INTRODUCTION

Despite extensive strides being made in health science research and health policy research and related areas, the burden of non-communicable diseases reported continues to be alarmingly high around the world, which adds to the public health spending for seeking treatment of these conditions. The latest World Health Organization fact sheet (WHO 2012) reports more that 36 million deaths accountable to non-communicable diseases across the world, out of which 80% occur in low and middle income countries. These countries include India and it is a concern given the fact that this spending exerts a drag on the already fraught Indian economy.

A major part of above reported deaths is directly accountable to cardiovascular and metabolic causes, which are responsible for 18.3 million deaths annually (WHO 2007). The main behavioral risk factors identified by WHO in this regard are all instrumental in precipitating a metabolic and physiological situation which is highly conducive to occurrence of adverse cardiovascular events. Cardiovascular deaths have been projected to rise to 25 million by 2030 (WHO 2012).

Another disturbing trend that has been observed in the face of high prevalence of non-communicable diseases, especially cardiovascular diseases and risk factors, is the characteristic dominance of these diseases in middle aged women, particularly in Indian populations (Ghosh et al 2010, Abbasi et al 2012, Gupta et al 2012). WHO (2009) observes that cardiovascular disease, often thought to be a problem more for males, is the leading cause of death in women, responsible for one third of all deaths in women (Global Health Observatory 2010). The major causative factor for such high prevalence in middle aged women is more often than not, the complex endocrino-metabolic changes that the female body undergoes around menopausal transition (Hart, Charkoudian and Miller 2011).
**MENOPAUSAL TRANSITION**

Menopause is an important physiologic phase and denotes the end of reproductive lifespan in women. Its defining feature is termination of periodic menstrual cycles and it is clinically defined as absence of menstrual periods for at least 12 consecutive months or more (Soules et al 2001). On an average, menopause occurs at the age of 51-52 years (Copeland 1993). The phenomenon of menopause is not a one point event, rather is a gradual endocrinological progression that culminates with stoppage of menstruation. Depending on the clinical stage of menstrual cycles, reproductive stage classification of women categorizes them into either:

- Premenopausal (reproductive/ferile phase),
- Peri menopausal (phase of transition from pre-menopause to cessation of menstrual cycles) or
- Post menopausal (after the menopausal transition is complete and menstrual cycles have completely stopped)

The instrumental factor for occurrence of menopause is the decline in ovarian follicles that are responsible for ovulation and production of sex steroids, including estrogens in women. By middle age, the reserve of ovarian follicles is exhausted and the endogenous estrogen production also declines. This is main hormonal feature that precipitates a range of physiological, biochemical and clinical changes in the female body (Williams 2012). The reason attributable to this occurrence is that estrogen is a key regulator of a wide variety of bodily functions and estrogen receptors are found in a host of organ systems in females. When the estrogen production falls, all these functions suffer estrogen withdrawal effects (Burger et al 2008). These effects range from physiological symptoms to altered metabolic milieu. The symptoms experienced hence are termed as the menopausal syndrome and depending on the system affected are classified into the following
a. Vasomotor symptoms

b. Psychological symptoms

c. Somatic symptoms and

d. Urogenital symptoms

**Menopausal Symptoms**

*Vasomotor Symptoms*: These include hot flashes and night sweats, where the person experiences sudden rise in temperature and feels unusually hot even in cool climates, which results in unusual perspiration as well. Estrogens are involved in major pathways in the temperature regulation center in the hypothalamus; hence estrogen withdrawal leads to vasomotor symptoms during menopause (Freedman 2001). Vasomotor symptoms in Indian populations have been reported to be as high as 56% in North Indian women, while it is 38% in Gujarat (Nair and Chauhan 2006).

*Psychological Symptoms* include irritability, depressed mood, anxiety, sudden mood swings, and crying spells among others. Estrogens are closely associated with neuroeffector mechanisms and the production and functioning of neurotransmitters dopamine and serotonin, which are key mood regulators. Thus loss of estrogens affects dopamine synthesis and reuptake, leading to changes in moods and the psychological equilibrium in general (Glazer et al 2002). Psychological symptoms in Indian women are reported to be around 36.4% (Kapur et al 2009).

