Review of relevant literature formulates a base for any scientific research. It provides the investigator an insight for deeper exploration on the subject and opens new ways for study. The review makes the researcher aware about the methods and content of the problems already investigated, presents a diagnostic approach & prepares a solid foundation for the new to be undertaken.

Non communicable disease epidemics are emerging or accelerating in most developed countries and cardiovascular diseases, cancer, diabetes and chronic obstructive pulmonary diseases are becoming major contributors to the burden of disease. India too illustrates the phenomenon of health transition which positions NCD’s as a major public health challenge of growing magnitude in the 21st century.

The present investigation is designed to study the effect of Spirulina on hypertensive and diabetic subjects to overcome this problem.

A wide range of work has been done at different levels to combat these diseases, therefore, related information from rural and urban areas is documented here for detailed analysis. The literature cited during research programme has been discussed and a paraphrased version under suitable sub-caption is arranged, as effects of various variables on health status with special reference to hypertension and diabetes, such as - Dietary habits, Age and sex, Dietary factor that control these diseases and Effect of Spirulina supplementation.

2.1 DIETARY HABITS –

W. L. Miller et al. (1992) studied the relationship between diet diversity and hypertension in a cross sectional exploratory study of 82 randomly
selected adults of Saba Island. A 24 hour dietary recall semi quantitative food frequency interview was used to calculate diet diversity, a measure of overall dietary pattern. Results suggest that hypertension is associated with lack of an overall balance of food groups in the daily diet beyond any imbalance of a particular dietary cation such as sodium, potassium or calcium.

Obesity is one of the nutritional problems in the world. It is defined as body weight more than 20% above the desirable weight. It is a disorder of energy balance, intake and expenditure. An imbalance in favour of intake results in surplus calories that cause increased fat synthesis and deposition in the body. Researches indicate that obesity epidemic is due to increased energy intake (diet) as a primary cause and physical inactivity as a contributory factor Whitney E. N. et al. (1984). Obesity itself is a disease and is a single contributing factor to the development of non communicable diseases like hypertension, diabetes mellitus, coronary heart diseases, hyperlipidemia, respiratory disease, gout, hyperthyroidism, arthritis etc. Khurram M. et al. (2006).

Sabina Aziz Asif et al. (2009) conducted a study to find out the prevalence of obesity in males in six socio-economically diverse areas of Peshawar and its relationship to energy intake and physical activity. They found the prevalence of obesity in males was 7% and overweight 34%. The respondents in urban area consumed 160 Kcal/day/person more than respondents in rural areas. Calories consumed constituted of 11-12% of proteins 32-33% carbohydrates and 50-56% fats.

Swinburn et al. (2004) stated that risk factors for obesity were sedentary life style and a high intake of energy dense micronutrient poor foods. The calories consumed were predominantly carbohydrates such as bread, rice and potatoes and fat consumption was high as all foods were cooked in ghee or
oil. Vyas et al. (2003) found that Pakistani men & women had the highest intake from carbohydrates.

2.2 DIETARY FACTORS WHICH PROTECT AGAINST HYPERTENSION AND DIABETES

Neal (2010) investigated whether a low fat vegan diet improves glycemic control and cardiovascular risk factors in individuals with type 2 diabetes. Individuals (n=99) were randomly assigned to a low fat vegan diet (n=49) or a diet following the American Diabetes Association (ADA) guidelines (n=50) for 22 weeks.

43% of the vegan group and 26% of the ADA group participants reduced diabetes medication. HbA1C decreased 0.96% points in the vegan group and 0.56% points in the ADA group, body weight decreased 6.5kg in vegan group and 3.1kg in the ADA group.

Vegan diet – (10% of energy from fat, 15% protein and 75% carbohydrate) consisted of vegetables, fruits, grains and legumes, animal products and added fat intake is avoidable. Beans and green leafy vegetables, low glycemic index foods are favoured. Portion sizes, energy intake and carbohydrate intake were unrestricted.

ADA diet - 15-20% protein, <7% saturated fat, 60-70% carbohydrate and monounsaturated fat and cholesterol ≤ 200 mg/day.

A low fat plant based diet influences nutrient intake and body composition. They affect insulin sensitivity because such diets are low in fat and high in fibre and they typically cause associated reductions in dietary energy density and energy intake Howarth N. C. et al. (2001).

Hua, N.W. et al. (2001) suggest that reduction in iron stores increase insulin sensitivity. A vegan diet provides iron in its nonheme form which is
somewhat less absorbable than heme iron. A study comparing 30 ovolacto vegetarians and 30 meat eaters showed that vegetarian had adequate but lower body iron stores compared with meat eaters. The vegetarians also demonstrated less insulin resistance.

