EFFECT OF SUPPLEMENTATION OF WHEAT GERM, WHEAT BRAN AND WHEAT GRASS TO SUBJECTS WITH SPECIFIC HEALTH ISSUES

UGC MINOR RESEARCH PROJECT No.F33-439/2007(SR)

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2008 – 2010

ACKNOWLEDGEMENT

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The investigators record their sincere thanks to **Thiru.T.K.Shanmuganandam,B.A.,B.L, Chancellor,** Avinashilingam University for Women, Coimbatore, for providing the infrastructural facilities and all the amenities for the conduct of the study.

The investigators are indebted to **Hon. Colonel Dr. (Tmt.) Saroja Prabhakaran, M.A., Dip. Ed. (Madras), Ph.D., (Mother Teresa), Vice Chancellor,** Avinashilingam University for Women, for providing all the facilities required for the conduct of the study.

The investigators record their gratitude to **Dr. (Tmt.) Gowri Ramakrishnan, M.Sc. (Madras), M.Phil., Ph.D. (Avinashilingam), Registrar,** Avinashilingam University for Women, for extending all possible help for the smooth conduct of the study.

The researchers express their sincere thanks to **Dr. (Tmt.) G.Krishnabai, M.Sc., Dip.Ed., M.Phil. (Madras), Ph.D., (Mother Teresa), Dean, Faculty of Home Science,** Avinashilingam University for Women, for her constant help and support in this investigation.

The investigators express their heartful thanks to **Tmt.S.Radha Devi,** M.Sc. (Kerala), Dip.Ed., M.Phil.,(Madras), Associate Professor, Department of Food Science and Nutrition, Avinashilingam University for Women, for her valuable suggestions and help rendered throughout the study.

The investigators are highly indebted and grateful to all the subjects for their co-operation rendered in the conduct of the survey.

The investigators gratefully acknowledge the University Grants Commission. New Delhi, for sanctioning this minor research project and providing financial assistance.

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INTRODUCTION

I. INTRODUCTION

Health is considered as a fundamental human right and a worldwide social goal. It encompasses all humans disregard of age. Geographical conditions, culture, economic status and life style of people have major impact on their health. Thanks to scientific advancements that the life style of the people is tremendously metamorphosing and their physical activities are getting minimal. The food style is not in conformity to the accustomed geographical or cultural conditions. This results in a wide range of health issues visibly seen as obesity, diabetes and related diseases. If this is the scenario midst the affluent population, malnutrition and low immunity - perpetuating secondary diseases are abounding with the poorest of the poor of the population.

In such a context, there arises an essentiality for a study addressing the entire gamut of issue through one single medium. With this as the setting to the research problem, the investigator chose to unravel the utility of wheat as the medium, fine tuning to the questions of addressing the health issues of Indian population, of both the affluent and the have-nots. Much not known components of wheat produce such as wheat bran, wheat germ and wheat grass are the subjective components of study as the investigator came across astounding facts of their nutritive values and medicinal potentials in the researcher's pilot studies conducted. The quintessence of the intended investigation rests upon the immense medicinal potential and nutritive value of wheat produce viz, wheat germ, wheat grass and wheat bran as they are capable of addressing the health of malnourished as well as obese population: a commonly seen amalgamation in all developing countries especially as ours. As a pioneering study the researcher sets out to study the effect of supplementation of wheat germ, grass and bran in subjects with specific health issues.

Prima facie, the present study warrants for a multi-disciplinarian approach: Physicians for identification of patients; biochemists for making critical analysis of the outcome of the result while the investigation rests on the pedestal of Food

Science and Nutrition. The scope of the study not only confines to laboratory investigations but to the community on the whole. That wheat is a familiar crop and thrives well in Indian climatic conditions; the cost-effectiveness for even a state sponsored supplementation of the proposed recipe to the poor population could be well affordable in the existing economy. As such the present study attains not only a discipline oriented relevance but also a valid social relevance.

Wheat germ

Long-term studies in the Department of Internal Medicine, Washington University, St.Louis on consumption of wheat germ by hypercholesterolemic human subjects have shown the beneficial effects on plasma lipids and lipoproteins. Through this investigation, the hypothesis has been validated with respect to hyperchlosterolemic population only. Wheat germ has brought about a decrease in the lipid profile without altering biomarkers of bone metabolism in postmenopausal women. Laboratory experiments at National Institute of Health and Medical Research, Marseille, France have proved that fermented wheat germ extract has reduced chemotherapy-induced febrile neutropenia in pediatric cancer patients. Wheat germ supplement reduces cyst and trophozoite passage in people with giardiasis. The bioavailability and possible benefits of wheat germ intake naturally enriched with selenium and its products is proved to be a boon to the decrease in symptoms of serenity.

Wheat bran

Studies at the Department of Pediatrics, School of Medicine, Semmelweis University, Hungary on wheat bran have identified the preventive potential of wheat bran fractions against experimental colon carcinogenesis. After meticulous study it has been concluded that wheat bran has human colon cancer preventive properties. Wheat bran and oat bran has effectively reduced oxidative stress induced by high-fat diets in pigs. Study on the effect of wheat bran fiber supplementation on bone loss in older people has concluded that it made no significant change. The supplementation of wheat bran to improve risk profile in patients with dysmetabolic cardiovascular syndrome has yielded significant positive impact. It is found that consumption of wheat fibre resulted in a significant decrease of systolic and diastolic blood pressure and glucose. Suppressive effects of dietary fiber in wheat bran fibre on the postprandial serum lipid levels in healthy adult male volunteers have been recorded experimentally. Oxidative stress and metabolic shifting for cardiac health on supplementation of wheat bran fibre to selected adults has been proved. Studies have also asserted that dietary fibre supplementation, rather than energy intake and dietary restriction, appears to be the main process retarding oxidative stress in cardiac tissues.

Wheat grass

Studies from the Department of Food Science and Nutrition, Clemson University, South California have identified that chlorophyll present in wheat grass had the potential to neutralize infections, heal wounds, overcome inflammations and get rid of parasitic infections. Through investigations, it has been found that wheat grass is an excellent source of vitamin C, E, beta carotene and vitamin B. It is also said to contain 90 different minerals, 19 amino acids and more iron than spinach and more protein than meat, fish, egg, beans or dairy products. Zinc and selenium in highly bio-available form is available. The most vital ingredient of wheat grass is chlorophyll and hence called by a pet name “concentrated solar energy”. Wheat grass juice contains significant concentration of folic acid, which may lead to reduction of high blood pressure. The role of wheat grass in reducing blood pressure has been established. Wheat grass juice supplementation to cancer patients has also proved to have a positive impact on them.

Significance of the Study

The present study attains significance under the pretext that the studies in India have not adequately exploited the vitality of wheat in the forms of germ, grass and bran. The present study is intended to fill this gap. The bountiful production of wheat and its high consumption among Indian populace are the encouraging factors for this intended investigation that attains social relevance too. The present study aims at redefining “wheat” as it is conventionally understood and utilized in India. It is now wheat germ, wheat grass and wheat bran, not a much known to common people. That the health issues of both the rich and poor could be addressed through the same components viz., wheat germ, wheat grass and wheat bran, this zealous venture claims realistic significance. This is a pioneering study that sets forth to synchronize food science, community nutrition and nutrition education. Impart of knowledge to the population is not outside the scope of the study.

The area of study is the District of Coimbatore in the State of Tamil Nadu. The population is respectively supported by industrial estates, factories and agricultural land. Coimbatore could be considered a miniature of India featuring urban, semi urban and rural population, with multicultural settings and varied socio-economic status. It sounds befitting and relevant for having Coimbatore as the area of the intended study since the findings could be applied universally in Indian context.

Objectives: The specific objectives constitute

1. Nutrient analysis of wheat germ, fresh wheat grass juice and wheat bran.
2. Formulation and standardization of recipes based on wheat germ, grass and bran.
3. Evaluation of both the individual and combined supplementation of wheat germ, grass and bran on selected population.

METHODOLOGY

II. METHODOLOGY

The study was conducted in three phases. In the first phase, wheat germ, fresh wheat grass juice and wheat bran was subjected to complete nutrient analysis. In the second phase, various nutritious and cost effective recipes were standardized incorporating wheat germ / grass / bran. In the third phase wheat germ, grass and bran was supplemented individually and in combination to human subjects to treat specific health problems and the impact was evaluated.

Phase I

Macro and micro nutrients in wheat germ , grass and bran was analyzed by the standard procedures of National Institute of Nutrition (NIN,1999).The amino acid profile, fatty acids, sterols and the total dietary fibre content (both soluble and insoluble) was analyzed (AOAC, 2000)

Phase II

Recipes including breakfast/ lunch /dinner items and snacks where there would be acceptable incorporation were formulated and standardized using the wheat germ, grass and bran individually as well as in combinations (wheat germ and grass; wheat germ and bran; wheat grass and bran; wheat germ, wheat grass and bran) by various methods of cooking. In order to test the acceptability of the recipes sensory evaluation test was done by semi trained panel members using triangle test of nine point hedonic rating scale.

Phase III

As a first step in the supplementation study an interview schedule was formulated to elicit information from all the 105 diabetic, 60 low immune and 105 obese subjects on their socioeconomic details including age, sex, education, family type, monthly income, food habits and dietary pattern through interview cum observation method. Details on type and duration of disease and familial disposition of disease were also collected. A pilot study was performed on five per cent of the selected sample as suggested by Kothari (2005) before the conduct of the survey. Based on the results, relevant modifications were made and the proforma was finalized (Appendix I). The investigator administered the interview schedule to all the subjects and required information was collected.

A. Assessment of anthropometric measurements and diet survey of the subjects

1. Anthropometric measurements

Anthropometrics is the gold standard for assessment of nutritional status (Elizabeth, 2000). To add, anthropometry is the single point portable invasive method of assessing body composition reflecting health and nutrition and predicting performance, health and survival (Ramalingaswami, 1993). While height is used to assess the past nutritional status, weight helps to assess the present. Body Mass Index (BMI) is frequently used as a popular and rapid clinical measure of relative obesity and malnutrition (Priyatomako *et al.,* 2001).

Accordingly, the anthropometric indicators namely weight (kg), height (cm), BMI (kg/m^2), waist and hip circumferences were measured for all the 105 subjects in the diabetic and obese groups respectively before and after the supplementation period. Genton *et al.,* (2005) suggest that in conditions like low immune where underweight is predominant the only useful parameter is anthropometrics and that would be weight loss, perhaps Mid Upper Arm Circumference (MUAC) and skinfold thickness. Therefore MUAC and skinfold thickness were assessed along with height, weight and BMI for all the 60 low immune subjects.

a. Weight

Measurement of weight serves as the indicator to profess the presence and progress of ailment. The weight of all the selected subjects in the three groups were determined by making them stand barefooted and erect on a portable weighing scale to the accuracy of 0.1kg before supplementation (Brahmam *et al*., 2005).

b. Height

Height is a constituent factor in the calculation of BMI and hence the height of all subjects was measured using a vertical measuring rod (anthropometer). The subjects were made to stand erect, barefooted on a levelled surface, with heels together and toes apart. The moving head piece of the anthropometer was placed in the sagital plane over the head of the subjects applying a slight pressure to reduce the thickness of hair. The reading was taken when the anthropometer was still in position to the accuracy of 0.1cm (Brahmam *et al*., 2005).

c. Body Mass Index (BMI)

BMI determines if weight is appropriate for the height and thus has good correlation with fitness (Bamji *et al.,* 2004). WHO (2000) has explained BMI as a simple index of weight for height that is commonly used to classify adults as underweight or overweight. BMI was calculated for all the selected subjects in the three groups using the following formula:

$$\text{BMI} = \frac{\text{Weight (kg)}}{(\text{Height})^2\ (\text{m})}$$

d. Waist circumference

Waist circumference was measured for all the selected subjects. The subjects were asked to stand erect with weight evenly balanced on both feet, which were placed about 25 to 30 cm apart. A mark was made at the level of the lowest rib margin. The iliac crest in the mid axillary line was felt and a mark was made. The measuring tape was passed around the waist horizontally midway between the lowest rib margin and iliac crest and the circumference in centimeter was measured upto the nearest millimeter. The observer sat on a stool in front of the subjects while taking the measurement (Brahmam *et al*., 2005).

e. Hip circumference

Hip circumference was measured for all the subjects. For measuring the hip circumference, the measuring tape was placed horizontally over the buttocks and the circumference was measured at the point yielding the maximum circumference in centimeter upto the nearest millimeter (Brahmam *et al*., 2005). According to Boyle *et al*., (2001) the waist circumference should be taken at the narrowest circumference between ribs and hips. For all the selected subjects in the diabetic and hyperlipidemic groups Waist Hip Ratio (WHR) was computed by dividing subject's waist circumference in centimeter by hip circumference in centimeters.

f. Mid Upper Arm Circumference (MUAC)

MUAC was measured for all the 60 low immune subjects. Assessment of protein compartments (muscle) can aid in the diagnosis of clients with wasting. MUAC provides an estimate of lean tissue and muscle mass of the patients and hence is a good indicator of wasting and weight loss. The MUAC was taken on the left forehand at the mid point between the tip of the acromion of scapula and the tip of the olecranon of the forearm bone of the patients. The arm was left freely hanging and flexible tape was used to measure the MUAC to the nearest millimetre with the tape still in position.

g. Skin fold thickness

Skin fold thickness is a measure of subcutaneous fat reserves which was evaluated for all the 60 low immune subjects. The skin fold at triceps is more reliable than that of sub scapular in the assessment of underweight and is more sensitive to the socio economic environment (Knechtle and Kohler, 2007). Triceps skin fold thickness was mid point where MUAC was measured. The skin fold was picked up between the thumb and the forefinger about one centimeter above the midpoint, taking care not to include the underlying muscle. The calipers were squeezed until they were equilibrated at the point for approximately three seconds. The measurements were read to the nearest millimetre and calibrated using previously published empirical equation (Felbinger, 2003).

2. Diet survey

According to Bamji *et al.,* (2004), diet is a vital determinant of health and nutritional status of people. Precise information of food consumption pattern of people through application of appropriate methodology is often needed not only for assessing the nutritional status of people, but also for elucidating the relationship of nutrient intake with deficiency as well as degenerative diseases. Precise information on food consumption pattern was collected through 24 hour recall method for one tenth of the selected subjects in all the three groups studied. The raw food equivalent of the cooked food was determined and the intake of macro and micro nutrients were computed using the values given in the 'Nutritive Value of the Indian Foods' (ICMR, 2004).