*Somatic Symptoms*, interchangeably called as physical symptoms, include most commonly, headaches, joint pain/aches, dizziness and fatigue. Estrogens exert vasodilatory effects on blood vessels; hence during low levels of estrogen, like in menopause, there is concomitant vasoconstriction which often results in headaches (Lucchesi et al 2012). Fatigue is related to lack of sleep due to night
sweats and anxiety spells, and tends to be physical and mental in nature (Moller et al. 2013). Singh (2012) estimated the prevalence of menopause related somatic complaints in Central Indian women from Hyderabad to be 32%. In south India, this figure was reported to be 43% (Bairy et al. 2009).

*Urogenital Symptoms* affect both the urinary system and the genitals, and include urine incontinence, drying and itching in the vagina and decline in sexual drive. The genito-urinary system has a number of estrogen receptors for regulation of various functions, and decline in estrogen leads to atrophy of vaginal muscles and urethral muscles, leading to urine incontinence and loss of secretions in the vagina (Warren, Shu and Dominiguez 2004). Singh (2012) estimated the prevalence of urogenital complaints in India populations to be 15.5%.

In addition to the menopausal syndrome, menopausal transition affects the cardio-metabolic processes, leading to increased prevalence of risk conditions in women and putting them at higher risk of developing adverse cardio-metabolic events. Following are the clinic-biochemical changes brought about by menopausal endocrinological shifts in female biology.

**MENOPAUSAL TRANSITION AND CARDIO-METABOLIC CHANGES**

**Body Composition, Obesity & Osteoporosis**

Sex steroid hormones are known to regulate energy metabolism pathways and hence affect body composition in females (Chen, Brown and Russo 2009). Misso et al. (2005) emphasized the role of androgens and endogenous estrogens in the homeostasis control over energy balance and adipogenesis, in a way comparable to leptin. Bhatia and Wade (1993) demonstrated that estrogens regulate either the activity and/ or the expression of the enzymes/proteins involved in the glucose transport pathway: Glycolysis / glucoegenesis $\rightarrow$ TCA
cycle → MRC-mediated electron transport / oxidative phosphorylation → ATP translocation. Toda et al (2001) demonstrated in mouse model that the absence of estrogen suppresses the mRNA expression of enzymes concerned with fatty acid metabolism: very long fatty acyl CoA synthase, medium chain acyl CoA dehydrogenase and peroxisomal acy-CoA oxidase. Consequently, depletion of estrogen results in an imbalance in the energy balance and frequently leads to obesity after menopause.

With regard to abdominal fat as well, it has been reported that peri menopause has links to increase in the fat depot and its redistribution to the abdomen, which leads to a shift from gynoid to android form of distribution of adipose tissue (Davis et al 2012). Obesity is reported to be prevalent to the order of 31% to 67% (Ebrahim et al 2010; Prasad et al 2011; Midha et al 2011; Gupta et al 2012; Singh et al 2012). The prevalence of abdominal obesity is even higher: 82.3% - 93% (Jyothi and Nayak 2010; Ghosh and Dhagat 2010; Khokhar, Kaur and Sidhu 2010; Singh et al 2012)

Estrogen withdrawal after menopause also affects the skeletal tissues and leads to loss of bone mass. Estrogens are involved in the biological phenomena of bone formation and inactivation of estrogen receptor ERα, resulting in increased bone loss that is not compensated with bone formation (Gallet et al 2013). Epidemiological studies have reported that the menopause, coupled with obesity, puts women at increased risk of fractures, which is an indicator of fragile bones resulting due to bone loss (van der Voort et al 2001). A recent large scale longitudinal study, Global Longitudinal study of Osteoporosis in Women (Compston et al 2011) looked into changes in bone at menopause and by considering endpoint as fractures, reported that post menopausal women had significantly higher number of ankle and leg fractures, particularly obese women, compared to pre menopausal normal weight women. The prevalence of osteoporosis in postmenopausal women in Southern Indian has been reported to be as high as 50% at any site (Paul et al 2008), while in North India, it has been found to be 53% (Aggarwal et al 2011).
**VASOMOTOR INSTABILITY AND HYPERTENSION**

