A. Inflammation and inflammatory disorders – recent update

1. Inflammatory response

Inflammation is typically a protective mechanism that is triggered by vascular tissue in response to noxious stimuli, for examples, infection, ischemia, antigen-antibody interaction, chemical, thermal or mechanical injuries, to guard the body and to hasten-up the recovery and repair processes (Gabay and Kushner, 1999; Ferrero-Miliani et al., 2007). Inflammatory response occur in three distinct phases, each apparently mediated by different mechanisms: an acute phase characterized by local vasodilatation and increased capillary permeability, a sub-acute phase characterized by infiltration of leukocytes and phagocytic cells, and a chronic proliferative phase, in which tissue degeneration and fibrosis occurs.

The main components of acute inflammatory response are cytokines, acute phase protein, and leukocytes (Gabay and Kushner, 1999). The systemic response following a local inflammation is known as the acute-phase response, which is characterized by marked fever, increased synthesis of hormones, elevated production of white blood cells (WBC), and increased production of acute phase proteins in the liver (Goldsby et al., 2001). The acute inflammatory response has two components – the innate immunity and the adaptive immunity. The innate immune response occurs immediately on injury or infection and comprises vascular and cellular elements. The tissue macrophages, bearing Toll like receptors recognize specific pathogen-associated molecular patterns on microorganism, and releases cytokines like interleukin (IL) -1 and tissue necrosis factor (TNF)-α which are responsible for post capillary vasodilatation, fluid exudation, and expression of adhesion molecules. Exudate contains enzyme cascades that generate bradykinin, C5a, and C3a, which lyses bacteria, stimulate histamine, and thereby dilates local arterioles. Tissue damage and cytokines release prostaglandin (PG) I2 and E2, and leukotriene B4. Cytokine stimulated nitric oxide (NO) increases vascular permeability. Using adhesion...
molecules, leucocytes roll on, adhere to, and finally migrate through vascular endothelium towards the pathogen, where phagocytosis and killing takes place.

The adaptive response is specific, acquired immune response that boosts the effectiveness of the innate response. It has two phases— the induction and the effector phase, the latter consisting of humoral and cell-mediated components. During the induction phase, naive T-cells bearing either the cluster of differentiation (CD) 4 or CD8 receptors are presented with antigen, triggering proliferation of CD8 bearing T-cells (develop into cytotoxic T-cells), CD4 bearing Th cells (develop into Th 1 and Th 2 cells). The effector phase depends on antibody- and cell–mediated responses.

The inflammatory response is a defense mechanism and not, ipso facto, a disease, and its role is to restore normal structure and function to the infected or damaged tissues. However, inflammatory response that is unchecked leads to chronic inflammatory disorders. The role of inflammation in different diseases is briefly described below.

2. Inflammation and liver injury

Liver is the biggest organ of the body that performs many vital functions necessary to maintain life including removal of xenobiotics. However, it is constantly exposed to environmental toxicants resulting in liver injury. The diseases of liver can be grouped into the nonalcoholic fatty liver diseases (NAFLD), alcoholic liver diseases (ALD), and drug induced liver toxicities. The NAFLD refers to spectrum of liver damage ranging from simple steatosis to steatohepatitis, advanced fibrosis, cirrhosis, and hepatocellular carcinoma (HCC). The innate immune response provides the first line of defense against microbes and toxins crossing the intestinal barrier and reaching the liver (Janeway and Medhitov, 2002). The microbes and toxins reaching the systemic circulation are frequently encountered by Kuffer cells (a resident macrophage in the liver) before they can be rapidly cleaned (Nagy, 2003). These Kuffer cells generate the inflammatory response leading to recruitment of inflammatory cells.
such as neutrophils, monocytes, T and B-lymphocytes as well as Natural Killer (NK) cells and NKT-cells to the liver ultimately facilitating liver damage (Mandrekar and Szabo, 2009). The Kuffer cell can also generate mediators of neutrophil inflammation including TNF-α, IL-1, IL-6, chemokines, and ROS (Sweet and Thume, 1996). The neutrophil-mediated liver injury has been reported in number of experimental animal models such as ischemia-reperfusion injury (Jaeschke et al., 1990), endotoxemia (Jaeschke et al., 1991), alcoholic hepatitis (Ramaiah et al., 2004), obstructive cholestasis (Gujral et al., 2003), α-naphthylisothiocyanate toxicity (Xu et al., 2004), and paracetamol toxicity (Liu et al., 2006). The neutrophil recruitment into the hepatic vasculature provides a link between inflammation and liver injury. It includes neutrophil activation, transmigration, extravasation, adhesion to hepatocytes, respiratory burst, and oxidative stress mediated killing of hepatocytes. It involves inflammatory mediators like TNF-α, complement proteins (C5a), interleukins (IL-1, IL-6, IL-8), platelet activation factor (PAF), and osteopontin (OPN) as well as adhesion molecules like intercellular adhesion molecule (ICAM), vascular adhesion molecule (VCAM)-1, E-selectin, β2-integrins, etc. (Ramaiah and Jaeschke, 2007).