B. Supplementation of wheat germ, bran and grass to diabetic, obese and low immune subjects

1. Grouping of subjects

Sampling is the selection of some part of an aggregate or totality on the basis of which a judgment or inference about the aggregate or totality is made. For the present study purposive sampling method was adopted, as the method has definite view point in selection, considering the nature, scope and criteria fixed for the study (Burney, 2003). The selection of subjects for the study, mainly depended on the discretion of the investigator, keeping in view the criteria fixed for the study.

During the initial rapport with the selected subjects, willingness to participate and cooperate till the completion of study was sought from the interview and obtained in the form of a consent letter. The 105 diabetics and 105 hyperlipidemics were divided randomly into seven groups of 15 each respectively. Group A received wheat germ, group B received wheat bran, group

C received wheat grass, group D received wheat germ and bran, group E received wheat germ and grass and group F received wheat bran and grass as supplements. Group G served as the control group and did not receive any supplements other than the usual medications.

Wheat bran's nutraceutical potential in alleviating symptoms of certain diseases were correlated only with the high insoluble fibre content (Borel *et al*., 2005). Further the experienced physicians suggested that wheat bran supplementation would irritate the bowel movements of low immune subjects and also inhibit the absorption of the medication. Thereby the supplementation of wheat bran to the low immune subjects was forgone on ethical reasons and only 60 low immune subjects were selected and divided into four groups of 15 each. Group A received wheat germ, group B received wheat grass and group C received wheat germ and grass as supplement. Group D served as the control group and did not receive any supplements. Figure I gives the grouping of subjects and the supplements tested.

Reasons for not forming a group for supplementing with Wheat Germ, Wheat Bran and Wheat Grass

Though it has been indicated in the Research Proposal submitted to the UGC, that supplementation would be carried out for a separate group with all the three components viz., Wheat germ, bran and grass, during the pilot study, the investigators observed a unprecedented fall in glucose level besides the subjects explicitly stated that the three components could not be consumed in a day due to their unacceptability in the form it was given. Since the alternative forms of recipes could not be supplemented for a specific group leaving the remaining groups, this group i.e. group VII, as enumerated in the research proposal could not be supplemented.

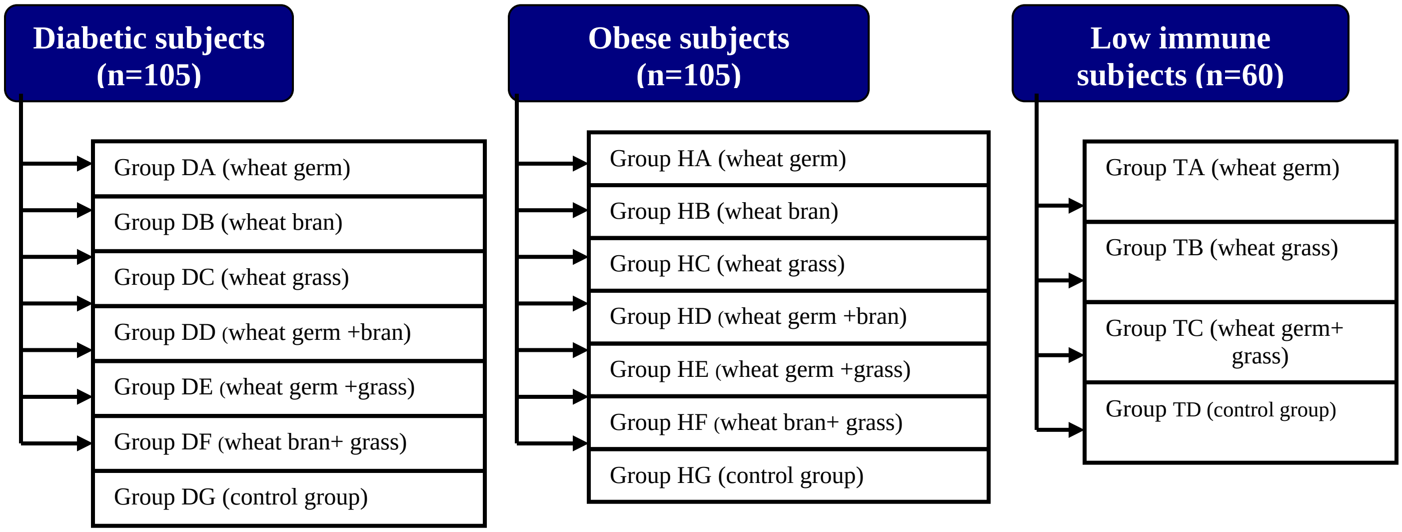


Figure I

Grouping of subjects

2. Procurement of wheat germ and bran

On a monthly basis 216 kg of wheat germ and 36 kg of wheat bran were procured for a period of six months.

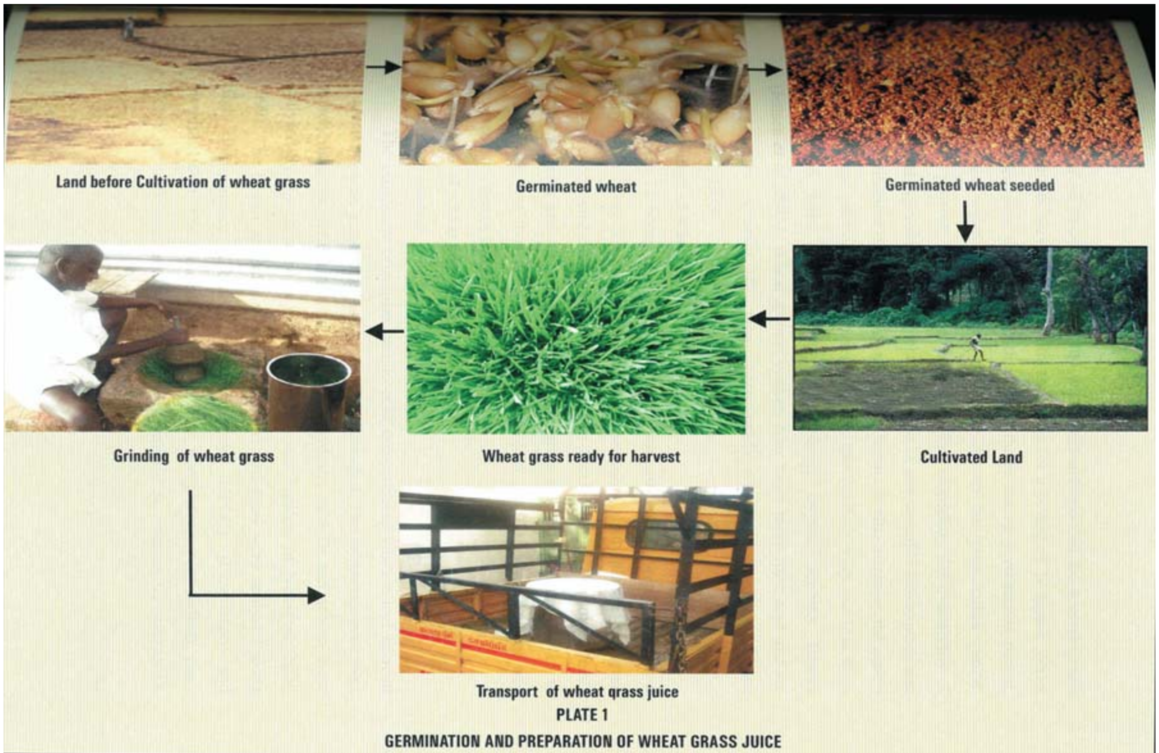
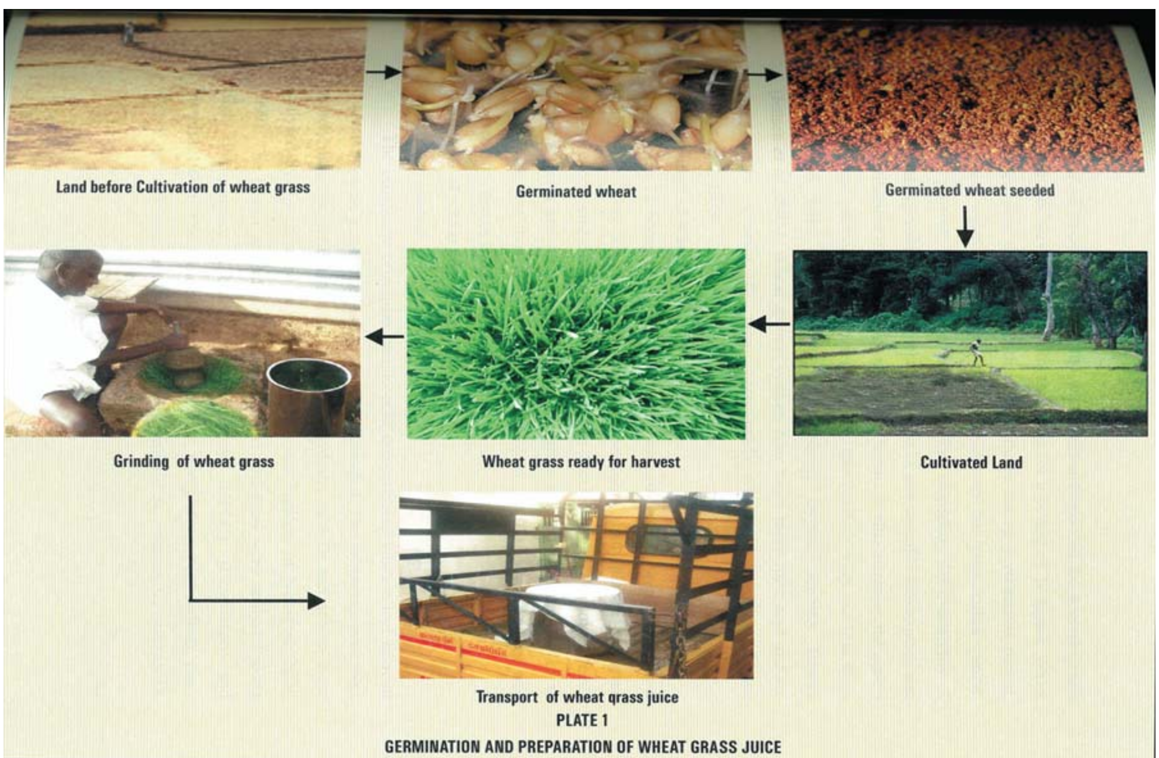


PLATE 1
GERMINATION AND PREPARATION OF WHEAT GRASS JUICE



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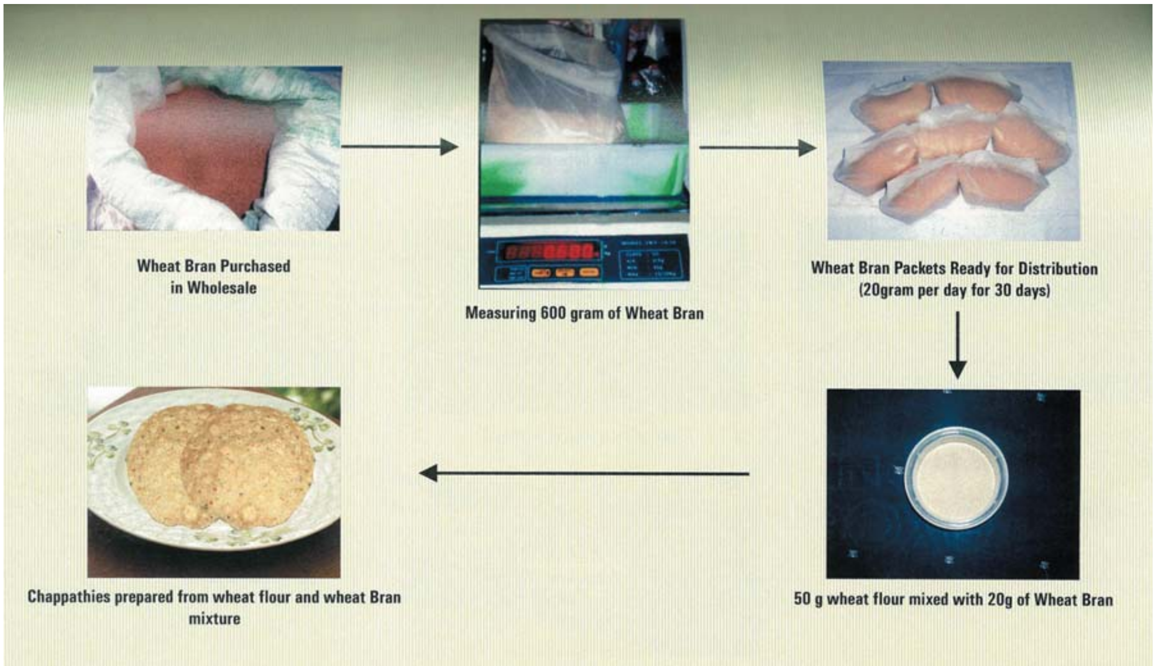


PLATE 3
PREPARATION OF CHAPPATHI FROM WHEAT BRAN

3. Germination and preparation of wheat grass juice

Among all types of grasses, wheat grass is the best (Fahey *et al*., 2005). Wheat grass is considered to be one of the best foods for all people in different age groups because of its nutrient content. The process of wheat grass cultivation consists of two steps namely germination of wheat grains and cultivation of wheat grass.

a. Germination of wheat grains

Superior good quality whole wheat was procured, and cleaned properly. The wheat grains were soaked in cold water for 12 hours. The process of soaking helps the wheat grains to become tender. It also reduces the phytin content of wheat. After 12 hours of soaking the water was strained and the soaked grains were tied in wet woven cotton cloth and hung for a period of 12 hours. Water was sprinkled over the cotton cloth at least thrice during germination period. Moisture and warm temperature are needed during the germination period. During this process, enzymes get activated, thus increasing the availability of nutrients and digestibility. It also increases ratio of non essential amino acids and content of vitamins like riboflavin, niacin and biotin. It also increases the action of cytases and pectinases. It releases minerals like calcium, zinc and iron from their bound form. This process also reduces trypsin inhibitor factors (Jensen *et al*., 2005). Wheat sprouts contain four times more folic acid and six times more vitamin C than unsprouted wheat or ordinary grass (Davis *et al*, 1999).

b. Cultivation of wheat grass

After 12 hours of germination, the germinated wheat were sowed in a shady place .Since wheat can grow in all temperatures, shady place is preferred to avoid excess nutrient loss due to exposure to direct sunlight. The sowed seeds started to grow and on the seventh day, the grass reached the length of 15 to 18cm which was then harvested (Ben and Goldin, 2002).150g of wheat was required to cultivate 100g of wheat grass.