Jenkins D. J. et al. (1987) stated that lipid lowering effect of vegan diets is attributable to their absence of dietary cholesterol, low saturated fat content and a specific cholesterol reducing effect of soluble fibres and other plant constituents is particularly important because cardiovascular complications are the primary cause of morbidity and mortality in diabetes. Diets high in refined carbohydrate increase triglyceride concentration. High fibre and low glycaemic index foods have opposite results.

Studies also suggest that vegan diet can be extremely beneficial for hypertensive patients also. One study involving 59 healthy omnivores revealed that both systolic and diastolic pressure fell when they ate a vegetarian diet. http://www.internetthehealthlibrary.

Foods rich in magnesium such as green vegetables, whole grain, nuts and yeast extracts help to normalize blood pressure.

Many researchers believe that reduced salt intake can help lower blood pressure. Adequate calcium and magnesium intake is instrumental in lowering blood pressure. Experts worldwide claim that 2 to 5 grams of salt daily does not pose any problem for most people. 90% of salt consumed is from food and 10% from water. American Heart Association and the WHO recommended limiting the sodium in drinking water to 20 mg/l. Better Nutrition (1990).

Denis Louran et al. (2005) examined the relation between the source and type of dietary fibre intake and cardiovascular disease risk factors. They concluded that high total dietary fibre and insoluble dietary fibre intakes were associated with a significant lower risk of overweight and blood
pressure etc. Soluble dietary fibre was less effective. Cereal, vegetables, dried fruits, seeds and pulses are good sources of fibre. Vasanthamani G. et al. (2000) conducted a study on ‘Incidence of disease in relation to type of plant oil consumption’. 50 adult male subjects of 25 to 55 years of age were selected. Adults consuming coconut oil had highest values of total cholesterol, triglycerides and very low density lipoproteins, while the lowest total cholesterol value was registered in adults consuming gingili oil. The incidence of diseases was minimum in the groundnut oil consuming subjects. It was found that plant oil consumption up to 30-50 gm per day does not produce adverse effects in serum lipid levels.

Ramadas S.V. et al. (2000) conducted a study on consumption pattern of fats and oils and serum lipid profile of selected adults. Results revealed that among the vegetarian coconut oil consumer coconut kernel with the fibre content had a beneficial effect. Fish consumption in coconut oil consumer did help in the maintenance of serum lipid profile. Hence population groups consuming coconut oil can have the oil consumption of 30 gm/day preferably with inclusion of coconut/fish in their diet.

Kochar G.K. (2000) conducted a study on effect of additional intake of milk on blood pressure and on plasma cholesterol. The study indicated that cream less milk and its products had hypocholesterimic effects only in hypertensive subjects and not in normotensive subjects.

2.3 AGE & SEX

Jaquet F et al. (1998) studied the effect of age and gender on ambulatory blood pressure patients. The result showed that blood pressure was higher in the elderly women than in the young group. In comparison to the young subjects both elderly men and women had higher diastolic blood pressure. Blood pressure variability while subjects were awake was higher in elderly, particularly in women. The higher levels of blood pressure variability
found in the elderly women indicate relatively higher risk of end organ damage such as silent cerebrovascular damage.

Alireza E. Steghamati et al. (2006) conducted study to determine the presence of diabetes mellitus and other coronary heart disease risk factor (cigarette smoking, hypertension, hyperlipidemia) in patients with acute coronary events. The study included 514 patients with myocardial infarction. The results showed-

a) Diabetic patients were older than non diabetic.
b) Diabetic patients were more hypertensive and had higher serum triglyceride.
c) Diabetes was more frequent among women than men and women were older than men.
d) 97% of all patients had at least one cardiovascular risk factors i.e. hypertension, smoking diabetes, high cholesterol & low HDL cholesterol level.

2.4 EFFECT OF SPIRULINA –

Aldo Ferreira et al. (2010) studied the hepato protective effects of spirulina maxima in patients with non alcoholic fatty liver disease. It has been proven in vivo and in vitro having hepato protective properties by maintaining liver lipid profile. They considered Spirulina maxima as an alternative treatment for patients with dislipidemic disorder. Results showed that initial hypercholesteremia prevalence was 27.8% but it was diminished after oral Spirulina administration for six weeks to 13.9%. The initial prevalence of hypertriacyl glycerolemia was 41.7% which was reduced to 22.2% after supplementation.