In case of alcoholic fatty liver diseases, steatohepatitis is one of the major complications and is characterized by hepatic fat accumulation, inflammatory cell infiltration, and hepatic parenchymal injury (Ramaiah and Jaeschke, 2007). Alcohol-induced sensitization of liver macrophages to portal endotoxin / lipopolysaccharides (LPS) is considered a hallmark of alcoholic liver diseases. Intracellular mechanisms associated with LPS-induced signaling play a crucial role in the initiation and progression of alcoholic liver injury (Mandrekar and Szabo, 2009). LPS- recognition by Toll-like receptor 4 (TLR-4) on macrophages (Goral et al., 2005) and other cell type in the liver, activation of downstream signaling pathways culminating in activation of transcription factors such as nuclear factor (NF) -kB, activator protein (AP)-1 leads to increased inflammatory cytokines like TNF-α production in ALD (Song et al., 2004). LPS -induced microtubule-associated protein kinase (MAPK) such as extracellular signal-
regulated Kinase (ERK) and p38 also contribute to liver injury (Drechsler et al., 2006). Alcohol induces ROS production by Kuffer cells (Thakur et al., 2006), which interact with LTR pathway in macrophages leading to inflammation.

Non-alcoholic fatty liver disease (NAFLD) refers to a spectrum of liver damage ranging from simple steatosis to non-alcoholic steatohepatitis (NASH), advanced fibrosis, and cirrhosis. It is strongly associated with insulin resistance and is defined by accumulation of liver fat > 5% per liver weight in the presence of <10 g of daily alcoholic consumption. NAFLD is a consequence of a 'two hit' insult (Byrne, 2010). As a consequence of insulin resistance, there is excessive accumulation of triglycerides in the hepatocytes, this being the first hit. Oxidative stress from the β-oxidation, increased expression of inflammatory cytokines by NF-kB dependent pathways, and adipocytokines are potential factors acting in concert as the second hit, resulting in hepatocytes injury, inflammation, and fibrosis. Due to increased mitochondrial fat oxidation, there is increased generation of ROS which leads to lipid peroxidation and mitochondrial dysfunction via adenosine triphosphate (ATP) depletion (Chen et al., 1998), involving peroxisome proliferator-activated receptor (PPAR)-α activation (Nakatani et al., 2002). The sub-cellular proteins necessary for endoplasmic reticulum functions are also affected by these "stress" environment (Ron, 2002), and thereby contributing to the liver injury.