Estrogen receptors are closely linked with vasomotor activities (baroreflex functioning) and central sympathetic activity, imbalance in both of which causes hypertension (Sadeghi et al 2011). Endogenous estrogens and androgens coordinate to enable a balance between vasodilatation and vasoconstriction; loss of this balance, leads to persistent vasoconstriction and eventually in the long run, results in hypertensive states. A number of studies have observed an epidemiological link between menopause and prevalence of hypertension, that suggest causative links between menopausal transition and occurrence of hypertension in women (Freedman and Woodward 1995; James et al 2004; Zanchetti et al 2005; Sadeghi et al 2011). Hypertension in middle aged women in several cities across all zones in India has been found to be ranging between 30%-54.4% (Bharti et al 2011; Meshram et al 2012; Gupta et al 2012; Gupta Deedwania and Achari 2013).

**GLUCOSE HOMEOSTASIS AND DIABETES**

Menopausal transition brings about: distributional body composition changes resulting in substantial increase in visceral fat depot. Abdominal fat depot is regarded as an endocrine organ in itself owing to its ability to secrete adipokines among other substances that are directly linked with metabolic diseases such as insulin resistance, diabetes and the metabolic syndrome. Additionally, decrease in levels of sex steroids leads to increased levels of the transport protein for sex steroid hormones in humans, serum sex hormone binding globulin/ SHBG, as positive feedback mechanism. High circulating SHBG has been found to be a potential independent indicator of risk of developing insulin resistance (Goodman-Gruen and Barret-Connor 1997; Thadani et al 2003; Jayagopal et al 2004) and diabetes (Perry et al 2009). SHBG has been increasingly associated with the pathogenesis of diabetes and cardiovascular diseases (Jorde et al 2006, Ding et al 2009, and Peter et al 2010). In postmenopausal women, SHBG levels
are negatively correlated with an adverse adipokine profile and visceral fat (Wildman et al. 2012).

Diabetes is single handedly responsible for 1.8 million deaths worldwide and the number of people with diabetes is projected to increase from 171 million right now to 366 million in 2030 (Wild et al. 2004). The prevalence of diabetes runs high in Indian populations, with Indian having the second most number of people with diabetes in the world, second only to China (International Diabetes Federation 2012). Bharati et al. (2011) estimated the prevalence in 1370 South Indian women to be 8.5%. Gupta et al. (2012) reported the age adjusted prevalence in 288 North Indian women to be 10.8%. Prasad et al. (2012) reported the crude prevalence in 1178 adults from Eastern India to be 15.7%. Insulin resistance too is found to be high in South Asians, especially Indians. Deepa et al. (2002) reported the prevalence of insulin resistance to be 18.7% in the middle income group in Southern India, while Kumar et al. (2005) found the the prevalence to be 11.8% in 350 adults from North India. Khoo et al. (2011) reported insulin resistance to be higher in Asian Indians compared to Chinese and Malays. Petersen et al. (2006) also reported insulin resistance to be 2-3 fold higher in Asian Indians compared to Eastern Asians, Blacks and Caucasians.

