The histopathological structure as well as content and distribution of mucosubstances in the mid-gut mucosa of the honeybee (Apis mellifera) treated with the phyto-pharmacological preparation Nozevit was studied by Gajger et al. (2011) and it induced the production and secretion of mucous from the epithelial layer of treated bees, and additionally coats the peritrophic membrane to form a firm and resilient envelope. Thus, the preparation may ensure protection from new invasions and also from normal physiological processes (Gajger et al., 2011).

The lepidopteran midgut appears to be a larval organ that responds promptly to the exposure to fenoxycarb (Leonardi et al., 1998). The epithelial columnar cells modify their absorptive functions at least with regard to amino acid uptake as well as their metabolic activity with a modification of the oxidative status of the cells (Habibi
et al., 2000). Phytohemagglutinin (PHA), a lectin from *Phaseolus vulgaris* L., on the western tarnished plant bug caused severe disruption of the midgut epithelial cells (Habibi et al., 2000). High histopathological disturbances were observed in the midgut and body wall cells of the *S. littoralis* larvae due to plant extract (Rawi et al., 2011).

Goniothalamin a styryl-pyrone completely destructed the midgut epithelium of the gut, with a disappearance of cellular components like nuclei *Spodoptera exigua* (Hübner) and the columnar cells of the gut were also damaged (Senthil Nathan et al., 2008). Similarly Harmaline provoked a severe cytotoxicity on the epithelial cells of the midgut of *Plodia interpunctella* (Rharrabe et al., 2007), the epithelial cells disruptions was also brought about by 20E in the mid gut of *P. interpunctella* (Rharrabe et al., 2009).

Histophysiological alterations such as loss of lining with dislocation of chitinous cuticular intima away from the epithelial lining, increasing the space between the epithelial cells while in the fat body the cells become denser and smaller in size and the damage and distraction of the fat body cell were clearly appear due to Saponins on *Spodoptera littoralis* (Adel and Sammour, 2012).

Other than the cell membrane damage the IGRs were found to cause cellular material damages like PHA causing closure of lumen due to epithelial cells swollen towards lumen (Habibi et al., 2000), vacuolization of the cytoplasm, appearance of numerous autophagic vesicles and lysosomic structures, fragmentation of rough endoplasmic reticulum cisternae, disruption of microvilli, rupture of the plasma membrane leading to shedding of the cytoplasm contents into the midgut lumen (Rharrabe et al., 2007; Rharrabe et al., 2009). Appearance of compacted chromatin opposed to the nuclear envelope in the nucleus and the cristae of mitochondria were
loosely disturbed and regenerative cells were not observed between the basement membrane and the epithelial cells due to 20E (Tanaka and Yukuhiro, 1999).

The rough endoplasmic reticulum dilation, disappearance and vaculation of mitochondrial cristaes the wall of goblet cell invagination, disordered inner organelle, concentrated chromatin and the quantities of secondary lysosome increased are due to fraxinellone and it let microvilli rupture or incline, even partially fall off Lu et al. (2010). IGR even caused developmental disruption, midgut epithelial cells death, energy reserve decrease and larval mortality (Rharrabe et al., 2009).

During the larval to pupal metamorphosis, the midgut undergoes remodeling, during which programmed cell death (PCD) within the larval midgut and development of the pupal midgut epithelium occur simultaneously the juvenile hormone analog, methoprene the JH analog, methoprene acts on Ae. aegypti by interfering with the expression of genes involved in 20E action resulting in a block in midgut remodeling and death during pupal stage (Uwo et al., 2002). Insight into this process has come from analysis of other insect species. In Drosophila, PCD in the midgut is regulated by steroids (Thummel, 2001; Yin and Thummel, 2005), and the caspases Dronc and Drice are thought to regulate PCD in Ae.aegypti (Wu et al., 2006).

The effects of methoprene on insects were same irrespective of mode of application (topical/oral) in Heliothis virescens juvenile hormone analogs inhibit both midgut remodeling and larval-pupal metamorphosis, and it blocked the differentiation of imaginal midgut cells in a dose-dependent manner. At higher to moderate doses, methoprene completely inhibited differentiation of imaginal cells in the midgut (Parthasarathy and Palli, 2007).
However, many aspects of midgut remodeling are still unclear. For example, the role of hemocytes and the regulation of their migration into the midgut are only beginning to be understood. Granular hemocytes have been shown to enter the midgut in metamorphically committed *B. mori* larvae to participate in the tissue remodelling. Hemocytes are thought to accumulate in the midgut where they secrete type IV collagen, a major component of basement membrane, during larval to pupal metamorphosis (Adachi *et al.*, 2005). Granular hemocytes accumulate in a layer surrounding the midgut epithelium during pupal metamorphosis the number of granular hemocytes increases in circulating hemolymph and hemocytes migrate from hematopoietic organs to the tissues that will undergo histolysis during larva development (Yang *et al.*, 2007).

Interestingly, regions of hemocyte accumulation are correlated with increased expression of the cathepsin B-like proteinase, which might play a key role in fat body and midgut histolysis during metamorphosis in *Helicoverpa armigera* Hubner. Cathepsin B has been shown to be involved in the breakdown of adult fat bodies in *H. armigera* (Yang *et al.*, 2006; Zhao *et al.*, 2005). Wang *et al.* (2007) has shown that high levels of *hmg176* gene are expressed in the midgut during molting, but not during metamorphosis. HMG176 protein was detected within the membrane of fat bodies and the basement membrane of the midgut of both molting and feeding larvae, but not in metamorphically committed larvae. *hmg176* transcripts mainly localized to the columnar cells of the midgut. Interestingly, a non-steroidal ecdysone agonist, RH-2485, significantly upregulated expression of *hmg176*.