Hepatic fibrosis is characterized by accumulation of extracellular matrix (ECM) proteins especially collagen type I and III, as well as increase in other ECM constituents such as proteoglycans, fibronectin, and laminin in response to live injury. The leukocytes that are recruited to the liver during injury join the Kuffer cell, and produce compounds that modulate Stellate cell (SC) behavior. Monocytes and macrophages are involved in inflammatory actions by producing large amount of NO and inflammatory cytokines TNF-α, which in turn stimulate SC collagen synthesis. Kuffer cell are also known to express the death ligands TNF-α, TNF related apoptosis inducing ligand (TRAIL), and Fas ligands (Canbay et al., 2003). The death ligands-mediated apoptosis also contribute to liver
inflammation and fibrosis (Jaeschke et al., 2002). The Fas ligand has also been shown to be pro-inflammatory (Chen et al., 1998). The activation of SC plays central role in liver fibrosis, which is regulated by several soluble factors (Kruppel-like factor, receptor tyrosine kinase) and products of oxidative stress. Tissue growth factor (TGF)-b and IL-6 are the two main fibrogenic cytokines that activates SC cells, inflammatory cells, and increases transcription of type I and III collagen genes.

In T-cell mediated liver diseases, there is increased neutrophil and lymphocytes (NKT and T-cell) infiltration followed by hepatic necrosis (Fujii et al., 2005; Zhu et al., 2007). Studies have established link between OPN and NKT-cells (Diao et al., 2004). OPN also acts as cytokine and called early T-cell activation factor (Patarca et al., 1989). It is potent mediator of hepatic NKT-cell, neutrophil, macrophage infiltration (Ramaiah and Rittling, 2007) and regulates chemotactic response of macrophages (Giachelli et al., 1998). Studies have demonstrated that OPN expression is increased during nonalcoholic steatohepatitis (Sahai et al., 2004), hepatocellular carcinoma (Luo et al., 2006), and hepatitis B associated hepatocytes carcinoma (Xie et al., 2007). Since inflammation is repair mechanism and not a disease, it is also involved in the liver regeneration. Therefore, future studies must be required to specify the role of inflammation in liver injury as well as liver regeneration.

3. Inflammation, hyperlipidemia and atherosclerosis

Atherosclerotic vascular disease is responsible for the majority of cases of cardiovascular diseases in both developing and developed countries. Atherosclerosis is now being considered as inflammatory disorder (Stainberg, 2005; Packard and Libby, 2008; Libby et al., 2009). Although LDL remains the most important factor for atherosclerosis, immune and inflammatory mechanisms of atherosclerosis have gained tremendous interest in the past 20 years (Hassan and Libby, 2006; Weber et al., 2008). Inflammation contributes to fatty plaque development from its inception throughout its course and rupture. The inflammatory response is initiated far before the fatty streak development (Stokes
et al., 2001). It is the elevated cholesterol that leads to initial changes in the vascular wall. Hypercholesterolemia, either by decreasing NO biosynthesis and its bioavailability or by generating superoxide, can produce profound effects on endothelium-dependent functions of the microcirculation including dilation of arterioles, fluid infiltration across capillaries, and leukocytes recruitment and thereby promotes inflammation (Stokes et al., 2002). It has been also observed that liver plays a key role in the initial inflammatory response evoked by dietary constituents (Kleemann and Kooistra, 2005). The endoplasmic reticulum stress induced by hypercholesterolemia also leads to oxidative stress and inflammation (Zhang, 2010).

The inflammatory response in atherosclerosis involves elements of both the innate and adaptive limbs of immunity (Libby et al., 2009). The innate immune response mounts rapidly, and combats perceived foreign invaders without prior “education” of immune system. There is early involvement of the monocyte/macrophages, the most prominent cellular components of innate immune system, during atherogenesis. Specialized cytokines known as chemokines are directing monocytes migration into the intima (Charo and Ranosohoff, 2006; Viola and Luster, 2008). Monocytes entry occurs not just during the initial stages of lesion formation but continues even in established lesions (Swirski et al., 2006) and there is monocyte heterogeneity in atherosclerosis (Libby et al., 2008). Experimental evidences suggested a disease relevant dimorphism of monocytes (Geissmann, 2003; Tacke et al., 2007). The mast cell also exhibits numerous functions implicated in atherosclerosis (Kovanen, 2007), for example releases of vasoactive small molecules such as histamine, leukotrienes, certain serine proteinases, heparin, and angiogenesis (Sun et al., 2007). Many links exists between lipoproteins and innate immunity. Modified lipoproteins interact with scavengers receptors and send inflammatory signals. Oxidized phospholipids may also drive inflammation. Lipoprotein-associated phospholipase A2 (La-PLA2) may generate pro-inflammatory derivatives of oxidatively modified lipoproteins (Serruys et al., 2008). Innate immunity also links atherosclerosis and thrombosis (Croce and Libby, 2007).
Thrombin can elicit the expression of pro-inflammatory cytokines from vascular endothelium and smooth muscle cells. Activated platelets can secrete preformed pro-inflammatory cytokines, exteriorize, and shed pro-inflammatory stimulus via CD40 ligands (Anand et al., 2003), and myeloid related protein (MRP)-8/14 (Healy et al., 2006). MRP-8/14 can bind TLR-4 receptor and activate innate immunity (Vogl et al., 2007).