**Lipid Homeostasis And Dyslipidemia**

Endogenous estrogens are known to be linked to lipid homeostasis in addition to lipid and energy metabolism. The pathways through which estrogen modifies lipids and atherogenic mechanisms are believed to be non-genomic and genomic as well (Herman et al 2010). The genomic pathways include transcriptional regulation of genes encoding for athero-protective genes, for example vascular endothelial growth factor and insulin-like growth factor-1 and concurrently downregulating the genes that code for pro-atherogenic states, including interleukin 6 and other inflammatory cytokines. The non-genomic pathways are

Pandey et al (2011) estimated the prevalence of elevated total cholesterol (TC) levels in urban women to be 28%. Gupta et al (2012) reported the prevalence in urban women to be 27%. The most recent documentation of lipid aberrations in Indian women is from a large scale study, Jaipur Heart Watch (JHW), spanning 739 subjects in North India (Gupta et al 2012), which reported the age adjusted prevalence of hypercholesterolemia to be 33% in women while that of low HDL levels was as high as 55.3%.

**INFLAMMATION AND METABOLIC SYNDROME**

Deleterious increases in inflammatory chemokines and adipokines have been observed to have a strong relationship with visceral adiposity during menopause. In a recent animal model study by Kireev et al (2010) it was reported that generation of proinflammatory cytokines IL-1b, IL-6 and TNFa, was higher in liver homogenates of old female rats coupled with a decreased IL-10 concentration, which is anti-inflammatory. The authors found that treatment with 17 β estradiol tended to inhibit the production of proinflammatory cytokines, resulting in reduced levels of marker of oxidative stress.

Estrogens have also been demonstrated to upregulate antioxidant genes in mitochondria in female Wistar rats, resulting in a decreased mitochondrial oxygen free radical production, eventually helping in prolonged longevity in females compared to males (Vina and Borras 2010).

The concurrent metabolic, inflammatory and energy metabolism changes taking place in the female biological system on account of fluctuations in ovarian steroids, puts the woman at a situation where she is at an increased of a cluster of cardio-metabolic risk factors, in other words, the metabolic syndrome. Because of menopausal transition, the above mentioned changes occur concomitantly and precipitate a condition where increased abdominal fat,
increased blood pressure, glucose dysregulation and imbalances in serum lipids co-exist. This has also been confirmed by epidemiological trend of increased prevalence of metabolic syndrome in middle aged women, especially in India. Sinha et al (2012) reported the prevalence to be almost 30% in a study of 300 women in South Delhi. Sawant et al (2010) found the prevalence in Western India to be 19.5% in a study on 548 adults. The highest prevalence reported so far is by Das et al (2011), where the urban women from Eastern India were found to have 57.8% metabolic syndrome prevalence. This implicates that one in every women has multiple risk factors and is at a high risk situation to develop cardiovascular complications.

**Thyroid Hormone Equilibrium And Subclinical Hypothyroidism**

Thyroid hormone regulation may change with changes in reproductive hormone changes. The prevalence of anti-thyroid antibodies and hypothyroidism has been found to increase with menopause (Sawin et al 1985). Thyrotropin (TSH) and prolactin levels were not found to be different between younger and older postmenopausal women, however there was a significant decline in the triiodothyronine (T3) concentration, indicating the stronger role of menopause than aging. The finding that the TSH and prolactin levels were strongly positively correlated over time despite a dramatic decrease in T3 levels led the researchers to deduce a slow intermittent pulsatility of TSH and prolactin and an impaired negative feedback on the hypothalamic-pituitary unit in the elderly menopausal women (Rossmanith et al 1992). Thyroid hormone functioning is also known to be affected by insulin resistance. Topçakal et al (2012) reported an exploratory study on 141 obese post menopausal Turkish women, where it was demonstrated that higher insulin resistance values were associated with significantly higher TSH values (p<0.001), reduced FT3 and FT4 (p<0.05). In Indian women, the prevalence of hypothyroidism is found to be prevalent to the order of 21.4%-37% in adult women (Ray et al 2009, Marwaha et al 2012).
The concurrent increase in the clinico-biochemical changes in middle aged women as seen above corroborates the complex endocrinological links of menopausal transition to cardio-metabolic changes and precipitation of risk conditions in middle aged women. Among these risk conditions, **hyperlipidemia has been found to be the most pressing problem and is highly prevalent in the middle aged female population across India.** This necessitates a holistic remedy which would attenuate the risk situation of Indian middle aged women. In this regard, dietary interventions, focusing on various active bio-molecules have shown positive impact in the management of primary hyperlipidemia, and prove to be the way forward.