Ble-Castillo J.L. et al. (2002) conducted studies on rats using intra peritoneal dose of ccl₄ (Carbon tetra chloride) in a dose of 2 mg/kg as a hepato-toxin, they found that when the diet of rats was supplemented with
5% spirulina maxima, decrease in liver triacylglycerols (TAG) and total cholesterol (TC) was observed, same pattern was observed in level of free fatty acids. These results suggest that spirulina has hepato protective properties through decrease in lipid profile and lipo peroxidation products.

Torres Duran P.V. et al. (2007) demonstrated anti-hyperlipidemic and antihypertensive effects of spirulina, although the exact biochemical mechanism by which spirulina reduces lipid levels was not well understood.

Nagoaka et al (2005) have presumed that its high C-phycocyanin content inhibits pancreatic lipase activity. Its C-phycocyanin content is also presumed to act together with glycolipid haemoglobin (Hb)₂ leading to a decrease in Jejunal cholesterol absorption and ileac bile acid re-absorption.

Chobarian A. V. et al. (2003) studied high blood pressure prevalence in total 36 samples before and after treatment with spirulina (4.5 gm/day for 6 weeks). The results showed that initial hypertension type 2 prevalence was 14% but it was diminished after the treatment to 3%, where as hypertension type 1 prevalence was diminished from 31% to 11%. Prevalence was analyzed by gender also. The results showed an initial prevalence of stage 1 of hypertension in both male and female population (30 and 31% respectively) was decreased after treatment (6% and 15% respectively) and in case of stage 2 of hypertension prevalence in men was decreased from 6% to 0% and in females was reduced from 20% to 5%. According to 7th report of JNL, patients with pre-hypertension and hypertension in any stage, have to include in their treatment a balanced diet & exercise.

Hee Jung Park et al. (2008) conducted a randomized double blind, placebo controlled study to establish the effect of Spirulina in elderly Koreans. 78 individuals between 60-87 years of age were randomly assigned in a blinded fashion to receive either Spirulina or placebo. The elderly were instructed to consume 8 gm/day for 16 weeks. The results demonstrated that
Spirulina had favourable effects on lipid profiles, Immune variables and antioxidant capacity in healthy elderly male and female subjects and is suitable as a functional food.

Scientists from the institute of human performance & rehabilitation in Greece found that supplementing the diet with Spirulina improved running capacity by 30% thus extending the time of exhaustion significantly. It also increased (a) fat oxidation, (b) reduced carbohydrate oxidation during an hour run, (c) reduced oxidative stress due to increased antioxidant activity.

The study utilized nine moderately trained individuals in a placebo controlled cross over study where the subjects received Spirulina supplementation or placebo for four weeks. The experiment was then repeated, the subjects who received placebo, received Spirulina and vice versa. Before and after supplementation all the subjects ran on a tread mill at 70-75% VO$_2$ maximum for two hours and then 95% VO$_2$ maximum to exhaustion. This study supported a previous study from the sports science research centre of the national Taiwan college of physical education which showed that supplementation with spirulina prevented skeletal muscle damage Amha Belay (2010).

Richard Kozilenko and Ronald H. Henson (2006) indicate that Spirulina can prevent cancers in human and animals; inhibit AIDS virus and improves immune system.

M.C. Paredes-Carbajal et al. (1998) studied effects of Spirulina on vasomotor response from rats fed a fructose rich diet. The results suggest that fructose increases vaso constricting metabolites and dietary Spirulina is able to prevent these effects.

Researches on animals indicate that Spirulina inhibits allergic reactions, increases antibody response and the activity of cells that destroy infected and cancerous cells. Researchers found Spirulina significantly stimulated the
cytokine interferon-g and moderately stimulated two other cytokines interleukin 4 and interleukin 1b. Interferons interfere with the ability of the virus to reproduce and interleukin stimulate growth and activities of white blood cells.

**INDIAN STUDIES**

Premkumar et al. (2004) found that Spirulina fusiformis protects against chemical induced genotoxicity in mice and increases the activity of cellular antioxidant enzymes like superoxide dismutase, catalase and glutathione peroxidase.

Parikh P. et al. (2001) studied the effect of spirulina supplementation at 2 mg/day dose for two months on blood glucose levels, glycosylated haemoglobin and lipid profile of twenty five diabetic type 1 subjects. They found a lowering of fasting, post-prandial blood glucose levels and in the HbA1C level. In another study, glucose level was kept stable during the period of study and change in lipid profile was observed. The result demonstrates a reduction of TAG (triacetyl glycerol) & TC (total cholesterol).

Samuel R et al. (2002) also observed similar effects in patients with hyperlipidemidic nephrotic syndrome after supplementation with Spirulina (1 gm/day) for 2 months.