Accumulating evidences support a key regulatory role for adaptive immunity in atherosclerosis and its complications (Weyand et al., 2008; Mallat et al., 2009). Dendritic cells populate atherosclerotic plaques and present antigens like heat shock proteins, products of plasma lipoproteins, and microbial structural components to T-cells, and incite adaptive immunity. Th1 cells amplify pro-inflammatory pathways by secretion of cytokines interferon-γ, and aggravate atherosclerosis. Th2 cells produced IL-4 that can modulate inflammation (Davenport and Tipping, 2003; van Wanrooji et al., 2007). Several mediators produced in lesions can recruit CD8 T-cells which are capable of killing smooth muscle cells and macrophages, a key process that link the atherosclerotic lesion growth and its complication (Ludewig et al., 2000). NKT-cell when activated produces pro-inflammatory cytokines that promote atherosclerosis (Tupin et al., 2004). Galkina and Ley (2009) reviewed the immunity and inflammatory mechanisms associated with atherosclerosis in details. The role of B-cells in atherosclerosis is controversial and is even believed to be protective (Hasson, 2002). Thus, the inflammatory concept of atherosclerosis is further supported by the fact that C-reactive protein (CRP) can be effectively used in the prediction of risk of cardiovascular diseases. The classical lipid lowering drugs, statins have also shown anti-inflammatory activity. The high density lipoproteins (HDL) and ATP-binding cassette (ABC) transporters have been found to show anti-inflammatory activity, and protected against atherosclerotic complications (Fitzgerald et al., 2010).
4. Inflammation and wound healing

Wound healing is a complex and highly dynamic process that rapidly closes a wound, and prevents infection after injury. It can be broadly divided into inflammatory, proliferative, and remodeling phases that involve numerous different cell types, some from the local area, while others are recruited upon injury (Gurtner et al., 2008). In an ideal world, repair would result in regeneration of the original tissue with structural, functional, and aesthetic attributes similar to that of uninjured skin. However, in normal wound healing process, the structural integrity is maintained by the replacement of damaged tissue with fibrotic material, leading to scarring (Stramer et al., 2007). However, foetal skin wound healing does not result in scarring. Additionally, certain tissues have reduced levels of scarring, and repair themselves more rapidly such as oral mucosa wounds (Schrementi et al., 2008). Both foetal and oral mucosa wound healing have limited inflammatory response during the repair process (Eming et al., 2007). Wounds that heal slowly with poor dermal quality, such as diabetic ulcers, have a robust inflammatory response that can play a role in prolonging healing time (Martin and Leibovich, 2005). Thus, inflammation plays crucial role in the wound healing.

Upon injury, platelets are the first blood cells on the scene; activated by binding to the exposed collagen of blood vessel lining due to injury, leading to rapid plugging of the wound with a fibrin-rich clot to prevent blood loss. Platelets secrete biologically active proteins that bind to the fibrin mesh, and to the ECM, creating chemotactic gradients that trigger the inflammatory phase of repair by recruiting immune cells to the wound (Martin and Leibovich, 2005). Neutrophils are the first nucleated immune cell to infiltrate a wound, acting as a first line of defense by decontaminating the wound. These cells phagocytize foreign material and infectious agents, and secrete anti-microbial substances such as ROS, cationic peptides and proteases. Neutrophils also secrete enzymes, such as matrix metalloproteinases (MMPs), which begin debriding devitalized tissue (Dovi

et al., 2004). Usually neutrophil infiltration ceases after a few days and the act of phagocytosis results in the neutrophil committing suicide by apoptosis.