**Natural Plant Based Interventions for Primary Hyperlipidemia**

Plant based products have been used in the traditional alternative healing systems since ancient times, before the development of modern medicine. Much of scientific research has also gone into many of these plants and plant products in the past few years and molecular research has helped pave way for the identification of active compounds in these herbs/fruit/plant products that are responsible for the desired effect. These compounds called phytochemicals or phytoneutrients or nutraceuticals, are the cornerstone of recommending natural food and plant products in alternative therapy for disease condition despite availability of synthetic pharmaceutical alternatives. Some of such interventions that have been documented in literature are reviewed below.

The bark of Terminalia arjuna tree (a deciduous tree native to the Indian subcontinent), has been found to contain a huge assortment of phytochemical compounds, namely treiterpenoids, saponins, gallic acid, phytosterols, proanthocyanidins and tannins, among others (Karthikeyan, Sarala Bai and Gauthaman 2003). Two recent systematic reviews on Terminalia arjuna and cardiovascular interventions (Dwivedi 2010; Maulik and Talwar 2012) concluded that there are ample studies which provide for clinical evidence of hypolipidemic
effect of the 1-5g/day of bark of Terminalia arjuna tree in individuals with and
without cardio-vascular complications.

The seed coat of black soya beans (Glycine max L.) has been found to contain
abundance of anthocyanins that have been purported to exert hypolipidemic
actions. Kwon et al (2007) investigated the effect of black soya bean
anthocyanins on rats fed on high fat diet to study the changes in weight and lipid
profile in them. The results indicated a favorable effect of the 10% black soya
bean diet (0.037% anthocyanins) on reduction in weight gain (p<0.05) as well as
significant reduction in serum TAG and TC (p<0.01) and increases in HDL
(p<0.05).

Spices have an important place in the Indian diet, nutritionally too, the role holds
relevance. Many Indian spices have been studied to confer health benefits, one
of the most popular one being turmeric (Curcuma longa). Several in vivo
intervention studies in animal model have demonstrated hypolipidemic activity of
turmeric with significant reductions in TC, TAG and LDL (Dixit, Jain and Joshi
1988; Babu and Srinivasan 1997; Khouri 2006; Jin et al 2011) and the active
compound identified that bestows these benefits is Curcumin (Srivastav 1989,
Khouri 2006). A recent review (Zingg, Hasan and Meydani 2013) studied the
molecular mechanisms of the hypolipidemic action of curcumin. The authors
reported free radical scavenging, induction of signal transduction of the Akt and
AMPK pathways and regulation of expression of genes involved in lipid
homeostasis (HMG-CoA reductase, carnitine palmitoyltransferase-I) to be the
likely mechanisms implicated in molecular and genetic studies reviewed.
Additionally, Jin et al (2011) also reported 23-40% inhibition of cholesteryl ester
transfer protein / CETP activity by 10µg/ml of turmeric extracts to be one of the
hypolipidemic mechanisms.

Artichoke leaf extract has also been speculated to exert hypolipidemic effects. A
recent Cochrane review on randomized controlled trials on artichoke leaf extracts
(Pittler, Thompson and Ernst 2002) on 167 participants reported significant
reductions in TC, TAG and LDL following supplementation with 1800mg artichoke leaf extract (p<0.0001). A yet another Cochrane review of three randomized controlled trials on artichoke leaf extracts (Wider et al 2009) also concluded that the intervention with 1280 mg of artichoke leaf extract has good potential of significantly reducing the serum lipids (p<0.05) in mildly hyperlipidemic subjects.

Various interventions in the Department have also shown positive results with fruits and herbal and botanical products. Iyer et al (2010) investigated the effect of fresh Panchratna juice (made from 50g gooseberry, 10g basil, 5g turmeric, 20g mint and 10g ginger) on 35 diabetic subjects for a period of 45 days, and found a non-significant but noteworthy 3.9% reduction in TC and 13.4% in TAG.