C. Analysis of wheat germ, bran and grass

a. Nutrient content

The proximate principles, amino acid composition, vitamin and mineral content of wheat germ, bran and grass were estimated. The proximate principles namely moisture, total ash, total fibre, carbohydrate, total fat and protein were analyzed by the standard procedures of National Institute of Nutrition (NIN, 1999). The amino acids for wheat germ, bran and grass were analyzed using High Performance Liquid Chromatography (HPLC) (Heinrikson and Meridith, 1984). The minerals namely calcium, phosphorus, iron, sodium, zinc, copper and selenium and vitamins namely vitamin A, vitamin C, vitamin D, vitamin E, thiamine, riboflavin, niacin, folate and vitmainB_{12} were analyzed using standard procedures of NIN (1999).

D. Determination of dosage and supplementation of wheat germ, bran and grass

a. Determination of dosage of wheat germ, bran and grass

Wheat germ is a good source of phytosterol and one such phytosterol is beta sistosterol which is a plant sterol found in almost all plants. According to

Cara *et al*., (2001) beta sistosterol regulates blood sugar and insulin levels in Type II diabetics by stimulating the release of insulin in the presence of non-stimulatory glucose concentrations and inhibiting glucose -6- phosphatase. In the liver, the enzyme glucose -6- phosphatase is the primary pathway for conversion of dietary carbohydrates to blood sugar. Glucose -6- phosphatase dephosphorylates glucose -6- phosphate to yield free D- glucose. Free D-glucose passes into the blood, thus elevating blood sugar levels.

Another study by Bourdon *et al*., (1999) reveals that beta sistosterol reduces cholesterol levels as it has a close chemical resemblance to cholesterol which enables it to block the absorption of cholesterol by competitive inhibition. The recommended requirement of beta sistosterol is 150-200 mg for exhibiting its property in reducing blood sugar and total cholesterol (Heimbach *et al*., 2007). Kharb (2001) considers that beta sistosterol not only boosts immunity but also enhances lymphocyte proliferation and natural killer - cell activity. Based on this literature and on the estimation of the phytosterol content in wheat germ it was decided to supplement 60 g of wheat germ which would provide 182.4 mg of beta sistosterol to diabetic, obese and low immune subjects.

The WHO recommends 20 to 40 g of dietary fiber a day. Higher intake of dietary fiber is associated with increased glycemic index of the diet thereby improving the blood glucose levels in diabetics (Sunkin *et al*., 2000). Moreover, plasma lipids and cholesterol assimilation decreased on intake of dietary fiber in hypercholesterolemic adults (Greenwald *et al*., 2006). Nutrient analysis of wheat bran revealed that 100g of wheat bran provides 42.8g of dietary fiber. Cade (2006) reported the beneficial effect of 20g of wheat bran supplementation on colon cancer patients. As 20g of wheat bran provides 8.56g of dietary fiber and also has been well tolerated by the colon rectal cancer subjects, it was decided to supplement 20 g of wheat bran to the diabetic and the obese group subjects in the study group.

The study conducted by Meyerowitz (2003) where 100g of wheat grass was supplemented to anemic subjects an increase in the blood haemoglobin levels was observed after a period of five months. Thereby, 100g wheat grass was supplemented in the present study to the diabetic, obese and low immune subjects.

Details of the daily dosage of wheat germ, bran and grass individually and in combination to the experimental groups are given in Table I.

TABLE I
DETAILS OF DOSAGE OF WHEAT GERM, BRAN AND GRASS SUPPLEMENTED TO THE EXPERIMENTAL GROUPS

Wheat products	Dosage of supplementation		
	Diabetic	Obese	Low immune
Wheat germ	60g	60g	60g
Wheat bran	20g	20g	-
Wheat grass	100g	100g	100g
Wheat germ +grass	60g+100g	60g+100g	60g+100g
Wheat germ+ bran	60g+20g	60g+20g	-
Wheat bran +wheat grass	20g+100g	20g+100g	-

b. Supplementation of wheat germ, bran and grass

Before starting the feeding trials, all the 225 subjects in the experimental groups were educated about the beneficial effect of the supplements in alleviating the disease conditions. Sixty grams of wheat germ and 20g of bran were supplied in sachets to the diabetic and obese groups every fortnight at the clinic premises. Wheat grass juice was supplemented for the 45 subjects each in the diabetic and the obese groups and 30 subjects in the low immune group. 3000 ml of fresh juice was prepared daily and distributed to the selected subjects.

The following procedure was adopted for feeding the supplements:

- ❖ 30g of wheat germ in 100ml of toned milk was consumed twice a day (at midmorning and at bed time)
- ❖ 10 g of wheat bran mixed in 50g of wheat flour was prepared as chappathi and taken twice a day (breakfast and dinner)
- ❖ Three kilogram of seventh day wheat grass was crushed using a stone grinder so as to avoid the mechanical disintegration of the chlorophyll molecule in wheat grass and 100 ml of the same was distributed to the subjects which was consumed at mid morning.

Thus on a daily basis 60g of wheat germ, 20g of wheat bran and 100g of wheat grass were consumed by each subject in the respective experimental groups for a period of six months.

E. Evaluation of the impact of supplementation

Impact of supplementation of wheat germ, bran and grass on selected subjects was evaluated by the following methods

1. Clinical examination and
2. Biochemical assessment

1. Clinical Examination

The physiological symptoms of diabetes and low immune were evaluated before and after the supplementation period using a check list (Appendix III). As no symptomatic subjects were selected for the obese group the physiological symptoms screened for diabetes and low immune include:

a. Diabetes

Polydypsia, polyphagia, nocturia, constipation, insomnia, shivering, giddiness, excessive sweating , burning sensation in extremities, impaired vision, burning sensation during micturation, hesitancy during micturation and frequency of micturation.

b. Low immune

Nausea, weakness, rapid weight loss, fever, night sweats, cough, chest pain and haemoptysis.

2. Biochemical assessment

Biochemical changes can be expected to occur prior to clinical manifestation. Therefore biochemical tests which can be conducted on easily accessible body fluids such as blood and urine can help to diagnose disease at the sub clinical stage (Davidson, 1990).All the biochemical parameters were evaluated initially and after six months of supplementation for all the subjects.

The parameters for biochemical assessment are listed in Table II.

TABLE II
PARAMETERS FOR BIOCHEMICAL ASSESSMENT

Ailment	Biochemical Parameters
Obesity	Lipid profile: Triglycerides, Lipoprotein (Lpa), VLDL, LDL, HDL cholesterol
Low immunocompetence*	Serum albumin Total protein Total Leucocyte Count (TLC) CD_4 count
Diabetes	Plasma glucose (Fasting and post prandial) GlycoHb (Hba_1C)

Earlier in the research proposal submitted to the UGC (Page 14), it has been indicated that the following biochemical parameters would be evaluated for low immunocompetence including Immunoglobulin A, G and M , complementary C3 and C4. However, since the researchers subsequently identified a better bio chemical assessment for evaluating the same afore said low immunocompetence, such as Serum albumin, Total protein, Total Leucocyte

Count (TLC) and CD4 count, the same tests were done. In the diabetes group the lipid profile was not performed as the same lipid profile is being evaluated for the obesity group.

RESULTS AND DISCUSSION

III. RESULTS AND DISCUSSION

Phase I

A. Nutrient content of wheat germ, bran and grass

The nutrient content of wheat germ, bran and grass as analyzed is given in Table III.

TABLE III

NUTRIENT CONTENT (per 100 g) OF WHEAT GERM, BRAN AND GRASS

Nutrients	Wheat germ	Wheat bran	Wheat grass
Moisture (g)	11.1	9.9	12.2
Ash (g)	4.2	5.8	6.8
Carbohydrates (g)	51.8	64.5	3.1
Dietary fiber (g)	13.2	42.8	17.3
Protein (g)	23.1	15.5	20.5
Tryptophan (mg)	317	282	11
Threonine (mg)	968	500	105
Isoleucine (mg)	847	486	88
Leucine (mg)	1571	928	162
Lysine (mg)	1468	600	82
Methionine (mg)	456	24	43
Cystine (mg)	458	371	22
Phenylalanine (mg)	928	595	108
Tyrosine (mg)	704	436	50
Valine (mg)	1198	726	125
Arginine (mg)	1867	1087	111
Histidine (mg)	643	430	45
Alanine (mg)	1477	765	137
Aspartic acid (mg)	2070	1130	222
Glutamic acid (mg)	3995	2874	242
Glycine (mg)	1424	898	117
Proline (mg)	1231	882	94
Serine (mg)	1102	684	242
Total fat (g)	9.7	4.3	0.0
Saturated fat (g)	1.7	0.6	0.0
Monounsaturated fat (mg)	1.4	0.6	0.0
Polyunsaturated fat (mg)	6.0	2.2	0.0
Vitamin C (mg)	9.2	9.5	14.1
Thiamine (mg)	1.9	0.43	0.08
Riboflavin (mg)	0.5	0.11	0.13
Niacin (mg)	6.8	4.3	0.11
Vitamin B6 (mg)	1.3	1.2	0.20
Folic acid (mcg)	281	100	86
Vitamin B12 (mcg)	2.3	103	99
Calcium (mg)	39	73	242
Iron (mg)	6.3	10.6	0.61
Magnesium (mg)	239	611	24
Phosphorus (mg)	842	1013	1210
Potassium (mg)	892	1182	147
Sodium (mg)	12	2.0	15.6
Zinc (mg)	12.3	7.3	0.33
Copper (mg)	0.8	1.0	0.2
Manganese (mg)	13.3	11.5	10.2
Selenium (mcg)	79.2	77.6	52.3

The moisture content of wheat germ, bran and grass were 11.1, 9.9 and 12.2g per 100g. The carbohydrate content of wheat bran was 64.5g followed by 51.8g in wheat germ and 3.1g in wheat grass. The dietary fiber content was also found to be highest in wheat bran (42.8g) followed by wheat grass with 17.3g and wheat germ with 13.2g. Wheat germ contained 23.1g of protein followed by 20.5g in wheat grass and 15.5g in wheat bran. The essential amino acid to non essential amino acid ratio of wheat germ, bran and grass were 0.52, 0.43 and 0.56 respectively proving a higher ratio in wheat grass. Total fat content of wheat germ was 9.7g followed by 4.3g in wheat bran. It was interesting to note that wheat grass did not contain any fat. Further the saturated, mono and polyunsaturated fat content of wheat germ were 1.7, 1.4 and 6.0g respectively. In wheat bran the saturated and monounsaturated fat were 0.6g and 06g respectively and the polyunsaturated fat was 2.2g revealing less content of saturated fat when compared to wheat germ. Wheat grass had the highest content of vitamin C (14.1mg) followed by wheat bran with 9.5mg and wheat germ with 9.2mg.

The thiamine (1.9mg), riboflavin (0.5mg), niacin (6.8mg), vitamin B_6 (1.3 mg) and folic acid (281mcg) content were found to be highest in wheat germ. Vitamin B_{12} (103mcg) was found to be highest in wheat bran. Calcium (242mg) was found to be highest in wheat grass followed by 73mg in wheat bran and 39mg in wheat germ .Iron (10.6mg) content was maximum in wheat bran, whereas the iron content of wheat germ was 6.3mg and that of wheat grass was 0.61mg.Wheat bran provided highest content of magnesium (611mg) and wheat grass provided 24 mg of magnesium. Wheat bran contained 1182 mg of potassium followed by 892mg in wheat germ and 1210mg in wheat grass. The zinc content of wheat germ was found to be highest (12.3 mg) followed by 7.3mg in wheat bran and only 0.33mg in wheat grass. Copper (1.0mg) was found to be highest in wheat bran. Manganese and selenium were found to be highest in wheat germ with 13.3mg and 79.2mcg respectively.

Phase II

Recipes including breakfast/ lunch /dinner items and snacks, where there would be acceptable incorporation were formulated and standardized using the wheat germ, grass and bran individually as well as in combinations (wheat germ and grass ; wheat germ and bran; wheat grass and bran; wheat germ, wheat grass and bran) by various methods of cooking. In order to test the acceptability of the recipes sensory evaluation test was done by semi trained panel members using triangle test of nine point hedonic rating scale is given in the form of a Booklet in Appendix II of Recipes on wheat bran, wheat grass and wheat germ.

B. Background details of the subjects

Age, sex, marital status, type of family and income are the factors that influence the socioeconomic profile. Background details and demographic factors play an important role on the pattern of consumption of food and nutrients (Rahman and Rao, 2002).The selected subjects in diabetic, obese and low immunity group were interviewed and the details of the background information as collected are given in Table IV.