Around 48 hours after the initial injury, monocytes are recruited via the numerous chemoattractants, including growth factors, cytokines and chemokines, produced by platelets, neutrophils, keratinocytes and fibroblast at the site of injury. In the wound, monocytes differentiate into macrophages, an abundant and active component throughout the repair process, lingering long after the wound has closed. During the repair process, macrophages are thought to play a pivotal role in fibrosis and scarring (Martin et al., 2003). Within the wound, macrophages clear the matrix and cell debris, including fibrin and the spent neutrophils. They also secrete a variety of cytokines, growth factors, and mediators of inflammation that can coordinate different cell actions, such as fibroblasts proliferation and angiogenesis, during wound closure. Successful repair entails resolution of the inflammatory response. The mechanisms that deactivate the inflammatory response within a wound are not so well understood. Macrophages are capable of switching off their own pro-inflammatory response by secreting anti-inflammatory mediators, such as IL-10 and soluble receptors, that sequester pro-inflammatory molecules. Immune cells dictate the quality and speed of tissue repair (Rajan and Murray, 2008).

Whenever the body's natural healing process is deregulated and wounds fail to progress through the typical orderly sequence of repair in a timely fashion, wounds heal with difficulties. Disruption of one or more of the healing stages can result in prolonged and incomplete repair, with lack of restoration of integrity. Non-healing wounds are a significant problem for healthcare systems all over the world. These wounds can cause significant pain and suffering, loss of independence, and often interfere with quality of life. Often the delay in tissue repair results from a disruption in the inflammatory phase of repair, with many different factors contributing to poor healing such as wound infection, foreign objects such as sutures, or the presence of debris and necrotic tissue. Non-healing wounds have some distinct characteristics. They frequently have high
bacterial load in combination with growth factor, inflammatory mediator and proteolytic enzyme imbalance that favor tissue degradation over repair. Neutrophils and macrophages are abundant in these wounds and secrete many of the bioactive substances that in high concentrations exacerbate tissue damage (Dovi et al., 2004). Excess secretion of proteases, such as the MMPs, capable of degrading essentially all extracellular components and basement membrane proteins, can lead to substantial tissue damage (Barrick et al., 1999). Re-epithelialization requires cells at the wound margin to loosen their ECM and cell-cell interactions in order to migrate across the wound, and MMPs function in part to facilitate this local ECM remodeling during repair (Gill and Parks, 2008). However, excess secretion can induce uncontrolled tissue degradation, including new granulation tissue and growth factors, delaying collagen deposition, so impairing the repair process. These enzymes and others in the wound activate additional enzymes, release growth factors from the cell surface or ECM, cleave cell adhesion molecules from the plasma membrane, and convert wound cytokines into an active or inactive form, contributing to the non-healing phenotype.

ROS released by these cells to fend off infection also inhibits cell migration and proliferation and can cause tissue damage, further exacerbating the problem (Wlaschek and Scharffetter-Kochanek, 2005). The continued production of pro-inflammatory cytokines and chemokines further attract and activate additional inflammatory cells, perpetuating the non-healing condition. The necrotic tissue itself also impairs healing as it provides a rich growth environment for bacteria, increasing the chance of infection and so increasing inflammation in the wound. Endotoxins from the devitalized tissue also inhibit fibroblasts and keratinocytes migration into the wound. For non-healing wounds, increased numbers of immune cells, their secreted bioactive substances, and inflammation can be inhibitory to repair, greatly prolonging healing time.