Iyer et al (2009) also found a significant reduction of 5.7% in TC, 9.4% in LDL and 8.3% in Non-HDL following gooseberry (*Emblica officinalis*) supplementation (35g/day) for a period of 60 days in 45 diabetic subjects.

Venugopal et al (2012) studied the impact of subatmospheric dehydrated barley grass powder (1.2g/day) on 59 stable diabetic subjects for a period of 60 days. The results indicated a 5.1% drop in TC, 8.2% decline in LDL and 7.7% fall in non-HDL levels and a rise of 5% in HDL levels, all values being statistically significant. The TAG levels also declined but non-significantly.

Mehta et al in 2007 (unpublished M.Sc. dissertation) evaluated the effect of 3 months of soy supplementation on 20 geriatric individuals and found and significant reduction in TC and significant 10% rise in HDL.

Mani et al (2011) conducted an open label supplementation study on flax seed (*Linum usitatissimum*) powder (10g/day) on 29 diabetic subjects for a period of one month. The authors reported a non significant reduction of 14.3% in TC, 17.5% in TAG, 21.8% in LDL and apolipoproteins B and an 11.9% increase in HDL at the end of the supplementation.
Nambiar et al (2010) reported hypolipidemic effects of dark chocolate supplementation (50g/day) for a period of 1 month in 40 healthy individuals. The supplementation saw a 12% reduction in TC, 17.7% in LDL and a 20% fall in non-HDL (p<0.05).

Thus among the many foods that have shown a hypolipidemic action, the ones that have been extensively investigated and proved to be beneficial include gooseberry, basil, flax seeds, soya bean and cocoa, among many others.

Thus, food and plant based natural interventions show promising results in treating hyperlipidemia, on account of their excellent phytochemical content. One such similar natural product popularly used for various ailments in the alternative healing systems is wheatgrass, which also hold promising possibilities to alleviate hyperlipidemia, on account of its nutraceutical content.

WHEATGRASS (Triticum aestivum) – THE WONDER HERB OF AYURVEDA

Wheatgrass is prepared from the cotyledons of the plant common wheat. Botanically, the grass of the wheat belongs to the family Poaceae (grass family) and the genus is Triticum (wheat), the species being Triticum aestivum (common wheat), thereby having the botanical name Triticum aestivum. It is an annual plant that grows to 4 feet in height and resembles any other grass.

The grains of wheat have been traditionally used in the ancient Indian system of healing, Ayurveda and the documentation of its uses is found in ancient Hindu treatise on medicine and healing, the Charaka Samhita, compiled by the Indian physician, Charaka.

In modern history, the use of wheatgrass was popularized by Anne Wigmore, in the 1950s, when advocated and started healing cancer patients with wheatgrass
juice. Later on she went ahead and started the Hippocrates Health Institute in 1961 to aid her wheatgrass therapy.

Qualitatively wheatgrass has been found to contain a huge variety of phytochemical compounds: Saponins, gums & mucilages, fructo oligosaccharides, phenolic compounds, sitosterols, triterpenes, hydroxycinnamic acids were found in the aqueous extracts of wheatgrass (Tulloch and Hoffman 1973; Carpita 1989; Estiarte et al 1999; Shirude 2011; Kothari 2011). Even more phenolic compounds are found in the alcohol extracts of wheatgrass: 834 to 1206mg per kg of hexane extracts of wheatgrass by weight is phytosterols, of which, 74% is β-sitosterol, and remaining constituents include campesterol and stigmasterol, all of which have been associated with hypolipidemic action (Dunford, Irnak and Jonnala 2009).