TABLE IV
BACKGROUND DETAILS OF THE SUBJECTS

Details		Diabetes mellitus						Obese						Low immunity					
		Male (N=60)		Female (N=65)		Total (N=105)		Male (74)		Female (N=31)		Total (N=105)		Male (N=38)		Female (N=22)		Total (N=60)	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Age (years) & Sex	40-45	23	38.3	14	31.1	37	35.2	14	18.9	14	45.2	28	26.7	7	18.4	5	22.7	12	20.0
	46-50	18	30.0	16	35.6	34	32.4	33	44.6	7	22.6	40	38.1	14	36.8	8	36.4	22	36.7
	51-55	19	31.7	15	33.3	34	32.4	27	36.5	10	32.3	37	35.2	17	44.7	9	40.9	26	43.3
Type of family	Joint	15	25.0	6	13.3	21	20.0	20	27.0	10	32.3	30	28.6	8	21.1	2	9.1	10	16.7
	Nuclear	45	75.0	39	86.7	84	80.0	54	73.0	21	67.7	75	71.4	30	79.0	20	90.9	50	83.3
Educational status	Illiterate	9	15.0	15	33.3	24	22.9	16	21.6	19	61.3	35	33.3	23	60.5	12	54.6	35	58.3
	Primary	24	40.0	18	40.0	42	40.0	22	29.7	6	19.4	28	26.7	6	15.8	3	13.6	9	15.0
	High school/Higher secondary	20	33.3	10	22.2	30	28.6	32	43.2	4	12.9	36	34.3	9	23.7	7	31.8	16	26.7
	Degree	7	11.7	2	4.4	9	8.6	4	5.4	2	6.5	6	5.7	-	-	-	-	-	-
Occupational status	Agriculture	38	63.3	4	8.9	42	40.0	-	-	-	-	-	-	30	79.0	5	22.7	35	58.3
	Business	2	3.3	-	-	2	1.9	15	14.9	-	-	11	10.5	-	-	-	-	-	-
	Government /Private job	20	33.3	3	6.7	23	21.9	59	79.7	15	48.4	90	85.7	8	21.1	-	-	8	13.3
	Housewives	-	-	38	84.4	38	36.2	-	-	16	12.9	4	3.8	-	-	17	77.3	17	28.3
Income status*	Low income	14	23.3	15	33.3	29	27.6	10	13.5	1	3.2	11	10.5	30	79.0	15	68.2	45	75.0
	Middle income	34	56.7	24	53.3	58	55.2	45	60.8	18	58.1	63	60.0	6	15.8	5	22.7	11	18.3
	High income	12	20.0	6	13.3	18	17.1	19	25.7	12	38.7	31	29.5	2	5.3	2	9.1	4	6.7
Duration of disease	<one year	7	11.7	13	28.9	13	12.4	13	17.6	6	19.4	9	8.6	38	100.0	22	100.0	60	100.0
	1-3 years	27	45.0	15	33.3	45	42.9	20	27.0	11	35.5	35	33.3	-	-	-	-	-	-
	4-6 years	26	43.3	17	37.8	47	44.8	41	55.4	14	45.2	61	58.1	-	-	-	-	-	-
Familial tendency**	Mother	23	38.3	20	44.0	43	41.0	41	55.4	23	74.2	64	61.0	3	7.9	2	9.1		
	Father	46	76.7	39	86.7	85	81.0	44	59.5	5	16.1	96	91.4	2	5.2	-	-	-	-
	Grandmother	8	13.3	5	11.1	13	12.4	8	10.8	15	48.4	23	21.9	-	-	-	-	-	-
	Grandfather	7	11.7	5	11.1	12	11.4	16	21.6	19	61.3	35	33.3	-	-	1	4.6	1	1.7
Mode of treatment taken	Unani	2	3.3	-	-	2	1.9	1	1.4	2	6.5	3	2.9	-	-	-	-	-	-
	Ayurvedha	15	25.0	10	22.2	25	23.8	31	41.9	8	25.8	46	43.8	7	18.4	5	22.7	12	20.0
	Homeopathy	9	15.0	10	22.2	19	18.1	7	9.5	5	16.1	12	11.4	6	15.8	7	31.8	13	21.7
	Siddha	18	30.0	11	24.4	35	33.3	13	17.6	5	16.1	8	7.6	12	31.6	5	22.7	17	28.3
	Allopathy	16	26.7	14	31.1	24	22.9	22	29.7	11	35.5	36	34.3	13	34.2	5	22.7	18	30.0

* Housing Urban Development Corporation (HUDCO), (2004); ** Multiple response

According to Rajiv*,* (1999) age is an important risk factor for diabetes. Of all the diabetic subjects selected 35.2 per cent were in the age group of 40-45 years, 32.4 per cent in the age group of 46-50 years and 32.4 per cent were in the age group of 51-55 years. Herman *et al*.,(1998) reported that the majority of the people with diabetes are in the age group of 45-64 years in the developing countries .

Age is one of the uncontrollable causes of obesity. As age increases the total cholesterol and LDL cholesterol increases (Kathleen, 2000). Of the selected obese subjects 26.7 per cent were in the age group of 40-45 years, 38.1 per cent in the age group of 46-50 years and 35.2 per cent in the age group of 51-55 years. Epidemiological studies in India have revealed that the incidence of myocardial infarction is on the increase, particularly the peak period being 41-55 years. Age is a non-modifiable risk factor for coronary obesity. The prevalence of obesity increases with doubling of rates between ages 45-54 years (American Heart Association, 2001).

In the low immunity group 20 per cent were in the age group of 40-45 years, 36.7 per cent were in the age group of 46-50 years and 43.3 per cent were in the age group of 51-55 years. Prevalence rate of low immunity rose with age. National Sample Survey conducted by ICMR (1998) described increase in prevalence rate of low immunity along with increase in age.

In the present study it can be noted that in the diabetic group there were 42.9 per cent women and 57.1 per cent men. Globally diabetes prevalence is similar in men and women but it is higher among men after the age of 50 years (Wild *et al*., 2004). In the obese group 70.5 per cent were males and 29.6 per cent were females. The data of the present study is in par with the study of Adam, (2001) where the prevalence rate of obesity was more prone in men than in women. According to Chadha (2005), 75 per cent of all the new pulmonary low immunity infection in India, are reported in men. Similarly in the low immunity group studied it was revealed that 63.3 per cent were males and only 36.7 per cent were females.

Sabarwal (2005) reports that joint family system is slowly disintegrating with the advent of modern utilization. The data on type of families of the present study revealed that 20 per cent of the diabetics belonged to joint family system and a majority of 80 per cent were in the nuclear type of family system.

In the obese group 28.6 and 71.4 per cent of subjects belonged to the joint and nuclear family type respectively. Low immunity group also showed the same trend where 83.3 per cent of low immunity subjects belonged to the nuclear family system and only 16.7 per cent of the low immunity subjects lived in the joint family system. This observation is in accordance with the reports published that more than 80 per cent of the families in India are of nuclear family type (Zimmet *et al.,* 2001).

Among the selected diabetics 40 per cent of the subjects had primary education, 28.6 per cent had completed high school / higher secondary education and only 8.6 per cent were degree holders. In the obese group, 26.7 per cent had completed primary education, 34.3 per cent had completed high school /higher secondary education and only 5.7 per cent were degree holders. Among the low immunity subjects 15 per cent had primary school education, 26.7 per cent had high school/higher secondary education and none of them were degree holders. In the diabetic, obese and the low immunity groups it was noted that 22.9, 33.3 and 58.3 per cent were illiterates. Illiteracy predisposes the adults to many infections and metabolic diseases and lack of awareness augments spread of the disease (WHO, 2007).

In the diabetic group, 40 per cent were agricultural landlords and only 1.9 per cent were doing business. Further 21.9 per cent were either in Government or private jobs. In the obese group, 85.7 per cent were government / private job holders and only 10.5 per cent constituted the agriculture group. Advent of modernization has resulted in low physical activity; these conditions are conducive for the onset of metabolic diseases (Vijay, 2005).

In the low immunity group 58.3 per cent were agriculturists and only 13.3 per cent were either in government or private jobs. This phenomenon of higher prevalence of low immunity in agriculture workers and labourers may be ascribed to poor living condition. Higher prevalence rate (61.88/1000) was observed in lower socio-economic class (Khan and Salfler, 2006).

As with the regard to income status, subjects in diabetes mellitus, obesity and low immunity groups were categorized according to the HUDCO (2004) classification. It was found in the diabetic group 27.6 per cent belonged to low income group (Rs.2,101-4,500),17.1 per cent belonged to high income group (Rs.>7500/-) and a majority of 55.2 per cent belonged to the middle income group (Rs.4,501-7,500). According to Dudeja (2001) prevalence of diabetes was lower among those with low income than among the high income group. When income level raises, people change their lifestyle pattern and dietary habits leading to diet related disorders.

The present observation is in line with the reported finding. In the obese group 60 per cent of the subjects belonged to middle income group (Rs.4,501-7,500) and 29.5 per cent belonged to the high income group (Rs.>7500/-). Only 10.5 per cent of the subjects belonged to the low income group (Rs.2,101-4,500). In developing countries, high socio-economic status is associated with higher risk of obesity and diabetes (Davey, 1997).Indeed obesity are even more numerous in India and China than in all economically developed countries in the world. Chronic diseases are emerging at a faster rate in developing countries (Baker and Frank, 1999).

In the low immunity group 75 per cent belonged to the low income group, 18.3 per cent belonged to the middle income group and only 6.7 per cent belonged to the high income group. The more prevalence of low immunity in low socio-economic class might be due to ignorance, poverty and closed proximity of positive cases in vicinity as well as within the family (Khan, 2006).

Duration of the disease as expressed by the diabetic subjects revealed that 58.6 per cent had the condition over four to six years, 42.9 per cent of the subjects had diagnosed within the past 1-3 years and only 12.4 per cent of them had diagnosed the condition during the past one year. In the obese group it could be noted that 58.1 per cent had diagnosed the condition before four to six years while 33.3 per cent of the subjects had the condition over one to three years and only 8.6 per cent of the obese subjects had diagnosed the condition during the past one year. All the 60 low immunity subjects had diagnosed the infection within one year.

Of the 62 per cent diabetic population in India having a positive family history of diabetes, 53 per cent have their first degree relatives as diabetics (Ramachandran, 1992). In accordance with this, among the selected 105 diabetic subjects 41 per cent of the mothers of the selected subjects were diabetic, 81 per cent of the fathers of the selected subjects were diabetic. Further it was also noted that 12.4 and 11.4 per cent of the grand mothers and grand fathers respectively were found to be diabetic. In the obese group 61 and 91.4 per cent of the mothers and fathers respectively of the selected subjects had obesity, 21.9 and 33.3 per cent of the grand mothers and grand fathers of the selected subjects had obesity. A family history of premature disease is strong risk factor, even when other risk factors are considered. A family history is considered to be positive when myocardial infarction and sudden death occurs before age of 55 in male first degree relative. Numerous types of obesity are inheritable and lead to premature atherosclerosis and coronary obesity (Wood, 2001).

Among the selected diabetic subjects 1.9, 23.8, 18.1, 33.3 and 22.9 per cent respectively had taken unani, ayurvedic, homeopathic, siddha and allopathic treatment and in the obese group, 2.9, 43.8, 11.4, 7.6 and 34.3 per cent were on unani, allopathic, ayurvedic, homeopathic, siddha and allopathic treatment respectively.

Regarding the mode of treatment undertaken by the subjects before getting admitted to the low immunity center revealed that 21.7, 16.7 and 35 per cent respectively were taking ayurvedic, homeopathic and siddha treatment. Only 20 per cent were undergoing allopathic treatment.

C. Anthropometric measurements of the subjects

The mean anthropometric measurements of the selected subjects are presented in Table V.

TABLE V

MEAN ANTHROPOMETRIC MEASUREMENTS OF DIABETIC, OBESE AND LOW IMMUNITY SUBJECTS

Groups	Weight (Kg)*		BMI●		Wait to hip ratio♦		MUAC (cm)		Skin fold thickness (cm)	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Diabetic	69.98	68.55	25.81	26.21	0.94	0.92	-	-	-	-
Obese	71.25	65.99	25.35	26.85	0.95	0.93	-	-	-	-
Low immunity	41.23	40.37	17.62	17.92	0.62	0.71	23.22	22.38	1.7	1.6

Standard: * Male: 60Kg; Female: 50Kg (ICMR, 2004)

● Normal: 20-25; grade I: 25-30; grade II :> 30 (Brahmam *et al*., 2005)

♦ 0.8 (Brahmam *et al*., 2005)

The mean weights of the diabetic male and female subjects were 69.98 and 68.55kg respectively. In the obese group the mean weights of the male and female subjects were 71.25 and 65.99 kg and in the low immunity group it could be noted that the male and female subjects weighed only 41.23 and 40.37kg respectively. The standard reference weight as recommended by ICMR (2004) was 60 and 50kg for male and female respectively. As compared with the reference standard, it would be revealed that the diabetic and obese male and female subjects were well above the normal standards confirming overweight as the risk factor for diabetes and obesity (Hennekens *et al*., 2004). In the low immunity group it could be noted that the male and female subjects were below the normal standards proving the muscle wasting in low immunity.

The Body Mass Index determined for the diabetic male and female subjects were 24.81 and 26.21 respectively. In case of obese subjects the BMI of males was 25.35 and that of the females was 26.85. In case of low immunity subjects BMI for male and female subjects were 17.62 and 17.92 respectively. From the classification of BMI according to Brahmam *et al*., (2005) it could be noted that the diabetic and obese male and female subjects were in the Grade I obesity (25-30) and the low immunity male and female subjects were in mild Chronic Energy Deficiency (CED)-grade I. According to Roulant (2004) in the urban Indian population BMI of >23 showed the risk of diabetes in both genders. Rabkin *et al*., (2003) revealed that the prevalence of dyslipidemia is related to BMI as LDL-C and triglyceride concentration were higher in those with higher BMI.

The Waist Hip Ratio (WHR) of the male and female diabetic subjects was 0.94 and 0.92 respectively. In the obese group the WHR of the male and female subjects were 0.95 and 0.93 respectively. Further in the low immunity group WHR was 0.62 for male and 0.71 for female subjects. The normal standard values for WHR as recommended by Brahmam *et al*., (2005) is 0.8 and it could be noted from the Table that both the diabetes and the obese group subjects were well above the normal standard values. Jerum (2003) opined that WHR is an indicator of abdominal obesity which indirectly leads to diabetes. Krause (2001) revealed that subjects with abdominal obesity are prone to obesity and also pointed out the precautionary measure to avoid obesity by avoiding abdominal obesity.

Mid upper arm circumference and skin fold thickness are related to the fatness or weight of an individual and these two measurements were measured on low immunity subjects. The MUAC of male and female subjects were 23.22 and 22.38 respectively and that of the skin fold thickness of the male and female subjects were 1.7 and 1.6 cm. Johan *et al*., (2002) explained that reduced food intake, nutrient malabsorption and altered protein and lipid metabolism are mechanisms that appear to contribute to loss of lean body mass.

D. Food pattern and dietary practices of the subjects

1. Food and nutrient intake of diabetic subjects

a. Food intake pattern

Table VI and Figure 2 present the data on the food intake by the diabetic subjects.