Research is rapidly providing clues that may allow the subtle harnessing of inflammation to improve the quality of healing. Discovery of the differential...
expression of cytokines and growth factors, such as IL-6, IL-10, platelet-derived growth factor (PDGF) and transforming growth factor-beta (TGF-β), in embryonic and adult wounds, has lead researchers to target altering their levels to recapitulate those found in foetal wounds in an effort to reduce inflammation and make the adult wound environment more foetal-like and improve repair (Liechty et al., 2000; Peranteau et al., 2008).

The up-regulated inflammation-associated genes identified are thought to contain genes that contribute to the negative side effects of inflammation, including retardation of re-epithelialization and fibrosis. One such gene, OPN has now been identified as a good therapeutic target to improve healing. Reducing levels of OPN in wounds has been shown to accelerate healing and reduce granulation tissue formation and scarring. The same study showed OPN is produced by wound fibroblasts in response to PDGF secreted by macrophages and that blocking PDGF receptor signaling reduces OPN levels (Mori et al., 2008). In a separate study, over-expression of PDGF in foetal wounds induced fibrosis (Haynes et al., 1994). Thus, both OPN and PDGF may be good potential therapeutic targets to improve the rate and quality of healing when given at early time points after healing. A number of other proteins have been identified as good targets to influence wound repair, including proteins such as connexin-43 (Coutinho et al., 2005). Reducing connexin-43 in wounds reduces immune cell infiltration to the wound, and leads to enhanced wound healing with a reduced overall area of granulation (Mori et al., 2006). The p38MAPK is a signaling molecule found to influence a whole host of cellular events, including inflammation (Ono and Han, 2005), and inhibit inflammation within the wound and prevent the subsequent apoptosis (Ipaktchi et al., 2006).

5. Inflammation and other diseases

Chronic inflammation induced by biological, chemical, mechanical or physical injuries has been associated with Alzheimer's disease, cancer, obesity, metabolic syndrome, type II diabetes, insulin resistance, frailty, and sarcopenia (Licastro et al., 2005).
B. *Clitoria ternatea* L. – medicinal profile

1. Introduction

*Clitoria ternatea* Linn. is perennial climber, occurs as two varieties – blue flowered and white flowered. The plant is popularly known as butterfly pea or conch flower. *Clitoria ternatea* (CT) is also known as Aparajita, Sankhapsuphi, Girikan, Visnukrana in India. The plant is also known as Blue-pea (Australia); Honte (French); Blaue Klitorie (German); Clitoria-azul (Portuguese); Bejuco de conchitas (Spanish); Cunha (Brazil); Pukingan (Phillippine); Bunga telang (Malaysia). The plant is distributed throughout the tropical countries of the world.

In the traditional Indian system of medicine, CT is known “Aparajita”, and is used in variety of disorders. The drug is also sold under the name of ‘Sankhapsuphi’ and is used as a ‘tonic of the nerves’, and laxative. The leaves and roots are used in the treatment of a number of ailments including body aches, especially infections, urinogenital disorders, and as an anthelmentic and antidote to animal stings. The roots have purgative, laxative and diuretic properties. The roots of blue-flowered variety are aphrodisiac, cures dysentery, sever bronchitis, and asthma. The root is used in the treatment of various diseases, like indigestion, constipation, fever, arthritis, and eye ailments. The roots and seeds are also employed in cases of ascetics, enlargement of the abdominal viscera, sore throat, and skin diseases. They are also demulcent and given in chronic bronchitis. The decoction or powder of root is given in rheumatism, and ear-diseases. The seeds are considered for colic, dropsy and enlargement of abdominal viscera; they are also used in swollen joints. The root, stem and flowers are recommended for the treatment of snakebite and scorpion sting in India. It is one of important constituents of “Misraka sneha”, and “Vata rakta antaka rasa”.

2. Botanical source and geographical distribution

*Clitoria ternatea* Linn. is perennial climber belonging to family: *Fabaceae* (alternatively *Leguminosae*) and subfamily: *Faboideae*. It is also placed in
Figure: 1 Photograph of *C. ternatea* plant showing morphological features.