The mineral composition of wheatgrass indicates presence of silicon, phosphorus, calcium, potassium, chlorine and sulphur (Hodson and Sangster 1988). Enzymes carboxypeptidases have also been found in wheatgrass (Mikola 1986). A diverse variety of antioxidant compounds that have been found in wheatgrass include α tocopherol, β carotene, glutathione, in addition to the phenolic compounds stated above (Bartoli et al 1999); and antioxidant enzymes catalase, ascorbate peroxidase, glutathione reductase, superoxide dismutase and glutathione peroxidase, in addition to the enzyme that produces endothelium protective nitric oxide: nitrate reductase, have been detected in young leaves (Rosales et al 2011, Devi, Kaur and Gupta 2012; Duke 2013). The nutrition content of wheatgrass is depicted in Table 1.1

Therapeutic value of wheatgrass has been investigated by several authors in relation to conditions like ulcerative colitis, anemia, thalassemia, iron overload, myelodysplastic syndrome, chemotherapy induced myelotoxicity, hyperglycemia, insulin resistance, oxidative stress, among others, but less so in case of hyperlipidemia.
<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount per 100g</th>
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<tbody>
<tr>
<td>Calories</td>
<td>500 kcal</td>
</tr>
<tr>
<td>Fat</td>
<td>0 g</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>66.7 g</td>
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<tr>
<td>Dietary Fiber</td>
<td>33.4 g</td>
</tr>
<tr>
<td>Protein</td>
<td>33.4 g</td>
</tr>
<tr>
<td>Amino acid score</td>
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</tr>
<tr>
<td>Vitamin A</td>
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</tr>
<tr>
<td>Vitamin C</td>
<td>233 mg</td>
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<tr>
<td>Vitamin D</td>
<td>~</td>
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<tr>
<td>Vitamin E (Alpha Tocopherol)</td>
<td>10.7 g</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>1.17 mg</td>
</tr>
<tr>
<td>Thiamin</td>
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<tr>
<td>Riboflavin</td>
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<tr>
<td>Niacin</td>
<td>8.4 g</td>
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<tr>
<td>Vitamin B6</td>
<td>1.3 g</td>
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<tr>
<td>Folate</td>
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<tr>
<td>Vitamin B12</td>
<td>3.3µg</td>
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<tr>
<td>Pantothenic Acid</td>
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</tr>
<tr>
<td>Choline</td>
<td>166 mg</td>
</tr>
<tr>
<td>Calcium</td>
<td>500 mg</td>
</tr>
<tr>
<td>Iron</td>
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</tr>
<tr>
<td>Magnesium</td>
<td>130 mg</td>
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<tr>
<td>Phosphorus</td>
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</tr>
<tr>
<td>Potassium</td>
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</tr>
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<td>Sodium</td>
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<tr>
<td>Zinc</td>
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<tr>
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<td>56.7 mg</td>
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<tr>
<td>Manganese</td>
<td>4.7 g</td>
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<td>Selenium</td>
<td>116 mg</td>
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</tbody>
</table>

Source: Self Nutrition Data 2012
Kothari and co-workers (2008) investigated the hypolipidemic effects of wheatgrass in rat model by administering 5ml and 10ml/kg of wheatgrass juice for a period of 21 days to normocholesterolemic rats. The supplementation resulted in dose dependant significant decline in the levels of total cholesterol (TC), triacylglycerols (TAG). Low density lipoprotein cholesterol (LDL) and very low density lipoprotein cholesterol (VLDL). It also resulted in non-significant increase in the high density lipoprotein cholesterol (HDL).

The same authors replicated the experiment in hyperlipidemic rats (Kothari et al 2011). The duration of the supplementation was reduced to 14 days, but still, the rats fed with 10ml/kg of fresh wheatgrass juice demonstrated significant reduction in TC, LDL, TAG and VLDL. The authors also reported an increased fecal fat excretion, indicating that the mechanism through which wheatgrass renders hypolipidemic effect is inhibition of cholesterol absorption in the gut.