TABLE VI

FOOD INTAKE PATTERN OF DIABETIC SUBJECTS

Food stuff (g)	Actual intake	Per cent adequacy	Suggested allowance*
Cereals	226	+132.9	170
Pulses	46	-76.7	60
Green leafy vegetables	16	-80	200
Other vegetables	79	-39.5	200
Fruits	48	-48	100
Milk and milk products	416	+138.7	300
Fats and oils	39	+260	10-15

***** Raghuram *et al*., (2007)

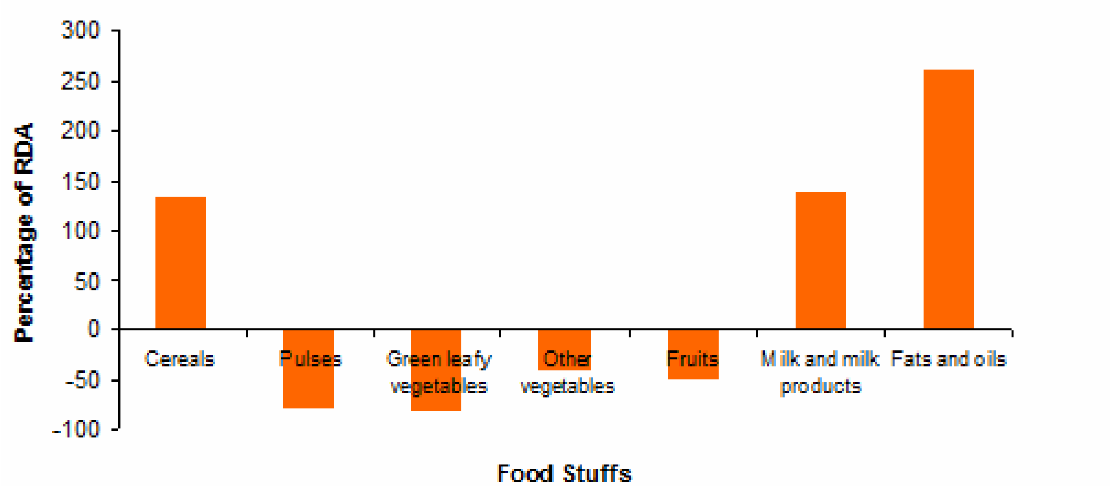


Figure 2

Percentage Adequacy of food intake of diabetic subjects

Consumption of cereals, milk and milk products and fats and oils were found to be excess and the percentage adequacy of these food stuffs included +132.9 per cent, +138.7 per cent and +260 per cent respectively. The consumption of pulses, green leafy vegetables and fruits were found to be in deficit when compared against the suggested allowance given by Raghuram *et al*., (2007) and the percentage inadequacy of pulses, green leafy vegetables, other vegetables and fruits were 76.7, 80, 39.5 and 48 respectively.

The Knowledge, Attitude and Practice scores obtained from the subjects before and after nutrition education did not show any significance hence the result is not presented. Further it could be correlated that sensitizing the subjects on nutrition education in a period less than six months (the Project Study Period) is practically not feasible.

b. Nutrient intake

Table VII presents the data on the nutrient intake by the diabetic subjects.

TABLE VII
NUTRIENT INTAKE OF DIABETIC SUBJECTS

Nutrients	Actual intake	Suggested allowance*
Energy (Kcal)	1688	1800
Carbohydrate (g)	251	245.50
Total fat (g)	51	30.2
Protein (g)	56.75	59.5
Dietary fiber (g)	39.37	34

*Raghuram *et al*., (2007)

The mean energy intake of the diabetic subjects was 1688 Kcal as against the suggested allowance of 1800 Kcal. The carbohydrate and fat content of the diabetic subjects was 251 and 51g respectively. The protein content of the diabetic subjects was 56.8g as against the suggested allowance of 59.5g and the dietary fiber content was 39.4g as against the suggested allowance of 34g. The high energy value of diets of diabetics was mainly due to high intake of fats and oils and milk and milk products.

2. Food and nutrient intake of the obese subjects

a. Food intake pattern

Table VIII presents the data on the food intake by the obese subjects.

TABLE VIII
FOOD INTAKE PATTERN OF OBESE SUBJECTS

Food stuff (g)	Actual intake	Per cent adequacy	Suggested allowance*
Cereals	250	+178.57	140
Pulses	59	+147.50	40
Green leafy vegetables	20	-13.33	150
Other vegetables	45	-45.00	100
Fruits	25	-25.00	100
Milk and milk products	450	+225.00	200
Fats and oils	45	+450	10

***** Ghafforunissa and Krishnasamy (2007)

Consumption of cereals, pulses, milk and milk products, fats and oils were found to be excess by 178.6,147.5,225 and 450 per cent respectively than the suggested values given by Ghafforunissa and Krishnasamy (2007). The consumption of green leafy vegetables (13.3%), other vegetables (45%) and fruits (25%) were inadequate when compared with the suggested values of Ghafforunissa and Krishnasamy (2007).

b. Nutrient intake

Table IX presents the data on the nutrient intake by the obese subjects.

TABLE IX

NUTRIENT INTAKE OF OBESE SUBJECTS

Nutrients	Actual intake	Suggested allowance*
Energy (Kcal)	2153	1800
Carbohydrate (g)	265	245.50
Total fat (g)	65	15.00
Protein (g)	53.26	59.5
Dietary fiber (g)	31.56	34

* Ghafforunissa and Krishnasamy., (2007)

The average energy intake of the obese subjects was 2153 Kcal as against the suggested values of 1800 Kcal. Similarly carbohydrate (65g) was also found to be in excess. Consumption of protein and dietary fiber was only 53.3 and 31.6g when compared with the suggested values given by Ghafforunissa and Krishnasamy (2007) i.e. 59.5 and 34g.

3. Food and nutrient intake of the low immunity subjects

a. Food intake pattern

Table X presents the data on the food intake by the low immunity subjects.

TABLE X

FOOD INTAKE PATTERN OF LOW IMMUNITY SUBJECTS

Food stuff (g)	Actual intake	Per cent adequacy	Suggested allowance*
Cereals	200	-47.6	420
Pulses	25	-27.8	90
Green leafy vegetables	25	-25	100
Other vegetables	40	-40	100
Fruits	10	-10	100
Milk and milk products	100	-25	400
Fats and oils	15	-75	20

*WHO (2003)

Consumption of all foodstuffs including cereals, pulses, green leafy vegetables, other vegetables, fruits, milk and milk products and fats and oils were well below the suggested values of WHO (2003). A deficit of 27.8 per cent was observed in pulse consumption and 25 per cent deficit was observed in the milk and milk products consumption. Consumption of green leafy vegetables was at a deficit of 25 per cent and that of cereals was 47.6 per cent.

2. Nutrient intake

Table XI presents the data on the nutrient intake by the low immunity subjects.

TABLE XI
NUTRIENT INTAKE OF LOW IMMUNITY SUBJECTS

Nutrients	Actual intake	Suggested allowance*
Energy (Kcal)	1756	2910
Carbohydrate (g)	159	290
Total fat (g)	20	30.2
Protein (g)	36	69

*WHO (2003)

The average energy intake of the low immunity subjects was 1756Kcal. The low energy value of diets of low immunity was mainly due to low intake of protein and carbohydrate which was only 36 and 159g respectively. The intake of carbohydrate (159 g) and fats (20g) was found to be below the suggested values when compared with suggested values given by WHO (2003).

E. Impact of evaluation of individual and combined supplementation of wheat germ, bran and grass on diabetic, obese and low immunity subjects

1. Effect of supplementation on diabetic subjects

a. Changes in the physiological symptoms

The change in the physiological symptoms before and after supplementation of the diabetic subjects is depicted in Table XII.

TABLE XII
CHANGES IN PHYSIOLOGICAL SYMPTOMS OF DIABETIC SUBJECTS

Symptoms*	Group DA		Group DB		Group DC		Group DD		Group DE		Group DF		Group DG	
	I	F	I	F	I	F	I	F	I	F	I	F	I	F
Polydypsia	10	1	12	2	10	1	11	2	10	-	10	1	9	9
Polyphagia	9	-	14	-	15	-	15	-	15	-	11	2	10	10
Polyuria	8	-	13	-	13	-	14	-	11	-	12	-	13	12
Nocturia	10	-	14	1	10	-	13	1	10	1	13	-	10	10
Constipation	12	-	10	-	9	-	10	-	15	-	10	-	5	5
Insomnia	-	-	1	1	-	-	-	-	1	1	-	-	-	-
Giddiness	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Impaired vision	-	-	2	2	-	-	-	-	-	-	-	-	-	-

* Multiple responses; I-Initial; F-Final

Of the various clinical parameters which indicate diabetes, polyuria, polydypsia, polyphagia, nocturia and constipation were found to be the most frequently occurring symptoms in all the groups studied. In the initial phase it was found that 10,12,10,11,10,10 and nine subjects in groups DA, DB, DC, DD, DE, DF and DG expressed the occurrence of polydypsia and 9,14,15,15,15,11 and 10 subjects of the groups DA, DB, DC, DD, DE, DF and DG expressed polyphagia as a symptom. Around 10 to 15 subjects in the entire supplemented groups were suffering from constipation initially. After six months of supplementation with wheat germ, bran and grass individually and in combination there was a drastic reduction in the physiological symptoms except for one or two subjects in whom symptoms like polyuria, polyphagia, nocturia and polydypsia were reduced. Further it was found that the subjects who expressed constipation as a problem expressed the relief of constipation after the supplementation. This can be owed to the high amount of soluble fiber in the supplements. As observed from the Table, there was not much improvement in the physiological symptoms in the control group. Many in the experimental groups studied desired to continue the supplementation even after the completion of the study due to the improvement shown in the various physiological symptoms.

b. Changes in biochemical picture

(i) Mean serum fasting and postprandial glucose and glycosylated hemoglobin levels

Table XIII and Figures 3, 4 and 5 give the mean serum fasting and postprandial glucose and glycosylated hemoglobin levels at the initial and final phase of the study period and results of the statistical analysis.

TABLE XIII
CHANGES IN MEAN SERUM FASTING AND POSTPRANDIAL GLUCOSE AND GLYCOSYLATED HEMOGLOBIN LEVELS

(N=15/Group)

Groups	Fasting Glucose (mg/dl)	Post prandial Glucose (mg/dl)	Glycosylated hemoglobin (%)
Group DA Initial	123.20 ±2.62	164.67 ±3.08	8.42 ±0.17
Final	101.13 ±0.92	123.93 ± 2.63	6.35 ±0.22
Difference	-22.07 ±2.91	-40.74 ± 4.20	-2.07 ±0.29
‘t’ value	29.32**	37.17**	27.79**
Group DB Initial	123.60 ±2.72	164.60 ±2.61	8.37 ±0.14
Final	100.80 ±1.15	124.80 ±2.11	6.41 ±0.18
Difference	-22.80 ± 3.03	-39.80 ± 3.88	-1.96 ±0.25
t’ value	29.16**	39.76**	30.85**
Group DC Initial	123.47 ±2.75	163.40 ±2.32	8.40 ±0.21
Final	101.40 ±1.77	115.47 ±1.88	6.41 ±0.10
Difference	-22.07 ±3.28	-47.93 ±3.17	-1.99 ±0.10
t’ value	26.03**	38.12**	33.08**
Group DD Initial	123.80 ±2.37	163.67 ±2.06	8.39 ±0.28
Final	100.53 ±1.36	115.47 ±1.88	5.49 ±0.17
Difference	-23.27 ±2.71	-48.20 ±3.17	-2.90 ±0.17
t’ value	42.05**	58.95**	30.17**
Group DE Initial	124.20 ±2.65	165.94 ±1.67	8.45 ±0.17
Final	95.87 ±1.46	113.07 ±1.62	5.26 ±0.12
Difference	-28.33 ± 2.71	-52.87 ±2.90	-3.19 ± 0.12
t’ value	36.12**	70.61**	56.11**
Group DF Initial	123.47 ±2.53	165.67 ±1.95	8.41 ±0.15
Final	100.01 ±1.63	114.20 ±1.47	5.34 ±0.11
Difference	-23.46 ±2.29	-51.47 ±2.53	-3.07 ±0.11
‘t’ value	39.53**	78.73**	64.59**
Group DG Initial	124.80 ±2.54	163.07 ±2.34	8.39 ± 0.21
Final	124.20 ±2.65	164.60 ±2.61	8.36 ±0.13
Difference	-0.60 ± 3.46	1.53 ±3.74	-0.03 ±0.13
‘t’ value	0.65 ^{NS}	1.53 ^{NS}	0.65 ^{NS}
‘F’ value between groups	140.29**	409.83**	538.94**

** Significant at one per cent level; ^{NS} not significant

Serum fasting glucose levels

The mean serum fasting glucose levels ranged from 123.20 to 124.80mg/dl in the experimental and control groups as against the normal range of 70 to 99 mg/dl as quoted by Raghuram *et al*., (2007). It is inferred that there was a reduction in fasting glucose levels on supplementation with wheat germ, bran and grass individually and in combination. Group DA supplemented with wheat germ and group DC supplemented with wheat grass had a minimal decrease of 22.07mg/dl. Group DB supplemented with wheat bran had a reduction of serum fasting glucose of 22.80mg/dl while group DF supplemented with wheat bran and grass had a reduction of 23.46mg/dl. Group DD supplemented with wheat germ and bran had a decrease of 23.27mg/dl while group DE supplemented with wheat germ and grass had a maximal decrease of 28.33mg/dl. The final values of the serum fasting glucose was significantly lower than the initial values (P<0.01) in all the experimental groups. The difference observed between the initial and final values of the control group DG was not significant.