(A) Twig of *Clitoria Ternatea* Linn.  
(B) Flower with Compound Leaf  
(C) Flower of Blue variety  
(D) Flower of White variety  
(E) Seeds (Good quality)  
(F) Seeds (Poor quality)
family: *Papilionaceae*. It occurs as two varieties—blue one and white one. It is also known as *Clitoria albiflora* Mattei., *Clitoria bracteata* Poir., *Clitoria mearnsii* De Wild., *Clitoria tanganicensis* Micheli., and *Clitoria zanzibarensis* Valke. Botanically the plant can be classified as follows,

<table>
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<tr>
<th>Kingdom</th>
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<tr>
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In India CT is also known as Sankhapuspi, Girikan, and Visnukrana. In the traditional Indian system of medicine, it is known as Aparajita, Koyala (Hindi), Gokarni (Gujarati), Aparajita (Bengali), Dintena (Telugu), Sangu pushpam (Malayalam), and Kakkattan (Tamil).

3. **Morphological and microscopic description**

Root system consists of a fairly stout taproot with few branches and many slender lateral roots. The root is woody, cream white with a few lenticels united to form transverse cracks. The fresh root is slightly bitter and acrid in taste. The transverse section shows outermost phloem composed of 12–25 rows of thin walled longitudinally elongated cells some of which are compressed and a few exfoliating. Phellogen is single layered and phelloderm is two to three layered,
some cells contain rhomboidal crystals of calcium oxalate. Cortex is composed of 10–12 layers of thin-walled almost polygonal or tangentially elongated cells, packed with mostly compound starch grains (Shah and Bole, 1961). Some of the cortical cells contain rhomboidal crystals of calcium oxalate. Central core consists of vascular elements. Phloem appears as conical strands separated by narrow medullary rays. Phloem fibers in groups of two to eight or a few solitary fibers are present. Some of the phloem parenchyma cells contain starch grains and a few others contain calcium oxalate crystals. Woody elements form the major and central part of the root consisting of vessels, wood parenchyma, wood fibers and mostly uniseriate to triseriate medullary rays. Three rays which start from the center are wider and four to five seriate. All the ray cells are fully packed with starch grains and few contain calcium oxalate crystals (Anonymous, 2001; Kalamani and Michael, 2001, 2003). Stems are fine twining, sparsely pubescent, sub-erect at base, and 0.5-3 m long. Seeds are subglobose, oblong or oval, somewhat flattened, 4.5-7 mm long, 3-4 mm wide, 6-11 per pod, brown to almost black, shiny, often mottled, minutely pitted; 23,000 seeds/kg (fig – 1).

4. Phytochemical review

The roots form nodules, which contain higher amount of plant growth substance such as indole acetic acid, kinetin and gibberelic acid. Rajagopalan (1964) investigated the presence of free amino acids and amides in the root nodules. The root nodules contains glycine, alanine, valine, leucine, α-aminobutyric acid, γ-aminobutyric acid, aspartic acid, glutamic acid, γ-methyleneglutamic acid, arginine, ornithine, histidine, and γ-aminobutyric acid. Banerjee and Chakravarti (1963) reported the isolation and identification of pentacyclic triterpenoids, taraxerol and taraxerone from the roots. Kumar et al., (2008) standardized root of CT for Taraxerol content by high performance thin layer chromatography.

The seed contains greenish-yellow fixed oil (Tiwari and Gupta, 1957). The fatty acid content of CT includes palmitic, stearic, oleic, linoleic, and linolenic acids (Husain and Devi, 1998). The seeds also contain a water-soluble mucilage
delphinidin 3,3,5-triglucoside, and three unidentified trypsin inhibitors (Macedo and Xavier-Filho, 1992). Other substances present in the seeds are p-hydroxycinnamic acid, flavonol-3-glycoside, ethyl-α-D-galactopyranoside, adenosine, 3,5,7,4'-tetrahydroxyflavone, 3-rhamnoglucoside, a polypeptide, hexacosanol, β-sitosterol, γ-sitosterol, anthoxanthin glucoside, flutulene, finotin, and flavonol glycoside (Mukherjee et al., 2008).