Anuradha V. et al. (2000) carried out study to see the impact of supplementation of Spirulina on lipid level of hyperlipidemic subjects. 18 male hyperlipidemic subjects with cholesterol level of 240 mg/dl (age 40-60 years) were selected and were divided into three groups, group I was control, to group II 2 gm of spirulina and to group III three gram of spirulina was supplemented for one month. There was a significant reduction in total cholesterol, triglycerides, LDL cholesterol and VLDL cholesterol after the supplementation period. This shows hypolipidemidic effect of Spirulina.
Fatima Kausar et al. (2001) studied the effect of Spirulina as a nutritional supplement on malnourished children. 20 malnourished children in the age group of 6 years were divided into 2 groups, 10 as experimental and 10 as control. Experimental group was given Spirulina (1gm/day) for 3 months and the control group was given placebo for the same period. Results showed that there was an increase in the serum haemoglobin and protein level in the experimental group after supplementation. There was also a definite change in the academic performance and intelligence level of children after supplementation. The difference in intelligence in the control group was not significant.

Seshadri E.V. et al. (1999) carried on a limited study on young women with hypochromic anaemia involving Spirulina administration (4 gm/day) for 30 days which increased the haemoglobin content by 2.1%. Dietary supplementation of Spirulina fusiformis at 2 gm/day on 20 subject over a period of 30 days showed 10% increase in haemoglobin content at the end of the study period.

Uliayar M et al. (2000) carried on study on 16 young (19-22 yrs) and old women (40-45 yrs). They were supplemented with Spirulina fusiform for 6 weeks. Results showed no significant change in haemoglobin levels but helped considerably in removing the symptoms of dysmenorrhoea.

Anuradha V. et al. (1999) studied the effect of Spirulina on blood pressure levels of selected hypertensives of Coimbatore city. 40 samples between 40 to 55 years who were not consuming any antihypertensive drug (freshly detected cases) were selected. Spirulina capsule was supplemented to the experimental group (3gm/day) for a period of 60 days. The study indicates that there was a significant reduction in the weight of the subjects. Spirulina had reduced the systolic and diastolic pressure in the experimental group.
after the study. The difference was significant at 1% level. In the control group there was no significant reduction.

Arodhyulu R.K. (1998) conducted experiment on 28 human subjects with Spirulina supplementation (4.2 g/day) which showed reduction in serum cholesterol level especially in subjects with higher initial levels and improved atherosclerosis index. He also reported that spiro zen capsule containing Spirulina powder play a vital role in reducing hypertension and is also a good source of nutrition. It has a unique blend of all the nutrients which contribute to lower the blood pressure and contains polyunsaturated fatty acids including gamma linoleic acid that reduces blood cholesterol.

Anuradha V. et al. (2001) studied the impact of administration of spirulina on the blood glucose levels of selected diabetic patients. 20 males and 20 females freshly detected diabetes patients in the age group of 40 to 60 years with fasting glucose levels between 120 and 160 mg/dl were selected for the study. 4 gm of Spirulina/day for a period of 60 days was administered to experimental group.

Results show that there was a significant decrease in body weight (at 1% level) and body mass index among both male and female patients. There was also a significant decrease in fasting/post prandial and random blood glucose levels. This proves that Spirulina has a hypoglycemic effect on non insulin dependent diabetics.

Arora et al. (1996) studied hypocholesteremic effect of Spirulina and found that high gamma linoenic acid content (3.4%) of Spirulina prevents accumulation of fat and cholesterol in body.

Ramamurty et al. (2002) of Avinashilingam institute of home-science Coimbatore India tested Spirulina on patients with high cholesterol and ischemic heart disease, they concluded that it plays a key role in lowering
blood cholesterol levels and improving lipid profiles [http://www.relte.com (2002)].

Palta A. et al (2006) studied the effect of Spirulina on weight and blood pressure levels of selected hypertensives in Raipur city. 30 male and 30 female subjects suffering from hypertension and not any anti-hypertensive medicine were selected. The subjects were divided into two groups i.e. experimental and control group. Experimental group was given 3 gm. of spirulina supplementation for 90 days. The study revealed that significant reduction in blood pressure level was seen in experimental group. Weight loss was also evident though the reduction in weight was not significant.

The review of literature indicated that most of the studies were conducted in western situation so an attempt has been made by the researcher to study the effect of Spirulina supplementation on blood glucose and blood pressure levels of selected diabetic and hypertensive subjects.

A 100% natural product grown under controlled conditions without use of pesticides will definitely be useful in combating disease like overweight, diabetes and hypertension.

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