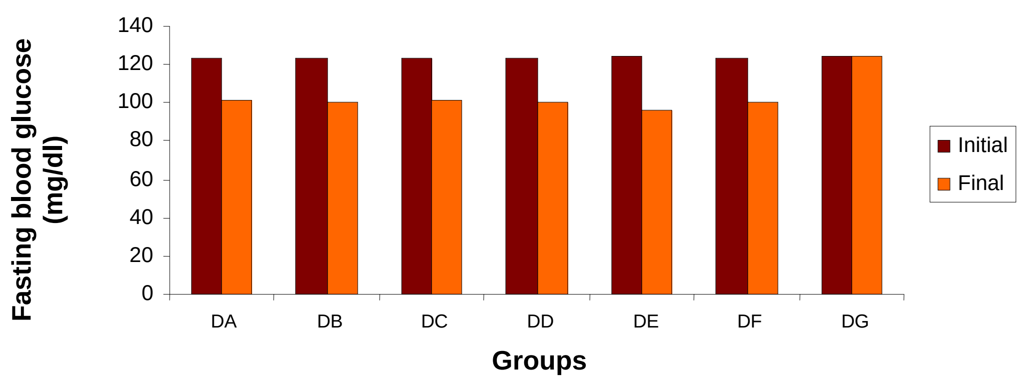


Figure 3
Changes in serum fasting blood glucose levels

The one way analysis of variance showed a statistically significant difference in the reduction of serum fasting glucose levels among the seven groups at one per cent level. The maximum reduction in the fasting blood glucose levels as observed in group DE supplemented with wheat germ and grass could be substantiated with the study done by Potter *et al*., (1981)where various test meals of varying dietary fiber content were tested on healthy subjects and these meals did decrease fasting blood glucose levels.

Serum postprandial glucose levels

The mean serum postprandial glucose levels of the experimental and control groups ranged from 184.40 to 188.53mg/dl whereas normal level ranges from 80 to 120 mg/dl as quoted by Raghuram *et al*.,(2007). The serum postprandial glucose levels reduced after individual as well as combined supplementation of wheat germ, bran and grass. The final mean serum postprandial glucose levels in the experimental groups after the supplementation ranged from 113.07 to 123.93 mg/dl. Among the supplemented groups, maximum reduction of 52.87mg/dl was noted in group DE supplemented with wheat germ and grass and the minimum reduction of 39.80mg/dl was noted in group DB supplemented with wheat bran. Group DA supplemented with wheat germ had a decrease of 40.74mg/dl while group DC supplemented with wheat grass had a decrease of 47.93 mg/dl. Group DD supplemented with wheat germ and bran had a decrease of 48.20 mg/dl. Group DF supplemented with wheat bran and grass showed a decrease of 51.47mg/dl which was almost closer to the decrease observed in group DE supplemented with wheat germ and grass. Decrease in serum postprandial glucose levels in the experimental groups were found to be significant at one per cent level whereas the change observed in the control group was not statistically significant.

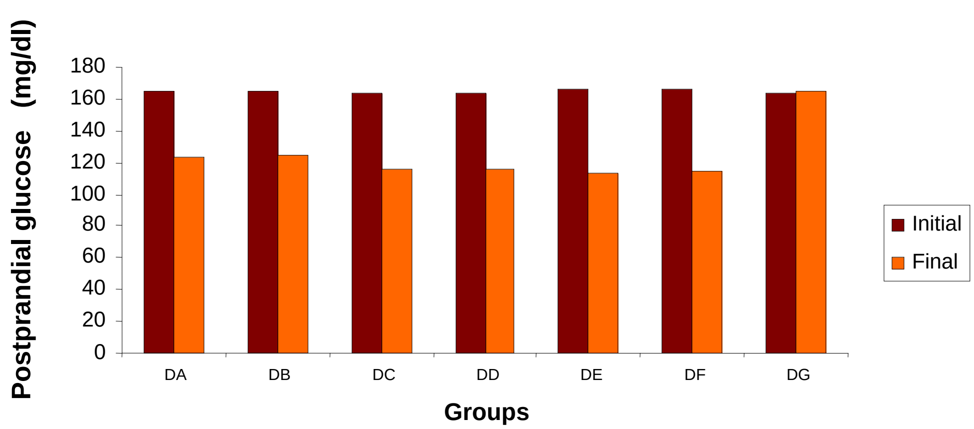


Figure 4
Changes in serum postprandial glucose levels

One way analysis of variance was performed and the difference between the groups was found to be significant at one per cent level. From the results it could be confirmed that the combined supplementation of wheat germ and grass is more efficient in reducing serum postprandial glucose levels than the individual supplementation of wheat germ, bran and grass or combined supplementation of wheat germ and bran or wheat bran and grass.

The results of the present study are in accordance with another study conducted by Cara *et al* .,(1992) in which insulin dependent diabetics treated with wheat germ oil along with insulin showed a glucose reduction of 20.35mg/dl. Murthy (2005) has demonstrated the beneficial potential of wheat grass powder on moderate diabetics by lowering the postprandial glucose by 19.25mg/dl.

Serum glycosylated hemoglobin levels

The glycosylated hemoglobin test (HbA_1C) is an excellent index of long term diabetes control. Unlike blood sugar which tends to fluctuate from day to day and even hour to hour, the HbA_1C test is a true index of the average blood glucose control during previous 2-3 months. HbA_1C test is done in the laboratory rapidly and precisely using the “gold standards” of the HbA_1C testing. The interpretation of the test results are as follows: normal: below 5.6 per cent, good control: 5.6 to 7 per cent, fair control: 7 to 8 per cent, unsatisfactory control: 8 to 10 per cent and poor control: above 10 per cent (American Diabetic Association, 2007). The mean initial glycosylated hemoglobin levels of the subjects in both the experimental and the control groups were between 8.39 to 8.45 per cent (unsatisfactory control). The impact evaluation showed that the HbA_1C had lowered by the individual supplementation of wheat germ, bran and grass as well as combinations of supplementation of wheat germ and bran, wheat germ and grass and wheat bran and grass over a period of six months. Group DA supplemented with wheat germ had a reduction of 2.07 per cent with the final values at 6.35 per cent which was considered as ‘good control’.

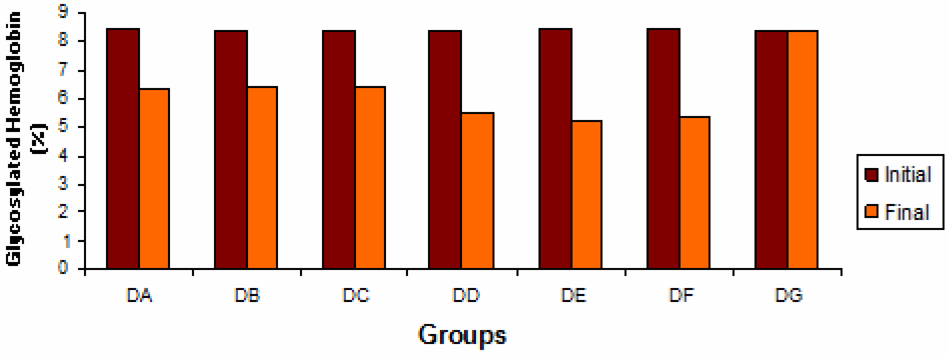


Figure 4

Changes in serum glycosylated hemoglobin levels

A similar effect was noted in groups DB and DC which had a reduction of 1.96 and 1.99 per cent respectively with the final values at 6.41 (good control). In all the three combined supplementation groups namely DD, DE and DF the final values were 5.49, 5.26 and 5. 34 per cent respectively which according to the gold standards set by the American Diabetic Association (2007) were normal. Further maximum reduction of the HbA_1C was noted in group DE supplemented with wheat germ and grass. The reduction between the mean initial and final values of HbA_1C in all the supplemented groups were significant at one per cent level. No such significance was observed in the control group. Study by Yukiko *et al*., (2007) proved that HbA_1C reduced on supplementation with Antioxidant Biofactor (AOB) a mixture of commercially available fermented grain foods which includes wheat.

2. Effect of supplementation on obese subjects

a. Changes in biochemical picture

(i) Changes in mean serum total cholesterol, triglyceride, LDL-cholesterol, HDL- cholesterol and VLDL-cholesterol levels

Table XIV and Figures 6 to 10 give the mean serum total cholesterol, triglyceride, LDL-cholesterol, HDL- cholesterol and VLDL-cholesterol at the initial and final phase of the study period and the results of the statistical appraisal of the data. In the obesity group lipo protein (Lpa) is not presented as there was no significant change after the supplementation.

TABLE XIV
CHANGES IN MEAN SERUM TOTAL CHOLESTEROL, TRIGLYCERIDES, LDL-C, HDL-C AND VLDL-C LEVELS

(N=15/group)

Groups	Total Cholesterol (mg/dl)	Triglyceride (mg/dl)	LDL cholesterol (mg/dl)	HDL cholesterol (mg/dl)	VLDL cholesterol (mg/dl)
Group HA Initial	213.80±2.14	188.53±2.26	142.13±1.64	34.23±1.60	37.70±0.89
Final	178.53±0.64	155.33±1.54	101.60±1.40	43.10±1.30	31.06±0.62
Difference	-35.27±2.15	-33.20±2.46	-40.53±2.29	8.87±2.10	-6.64±0.99
‘t’value	63.42**	38.91**	68.41**	21.89 **	26.08**
Group HB Initial	214.73±0.88	186.13±2.07	143.27±1.33	33.87±1.77	37.26±0.25
Final	170.33±0.49	142.73±1.22	102.07±1.83	41.67±0.82	28.53±0.64
Difference	-44.40±1.30	-43.40±2.06	-41.20±2.21	7.80±1.74	-8.73±0.71
‘t’value	127.74**	78.34**	72.19**	17.36**	47.28**
Group HC Initial	216.07±0.88	185.33±2.13	145.27±4.86	33.73±1.87	37.07±0.39
Final	193.60±0.63	152.53±1.81	128.40±0.99	40.53±0.52	30.47±0.64
Difference	-22.47±1.41	-32.80±3.19	-16.87±5.00	6.80±2.01	-6.60±0.69
‘t’value	61.82**	29.00**	13.07**	13.12**	37.10**
Group HD Initial	204.67±3.60	184.67±3.04	143.47±1.18	35.13±1.78	36.87±1.06
Final	155.80±38.81	132.60±1.40	102.07±1.83	44.67±0.99	26.52±0.28
Difference	-48.87±37.68	-52.07±2.94	-41.40±2.21	9.54±1.60	-10.35±1.08
‘t’value	5.02**	3.16**	49.33**	18.51**	36.96**
Group HE Initial	214.13±1.06	185.27±3.03	143.20±1.26	34.20±1.90	37.07±1.16
Final	185.87±1.13	142.13±1.06	115.73±1.98	39.73±1.44	28.40±0.63
Difference	-28.26±1.22	-43.14±3.07	-27.47±2.50	5.53±2.36	-8.67±0.82
‘t’value	89.53**	10.10**	42.50**	9.10**	41.11**
Group HF Initial	214.07±0.26	185.93±2.46	143.80±1.57	32.87±2.07	37.42±0.17
Final	181.07±1.03	146.00±1.41	107.13±3.54	38.57±0.52	29.20±0.41
Difference	-33.00±1.13	-39.93±2.34	-36.67±4.37	5.70±2.10	-8.22±0.42
‘t’value	112.72**	37.84**	32.50**	28.98**	67.24**
Group HG Initial	215.27±1.79	184.40±2.56	143.60±1.45	32.87±1.41	36.87±0.64
Final	216.00±6.08	186.13±2.07	143.80±1.57	33.60±2.20	36.20±0.86
Difference	0.73±3.06	1.73±3.31	0.20±1.97	-0.73±1.56	-0.67±1.11
‘t’value	0.93 ^{NS}	0.34 ^{NS}	0.39 ^{NS}	0.65 ^{NS}	1.16 ^{NS}
‘F’ Value	17.60**	532.19**	321.60**	2622.735**	11995.54**

**Significant at one per cent level; ^{NS} not significant

Serum total cholesterol levels

The mean initial serum total cholesterol level of the obese subjects in all the groups were in the range of 204.67 to 215.27mg/dl as against the normal value of < 200mg/dl quoted by Raghuram *et al*., (2007) and Ghafforunissa and Krishnasamy (2007).Six months of supplementation of wheat products including wheat germ, bran, grass and their combinations brought about a marked reduction in the serum total cholesterol values in all the supplemented groups. Group HA supplemented with wheat germ had a decrease of 35.27mg/dl in the serum total cholesterol levels while group HB supplemented with wheat bran had a reduction of 44.10mg/dl. Group HC supplemented with wheat germ and grass had a minimal decrease of 22.47mg/dl among the supplemented groups while group HD supplemented with wheat germ and bran had the maximum reduction of 48.87mg/dl. Group HE supplemented with wheat germ and grass had a decrease of 28.26mg/dl followed by group HF supplemented with wheat bran and grass which had a decrease of only 33mg/dl in the serum total cholesterol level. Group HG which served as the control group had an increase of 0.73mg/dl over a period of six months without any supplementation. The final values of the serum total cholesterol were found to be significantly lower than the initial values ($P<0.01$) in all the experimental groups except the control group HG.

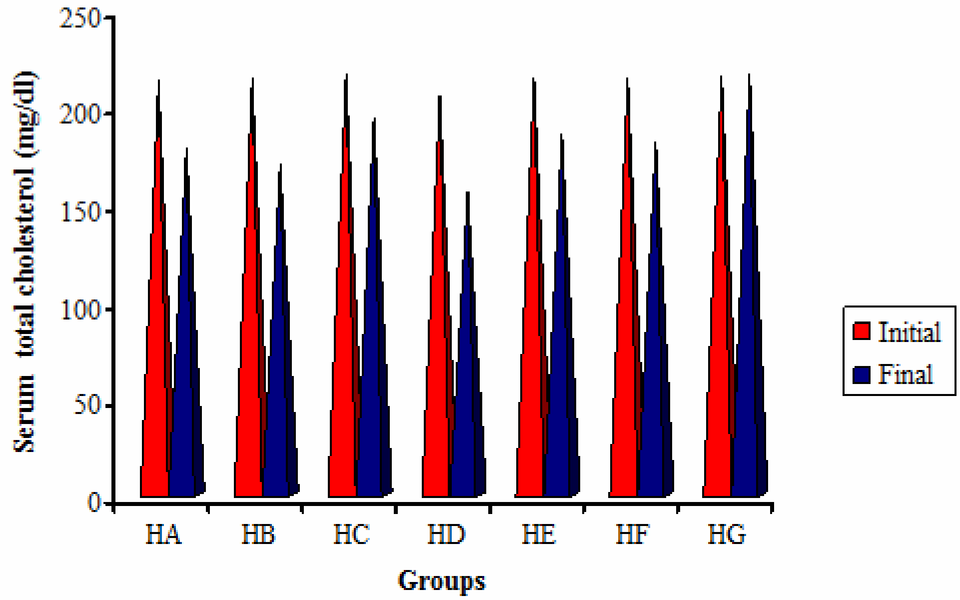


Figure 5

Changes in serum total cholesterol levels

The one way analysis of variance showed a statistically significant difference in the reduction of serum total cholesterol levels among the groups at one per cent level.