Shirude (2011) conducted a rat model study to investigate the hypoglycemic properties of wheatgrass. Wheatgrass was administered at100mg/kg for a period of 14 days to hyperglycemic rats; parallel gliclazide and control group were also maintained. The results revealed that wheatgrass showed significant (p<0.05) reduction in the blood glucose levels of the supplemented rats, comparable to gliclazide.

With regard to wheatgrass’s anti-inflammatory role in ulcerative colitis, Ben-Arye et al (2002) conducted a randomized placebo controlled trial on twenty three patients with distal ulcerative colitis, where patients in the experimental group were supplemented with 100ml of wheatgrass juice for a month. The intervention resulted in significant reduction in the disease activity index (p<0.05) and the rectal bleeding (p<0.05), exhibiting antioxidant healing properties in inflammation states.

The sole human trial conducted on wheatgrass targeting hyperlipidemia, is by Shyam et al (2007), which investigated the efficacy of 500mg wheatgrass for 30 days in attenuation of oxidative stress in adult subjects. The findings reflected
that wheatgrass supplementation resulted in significant decline in the malondialdehyde levels (p<0.05), which is a marker for oxidative stress; and a parallel increase in the antioxidant ascorbic acid levels and superoxide dismutase levels.

Studies conducted in the department on wheatgrass have focused on its effects on alleviating anemia. Iyer et al (2010) evaluated the acceptability and lipemic responses of wheatgrass incorporated common Indian recipes. It was found that the level of incorporation at which the recipes were most acceptable was 15g of wheatgrass per serving of the recipe. At this level, incorporation of wheatgrass also reduced the lipemic responses of the recipes with the rise in serum TAG after ingestion of the recipe to be around 1.5 to 32%.

Sharma et al in 2001 (unpublished M.Sc. dissertation) investigated the impact of 100ml wheatgrass juice supplementation on 80 adult women for a period of 30 days and found a significant increase 0.85 g/dl (p<0.05) in the mean hemoglobin levels of the supplemented group.

It can be inferred from these studies that the extent of clinic biochemical changes in Indian middle aged from different parts of India is alarming and hence the need of the hour is a comprehensive remedy that targets the complex endocrinological changes that occur in middle aged women. For this different food and plant based interventions have been evaluated, but their efficacy has not been established by a judiciously designed trial. Therefore more research is needed to investigate and explore the benefits and toxic effects of natural plant products and their utility to manage cardio-metabolic risk conditions.

Evidently, the above review leaves behind certain research questions that need to be addressed. Following are some of them:
1. What is the burden of cardio-metabolic risk conditions and menopausal symptoms in Indian menopausal women, who are in different stages of menopause?

2. What is the distribution of these risk conditions in a free-living population vis-à-vis a population that attends a clinical health check up facility?

3. Which is the most pressing problem in the menopausal women, with regard to cardio-metabolic risk factors/conditions?

4. How prompt are the health-seeking practices of Indian middle aged women when faced with a cardio-metabolic risk condition?

5. What are the longitudinal trends in the anthropometric indices and blood pressure values of Indian menopausal women?

6. What is the nutritional content of freeze dried wheatgrass?

7. Can wheatgrass powder in a freeze dried from be used as a functional food, by incorporating it in common Indian recipes?

8. What would be the acceptability of recipes that would have been developed by incorporating freeze dried wheatgrass powder?

9. How effective would freeze dried wheatgrass powder be, for the management of primary hyperlipidemia in Indian menopausal women?

Consequently, the present set of studies was planned to address the above questions, with the following main objectives:

1. To study the extent of metabolic derangements in pre, peri and post menopausal women in a free-living population and in women who attend a health check up facility.

2. To study the longitudinal outcomes of a health check-up after a period of 2 years, with regard to health seeking practices and anthropometric indices and blood pressure levels.
3. To analyze the nutritional quality of wheatgrass powder, incorporate it in different recipes as a functional food and evaluate the acceptability of these recipes.

4. To investigate the impact of wheatgrass powder supplementation on lipoprotein status and menopausal symptoms in primary hyperlipidemic women.