IGR like azadirachtin inhibits the growth, affects survival, cause repellence and feeding deterrence, reduces the fertility of females and causes anatomical abnormalities
in several species of insects (Martinez and Emden, 1999; Mordue and Nisbet, 2000). In insects, azadirachtin has direct cytotoxic effects on glands (Sayah, 2002), reproductive organs (Sayah et al., 1996) and intestine (Nogueira et al., 1997; Correia et al., 2009). In addition, it affects protein metabolism (Huang et al., 2007) and enzyme synthesis in insects (Lowery and Smirle, 2000), the cells of the midgut epithelium and fat body (Almeida et al., 2014). So a single compound negatively affecting the physiological and biological parameters leads to challenge the survival of an insect.

The diversity of the insecta is reflected in the large and varied microbial communities inhabiting the gut. There are many reports on the distribution and diversity of gut bacteria in several species of insects, but exploratory studies on functional role of microbiota in insects are limited. The gut microbiology of lepidopteran insects received less attention in the earlier decades as it was thought that owing to their simple digestive tract, they do not harbour significant microbial load. However, recent studies using tools of biochemistry and molecular biology allow identification of new groups of microbes which have hitherto been unexplored.

Many reports have been published regarding bacteria of the digestive tract of insects. Presence of bacteria in the gut of mulberry silkworm has been reported by Roy et al. (2000). Eleven isolates of gram positive and negative bacteria were obtained from the digestive tract of insects. Nine lipase producing bacteria were identified in B.mori (Feng et al., 2011) eleven isolates were obtained from the digestive tract of cross breed silk worm (Khyade and Marathe, 2012). And these gut microflora were found to vary among different instars or stages of insect life (Sekar et al., 2010) and positive correlation also exist among the bacterial count and the stage of development (Ademolu and Idowu, 2011).
Microorganisms were found to play an important role in nutrition and digestion among lepidopterans (Bignell and Eggleton, 1995), because bacteria were found to produce digestive enzymes that help digesting mulberry leaf (Dillon and Dillion, 2004). The relationship between the gut bacteria and digestion are found in the digestive tract of the ground beetle (Lehman et al., 2008) in the gut diverticulam of Aedes aegypti (Gusmao et al., 2007).

The diet has a significant impact on the gut bacterial community, in cockroaches (Kane and Breznak, 1991) in crickets (Domingo et al., 1998) and in silk worm (Feng et al., 2011), where microbial populations fluctuate in response to dietary changes. Loss of microorganisms often results in abnormal development and results in abnormal development and reduces survival of the insect’s host (Fukatsu and Hosokawa, 2002).

The bacteria inhabiting the gut of silkworm were found to be elaborating amylase, caesinase, gelatinase, lipase and urease (Kalpana et al., 1994). Cellulose, xylan, pectin and starch degrading bacteria were isolated characterized from the gut of B.mori (Anand et al., 2010), Aeromonas species with Xylanase activity was isolated from the intestine of Samia cynthia pryeri (Roy et al., 2003) Xylanolytic bacteria and cellulose degrading bacteria were reported by Anand and Sripathi (2004). Bacteria supporting the Starch utilization activity was studied by Murakami (1989), Indira Gandhi et al., (2008) reported on chitinase producing S. marcescens, the contribution of proteolytic role in Anticarsia gemmatalis (Visotto et al., 2009), lipase producing bacterial function, in B.mori ( Feng et al., 2011) and the efficiency of digestion brought about by the cellulolytic bacteria (Khyade and Marathe, 2012).
The gut bacteria in silk worm were found to play the key physiological process in the insects. Apart from digestion, microbes were also found to involve in host defence, the silk yield and the quality in silkworm were found to be improved by members of gram negative bacteria (Ramesh et al., 2009), influence in growth enhancement and development by chitinase-producing S. marcescens (a gut bacterium) in P. xylostella larva (Indira Gandhi et al., 2007: 2008), lipase producing bacteria related with the disease resistance in B.mori (Feng et al., 2011). Other enzymes like pectinase were found to play a role in egg laying behavior (Boyd et al., 2002). Extensive studies have been undertaken on the contribution of endosymbionts and gut microbiota in host nutrition (Douglas and Beard, 1997; Tanada and Kaya, 1993). Bourtzis and Miller (2003) enlisted functional role of several species of gut bacteria including E. aerogens, Y. enterocolitica in the gut of diverse group of insects.

Certain internal microbiota in the insect’s digestive tracts may become pathogenic and cause infectious when condition of the insect is weakened by stress, such as starvation, high humidity, temperature etc (Tanada, 1993). K. pneumoniae a common gut bacterium was involved in the degradation of endosulfan which degrades the insecticide without the formation of toxic metabolite endosulfan sulfate. There are reports on the isolation of methylparathion degrading B. subtilis strains, E. aerogens, K. pneumoniae sp. pneumoniae, and Y. enterocolitica have been elucidated as beneficial gut microbes of insects contributing for the growth and development, host defense, insecticide degradation and antagonism to entomopathogens (Ramesh et al., 2009).