The maximum reduction in mean serum total cholesterol was noted in group HD which had a combined supplementation of wheat germ and bran. Similarly maximum reduction was recorded in group HB which was individually supplemented with wheat bran. Study by Vorster *et al*., (1986) proved the role of dietary fibre in oat bran through supplementation of oat bran as tablets in lowering total cholesterol. Similarly the dietary fibre in wheat bran might have posed to decrease the serum total cholesterol as 100g of wheat bran contains 42.8g of dietary fiber. According to Khaw and Barrett-Connor (1987) cereal fiber reduces cholesterol on regular intake. Further a study conducted by Ostlund *et al*., (2003) demonstrated that purified plant sterols (phytosterol) have cholesterol lowering effect. Similarly the phytosterol in wheat germ might have been the useful component in lowering cholesterol levels. Dietary fiber and phytosterol prevents the oxidation of LDL- cholesterol thereby reduces total cholesterol (Mohammed, 2000).

Serum triglyceride levels

The mean serum triglyceride levels ranged from 184.40 to 188.53mg/dl whereas normal serum triglyceride level is less than 150mg/dl (Ghafforunissa and Krishnasamy, 2007). The serum triglyceride levels reduced after individual supplementation with wheat germ, bran and grass and also in combination. The final values of the mean serum triglyceride levels in the experimental groups after the supplementation ranged from 132.60 to 155.33mg/dl. Among the supplemented groups, maximum reduction of 52.07mg/dl was noted in group HD supplemented with wheat germ and bran and the minimum reduction of 32.80mg/dl was noted in group HC supplemented with wheat grass. Group HA supplemented with wheat germ had a decrease of 33.20mg/dl while group HB supplemented with wheat bran had a decrease of 43.40mg/dl. Group HE supplemented with wheat germ and grass had a decrease of 43.14 mg/dl almost nearing the decrease recorded in group HB supplemented with only wheat bran. Group HF supplemented with wheat bran and grass showed a decrease of 39.33mg/dl which was much below the decrease observed in group HB supplemented with wheat bran. Decrease in serum triglyceride levels in the experimental groups were found to be significant at one per cent level whereas the change observed in the control group was not statistically significant.

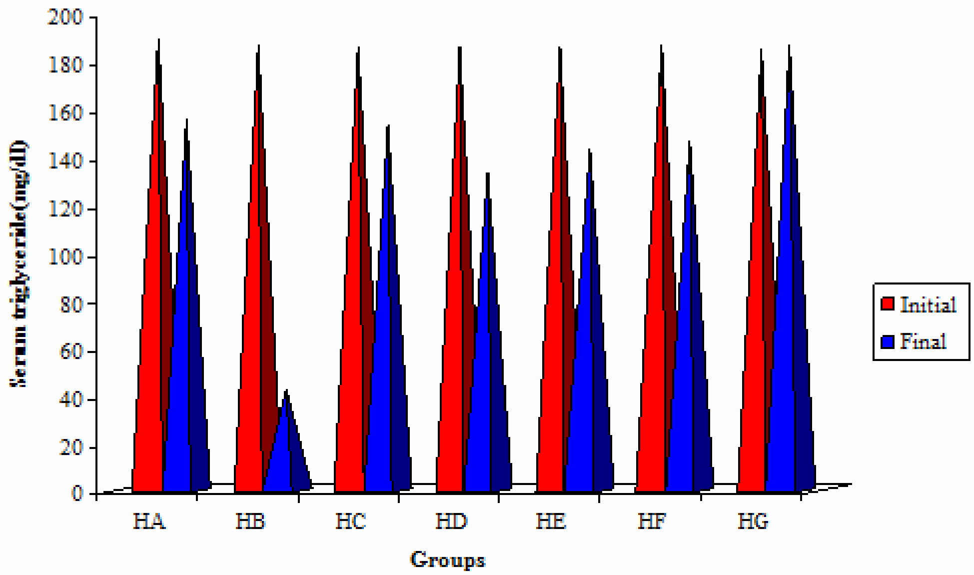


Figure 6

Changes in serum triglyceride levels

Further to 't' test one way analysis of variance was performed and found to be significant at one per cent level between the groups. Similar to the results of serum total cholesterol maximum reduction of 52.07mg/dl was noted in group HD supplemented with wheat germ and bran where individual supplementation of wheat bran in group HB had a reduction of 43.40 mg/dl and group HA supplemented with wheat germ had a reduction of 38.91mg/dl. The reduction in groups HB and HD supplemented with wheat bran and wheat germ and bran respectively was in par with the study conducted by Swain *et al*.,(1990) where the serum triglyceride levels lowered on supplementation with wheat bran and oat bran on normolipidemic males. The serum triglyceride lowering potential of wheat germ in groups HA, HD and HE could be supported by the study of Martine *et al*., (1992) where short-term supplementation of wheat germ lowered plasma triglyceride levels in rats.

Serum LDL-cholesterol level

Yet another comprehensible utility of the supplementation was the demonstrably distinct decrease of mean serum LDL-cholesterol levels. The initial mean serum LDL-cholesterol levels in both the experimental and control groups ranged from 142.13 to 145.27mg/dl which was much higher than the normal levels of < 130mg/dl (Raghuram *et al*., 2007). The impact evaluation showed that the serum LDL – cholesterol had lowered by the individual supplementation of wheat germ, bran and grass as well as combinations of wheat germ and bran, wheat germ and grass and wheat bran and grass over a period of six months. Group HA supplemented with wheat germ had a reduction of 40.53mg/dl while group HB supplemented with wheat bran had a reduction of 41.20mg/dl and group HC supplemented with wheat grass had a minimal decrease of 16.87mg/dl. In the group HD supplemented with wheat germ and bran had a maximum reduction of 41.40mg/dl followed by group HF supplemented with wheat bran and grass with a decrease of 36.67mg/dl. Group HE supplemented with wheat germ and grass had a decrease of 27.47mg/dl in the mean LDL-cholesterol after six months of supplementation. The reduction in the serum LDL-cholesterol level of all the experimental groups except the control group were significant at one per cent level.

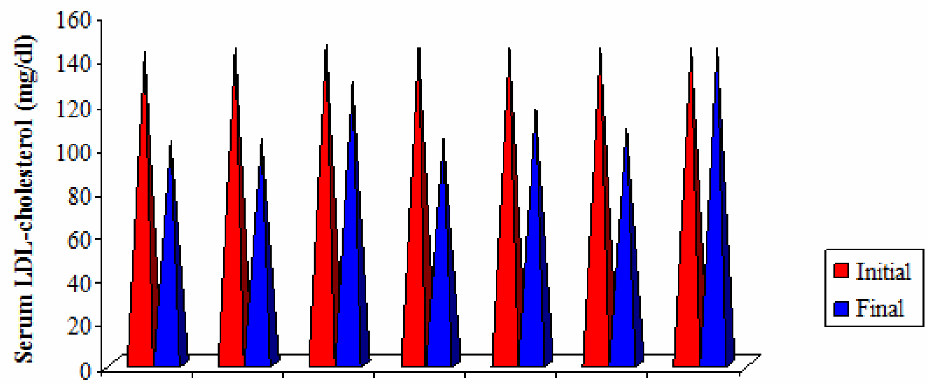


Figure 7

Changes in serum LDL-cholesterol levels

Groups HA and HB supplemented with wheat germ and wheat bran respectively resulted in significant reduction in LDL- cholesterol as against groups HC,HE and HF proving individual supplementation of wheat germ and bran to be even better than supplementation of wheat bran and grass. Groups HA, HB and HD supplemented with wheat germ, wheat bran and wheat germ and bran respectively showed significant reduction of LDL - cholesterol over the groups HC, HE and HF which were supplemented with wheat grass, wheat germ and grass and wheat bran and grass respectively proving supplementation of wheat germ and bran individually or in combination is beneficial.

Through the statistical analysis it is clearly defined that the group HD supplemented with wheat germ and bran had a maximum reduction followed by the individual supplements namely wheat germ and wheat bran. The present investigation is in par with a study conducted by Venketasan *et al*., (2007) where the potential of a fibre cocktail of fenugreek, guar gum and wheat bran reduced oxidative modification of LDL induced by an atherogenic diet in rats. Further a French study found that eating 30 grams, or about a quarter of a cup of raw wheat germ a day for 14 weeks lowered LDL cholesterol by 7.2 per cent (Illmer *et al*., 2005). Wheat germ success against LDL cholesterol could stem for its antioxidant powers. Studies show that fiber and antioxidants from foods prevented LDL particles from becoming oxidized (Kacprzak *et al*., 2002). Oxidized LDL - cholesterol presents a much greater danger to health. When a fat such as LDL- cholesterol undergoes oxidation, it is more prone to collect in blood vessels to form plaque. Over time, the plaques narrow the blood vessels or unleash a clot, which can result in a heart attack or stroke.

Serum HDL-cholesterol levels

The mean initial HDL-cholesterol levels of the experimental and the control groups was around 35mg/dl whereas normal HDL –cholesterol levels should be more than 50mg/dl (Ghafforunissa and Krishnasamy, 2007).There was an increase in the HDL-cholesterol levels on supplementation. Maximum increase of 9.4 mg/dl was observed in group HD supplemented with wheat germ and bran while the least increase of 5.53mg/dl was noted in group HF supplemented with wheat bran and grass. Group HA supplemented with wheat germ had registered an increase of 8.87mg/dl while group HB supplemented with wheat bran recorded an increase of 7.80mg/dl and group HC supplemented with wheat grass had recorded an increase of 5.70mg/dl. The increments in the HDL-cholesterol were found to be significant ($P<0.01$) in the experimental groups.

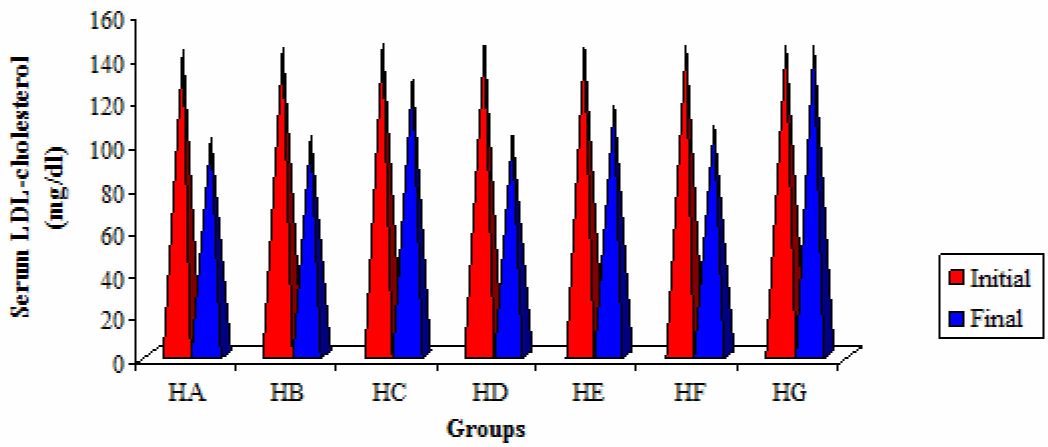


Figure 8

Changes in serum HDL-cholesterol levels

The negligible change from the initial value observed in the control group was not statistically significant. One way analysis of variance conducted to substantiate the significance between the groups also proved to be significant at one per cent level

This could be further supported by a study by Jean *et al., (*1987) where HDL cholesterol increased by five per cent for every five per cent decrease in total cholesterol on pectin and wheat bran supplementation. Further according to Brenda *et al.,* (1987), there was a negative correlation between HDL- cholesterol and obesity risk. Dietary supplementations with wheat germ and bran have shown a positive effect on HDL cholesterol levels, thereby proving to be an effective treatment for obeses.

Serum VLDL-cholesterol

On pondering over the serum VLDL - cholesterol levels of the experimental and the control groups it could be noted that the mean initial VLDL cholesterol levels did vary from 36.87 to 37.70mg/dl which were above the normal values of less than 35mg/dl (Ghafforunissa and Krishnasamy, 2007).After supplementation of wheat germ, bran and grass both individually as well as in combinations there was a reduction in VLDL-cholesterol levels in all the experimental groups. Group HA supplemented with wheat germ had a reduction of 6.64mg/dl while group HB supplemented with wheat bran had a reduction of 8.73mg/dl and group HC supplemented with wheat grass showed a minimal reduction of 6.06 mg /dl among the supplemented groups. Group HF supplemented with wheat bran and grass had a reduction of 8.22mg/dl while group HE supplemented with wheat bran and grass had a decrease of 8.67mg/dl. Maximum reduction of 10.35mg/dl was observed in group HD supplemented with wheat germ and bran. Students 't' test revealed one per cent level of significance in the reduction observed in all the experimental groups whereas the difference observed in the control group was not found to be significant. The one way analysis of variance showed a statistical significance at one per cent level between the groups.

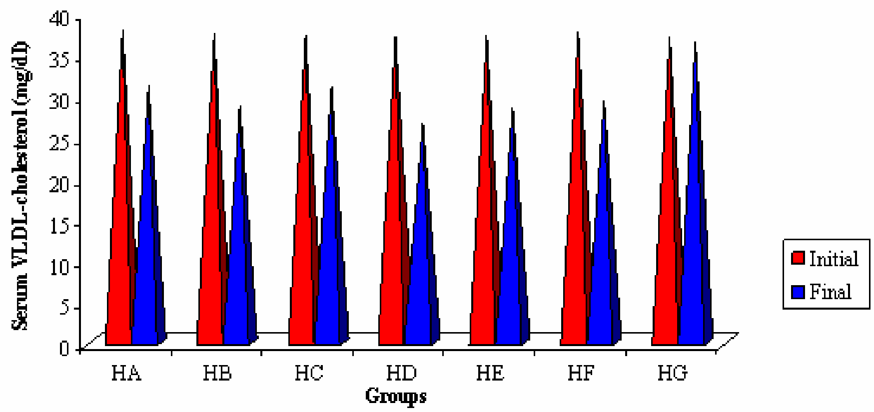


Figure 9

Changes in serum VLDL-cholesterol levels

Similar to other parameters it could be culled out that a combined supplementation of wheat germ with bran has proved to lower serum VLDL-cholesterol levels. The results are in par with the study conducted by Illman and Topping (1985) where 30g of wheat germ supplemented for a period of 14 weeks reduced VLDL - cholesterol. Further a study by Venketesan *et al*., (2007) also has proved a reduction in VLDL cholesterol where fiber cocktail of fenugreek, guar gum and wheat bran were supplemented as atherogenic diet to LDL induced rats.