5. Medicinal and non-medicinal uses

The leaves and roots of CT are used in the treatment of a number of ailments including body aches, infections, urinogenital disorders, and as an anthelmintic and antidote to animal stings. The roots have purgative, laxative and diuretic properties. The root of blue-flowered variety has all the properties of the white-flowered variety, in addition, it is aphrodisiac, cures dysentery, severe bronchitis, and asthma. The root is used in the treatment of various diseases, like indigestion, constipation, fever, arthritis and eye ailments. It is also employed in cases of ascetics, enlargement of the abdominal viscera, sore throat, and skin diseases (Anonymous, 1995). They are also demulcent and given in chronic bronchitis. Though they are purgative, they cause griping and tenderness, and hence are not recommended (Nadkarni, 1976). They are, however, administered with honey and ghee as a general tonic to children for improving mental activities, muscular strength, as complexion tonics, and in epilepsy as well as insanity (Anonymous, 1976). The root-juice of the white-flowered variety is blown up the nostrils as a remedy for hemicrania. The decoction or powder of root is given in rheumatism, and ear-diseases. Powdered seeds are mixed with ginger and given as a laxative; however, this action is accompanied by griping in lower abdomen. The seeds are considered for colic, dropsy and enlargement of abdominal viscera, and are also used in swollen joints (Morris, 1999; Anonymous, 2001). The root, stem, and flower are recommended for the treatment of snakebite and scorpion sting in India (Kirtikar and Basu, 1935). It is one of important constituents of Ayurvedic preparations “Misraka sneha”, and Ph.D. Thesis, June – 2010.
"Vata rakta antaka rasa". In India, the roots and seeds are sold under the name of 'Sankhapushpi' and are used as a "brain tonic".

In Cuba decoction of roots and flowers, is considered emmenagogue. The roots are also used to promote menstruation and induce uterine contractions. The preparation of flowers and roots known as medicamento magnifico (magnificent medicine) is used to treat chlorosis (probably anemia), liver disorders, and intestinal problems. Seeds are said to be laxative, vermifugal, and slightly emetic. Fantz (1991) reported economic uses for 23 species of Clitoria. The seeds are used as antihelminthic (Crevost and Petelot, 1929), diuretic, antidote in poison, and refrigerant (Duke, 1986) as well as in reproductive disorders.

CT is a highly palatable forage legume exhibiting excellent re-growth after cutting or grazing within short period and produce high yields. It yields a useful green fodder throughout the year (Anonymous, 2001). It is also used as a cover crop and green manure. Due to its attractive flower color, it is also grown as an ornamental plant (Michael and Kalamani, 2003). The young shoots, leaves, flowers and tender pods are eaten as vegetable in India and Philippines. In Malaysia, the leaves are employed to impart a green color to food, and the flowers to impart a bright blue color to rice cakes.

6. Pharmacological review

CT has been widely screened for its various pharmacological activities. It has relatively well documented neuropharmacological actions such as enhancing acetylcholine content, nootropic, anti-stress, anxiolytic, antidepressant, anti-convulsant, tranquilizing and sedative activities which justify its use in CNS diseases in Ayurvedic system of medicine. It has antimicrobial, antipyretic, anti-inflammatory, analgesic, diuretic, local anesthetic, anti-diabetic, insecticidal, blood platelet aggregation inhibiting and vascular smooth muscle relaxant properties. Mukherjee et al., (2008) have discussed the pharmacological activities of CT in detail (table – 1).
Table: 1 Pharmacological screening of C. ternatea Linn.

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<tr>
<th>Sr. No</th>
<th>Plant part</th>
<th>Extract / compound(s)</th>
<th>Activity</th>
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<td>1</td>
<td>Roots</td>
<td>Alcoholic extract</td>
<td>Diuretic activity in dogs</td>
<td>Piala et al., (1962)</td>
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<tr>
<td>2</td>
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