3. Effect of individual and combined supplementation of wheat germ, bran and grass on selected low immunity subjects

a. Changes in the physiological symptoms

The physiological symptoms before and after treatment of the low immune subjects is depicted in Table XV.

TABLE XV
CHANGES IN PHYSIOLOGICAL SYMPTOMS OF LOW IMMUNE SUBJECTS*

Symptoms	Group TA		Group TB		Group TC		Group TG	
	I	F	I	F	I	F	I	F
Cough with sputum	13	2	15	5	15	3	15	12
Dry cough	12	5	13	3	15	9	15	12
Loss of weight	14	1	13	-	15	-	15	2
Loss of appetite	13	-	5	-	15	-	15	15
Chest pain	10	4	10	4	15	6	15	13
Shortness of breath	11	3	14	4	10	2	15	12
Low grade fever	13	-	13	-	12	1	13	13
Night sweats	11	4	10	3	11	9	10	10
Anorexia	14	-	11	2	15	-	15	15
Clubbing	1	1	1	1	4	4	3	5
Peripheral lymphadenopathy	2	2	3	3	2	2	7	9
Hemoptysis	1	1	-	-	-	-	8	8

* Multiple responses

Of the various clinical parameters indicative of low immune, cough with sputum was present in 13 subjects in group TA, 15 subjects each in groups TB, TC and TD. After the supplementation it was noted that group TA supplemented with wheat germ, group TB supplemented with wheat grass and group TC supplemented with wheat germ and grass had only two, five and three subjects with cough and sputum respectively. Dry cough was prevalent among 12, 13 and 15 subjects in groups TA, TB and TC respectively whereas after the supplementation period it was noted that only five, three and five subjects respectively had dry cough. Loss of weight greatly reduced at the end of the study among all the supplemented subjects. The loss of appetite which was present initially disappeared completely in the supplemented groups after the supplementation period. Chest pain, shortness of breath, low grade fever and anorexia was present in most of the subjects before supplementation which was not present after the supplementation. Such improvements were not observed among the control group subjects.

b. Changes in biochemical picture

(i) Changes in the total protein and albumin levels

Table XVI and Figures 11 and 12 present the changes in the serum total proteinand albumin levels observed among the low immune subjects after supplementation.

TABLE XVI

CHANGES IN MEAN SERUM TOTAL PROTEIN AND ALBUMIN LEVELS (N=15/group)

Groups	Total protein (g/dl)	Albumin (g/dl)
Group TA		
Initial	7.4±1.24	3.0±0.13
Final	8.8±1.46	3.5±0.03
Difference	1.4±0.96	0.5±0.22
‘t’ value	14.50**	9.68**
Group TB		
Initial	7.4±0.74	3.1±0.51
Final	8.4±5.36	3.3±0.68
Difference	1.0±0.20	0.2±0.15
t’ value	2.26**	5.16**
Group TC		
Initial	7.6±2.77	3.0±0.26
Final	9.4±1.12	3.7±0.19
Difference	1.8±3.53	0.7±0.31
t’ value	9.25**	8.73**
Group TD		
Initial	7.1±1.24	3.1±0.91
Final	7.5±2.51	3.2±0.92
Difference	0.4±.2.12	0.1±0.18
t’ value	2.46*	2.15*
‘F’ value between groups	8.83**	13.07**

** Significant at one per cent level;* Significant at five per cent level

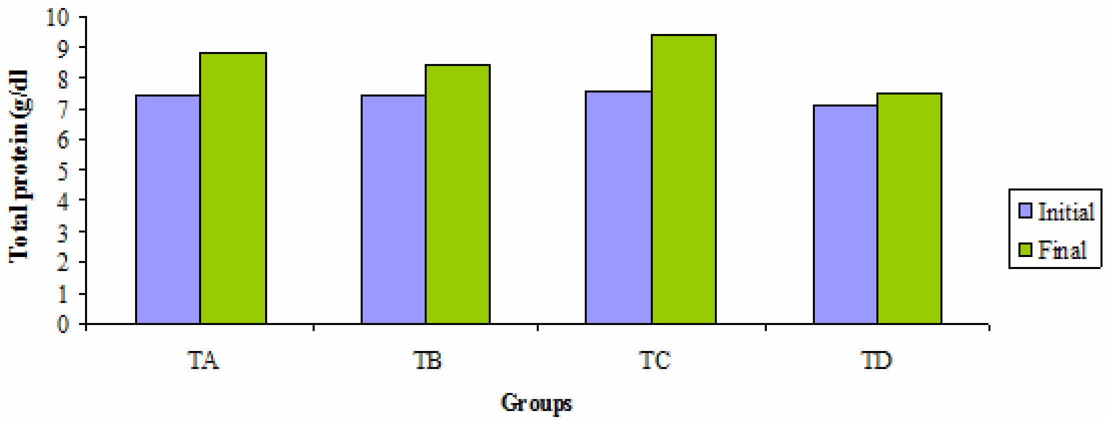


Figure 10

Changes in serum total protein level

Serum total protein levels

The mean initial serum total protein levels of the experimental and the control groups ranged from 7.1 to 7.6 g/dl which was in the lower range of the normal serum total protein levels i.e. 7-9g/dl (Varun *et al*.,2007).There was an increase in the serum total protein levels on supplementation. Maximum increase of 1.8 g/dl was observed in group TC supplemented with wheat germ and grass while an increase of 1.4g/dl was noted in group TA supplemented with wheat germ only. Group TB supplemented with wheat bran had registered an increase of 1g/dl. The final values of the serum total protein when compared with the initial values were found to be significantly greater (P<0.01) in the experimental and control groups. One way analysis of variance conducted to substantiate the significance between the groups also proved to be significant at one per cent level.

It was recorded that supplementation with wheat germ and grass resulted in significantly greater increments in serum total protein over the supplementation of wheat germ and wheat grass individually.

Serum albumin levels

The serum albumin levels of the experimental and the control groups ranged between 3 and 3.1g/dl whereas the normal range of the serum albumin is 3.5-5.0g/l as quoted by Varun *et al*., (2007). On supplementation with wheat products including wheat germ, grass and their combination there was an improvement in the serum albumin levels after six months. Group TC supplemented with wheat germ and grass had a maximum increase of 0.7g/dl. Group TA supplemented with wheat germ had an increase of 0.5g/dl followed by group TB supplemented with wheat grass with a mean increase of 0.2g/dl. The changes observed in the mean serum albumin levels in the experimental and the control groups were found to be significant at one per cent level .One way analysis of variance also proved to be significant at one per cent level between the four groups compared.

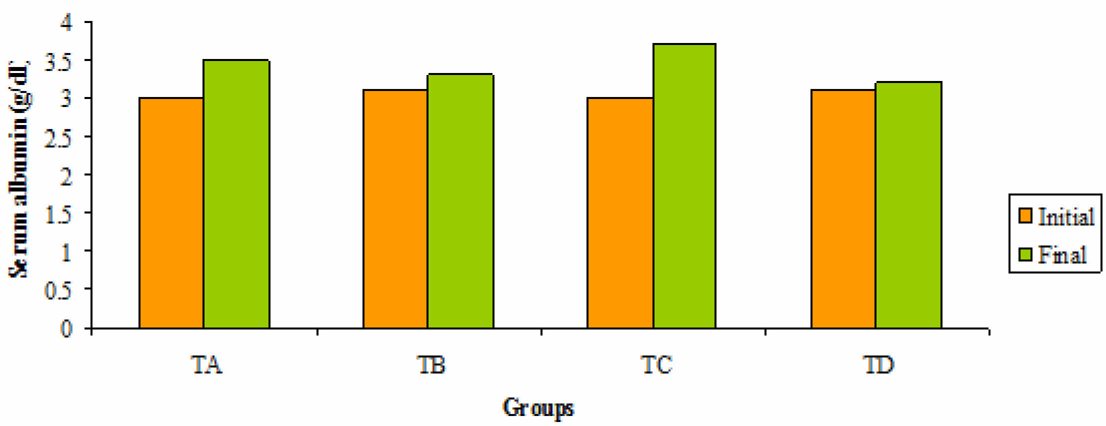


Figure 11

Changes in serum albumin level

In the present study lower levels of serum total protein and albumin were present in the pulmonary low immune subjects before the supplementation study. This agrees with Sasaki *et al.,* (1999) who stated that albumin and total protein were significantly lower in pulmonary low immune. The increase in the total protein and the serum albumin levels on supplementation could be compared with the study of Robert and Jarlier (2002) where there was a slight increase in total protein and serum albumin on supplementation of wheat germ to multi drug resistant low immune subjects. Arinola and Igbi (1998) reported high levels of IgG and IgM in pulmonary low immune. Nagayama *et al*.,(1999) also stated that hyperglobulinaemia in low immune is one of the predictive factors for the development of residual pleural thickening in tuberculous pleurisy.

(ii) Changes in the TLC and CD_4 levels

Table XVII and Figures 13 and 14 show the changes in the TLC and CD_4 of low immune subjects after supplementation.

TABLE XVII

CHANGES IN SERUM TLC AND CD_4 LEVELS

(N=15/group)

Groups	TLC(cells/m^3)	CD_4(cells/m^3)
Group TA		
Initial	8615.87±214.81	324.13±3.83
Final	7747.47±114.53	501.73±0.96
Difference	-868.40±112.17	177.60±3.83
‘t’ value	28.95**	173.43**
Group TB		
Initial	8863.80±210.13	334.07±3.85
Final	8298.73±111.79	477.40±5.32
Difference	-565.07±141.35	143.33±3.25
t’ value	14.94**	164.94**
Group TC		
Initial	8423.73±218.23	322.93±2.25
Final	7335.13±115.00	573.93±0.25
Difference	-1088.60±119.19	251.00±3.56
t’ value	34.16**	263.69**
Group TD		
Initial	8088.60±212.23	332.80±1.61
Final	7864.40±111.20	441.40±3.23
Difference	-224.20±129.25	108.60±3.29
t’ value	6.49**	123.45**
‘F’ value between groups	16.60**	12.18**

** Significant at one per cent level

Serum TLC levels

The mean initial serum TLC of the low immune subjects in all the groups were in the range of 8088.60 to 8863.80 cells/m^3 as against the normal value of 1891-4800 cells/ m^3 as quoted by Robert and Jarlier (2002). Six months of supplementation of wheat products including wheat germ, grass and their combination brought about a marked reduction in the serum TLC values in all the supplemented groups. Group TA supplemented with wheat germ had a decrease of 868.40 cells/m^3 in the serum TLC levels while group TB supplemented with wheat grass had a reduction of 565.07 cells/m^3 only. Group TC supplemented with wheat germ and grass had a maximal decrease of 1088.60 cells/m^3 among the supplemented groups. Group TD which served as the control group had a decrease of 224.20 cells/m^3 over a period of six months without any supplementation. The final values of the serum TLC were significantly lower than the initial values ($P<0.01$) in the experimental and control groups.

The one way analysis of variance also showed a statistically significant difference in the reduction of serum TLC levels among the four groups at one per cent level. Further the mean differences of group TC supplemented with wheat germ and grass showed significance over groups TB and TA supplemented with wheat grass and germ proving the combined supplementation of wheat germ and grass to be effective.

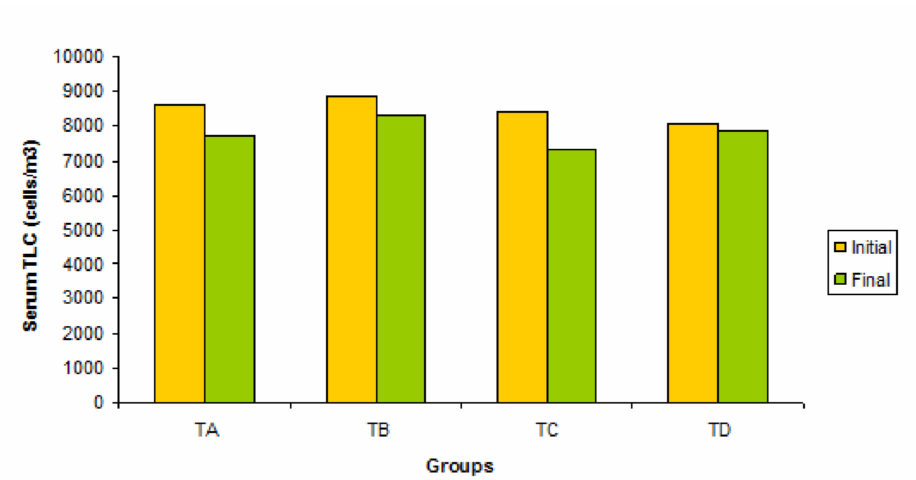


Figure 12
Changes in serum TLC levels

The elevated levels of TLC levels before the start of the supplementation study may be due to the chronic infection as TLC is accelerated in many diseases including pulmonary low immune (Nefedov *et al*., 2007).

Serum CD_4 count

The initial mean CD_4 count of the selected subjects in the experimental and control groups ranged from 322.93 to 334.07 cells/m^3 whereas normal CD_4 level ranges from 690-2420cells/m^3 (Robert and Jarlier, 2002). The CD_4 levels increased after individual as well as combined supplementation with wheat germ and grass. The final values of the mean CD_4 levels in the experimental groups after the supplementation ranged from 441.40 to 573.93 cells/m^3. Among the supplemented groups, maximum increase of 251 cells/m^3 was noted in group TC supplemented with wheat germ and grass and the minimum increase of 143.33 cells/m^3 was noted in group TB supplemented with wheat grass. Group TA supplemented with wheat germ had an increase of 177.60 cells/m$^{3.}$ Increase in the initial and final values of CD_4 count in the experimental and control groups were found to be significant at one per cent level.

One way analysis of variance indicated significance between the groups at one per cent level. Further the mean difference in group TC supplemented with wheat germ and grass showed significance over the groups TB and TA supplemented with wheat grass and germ proving the combined supplementation of wheat germ and grass to be effective.

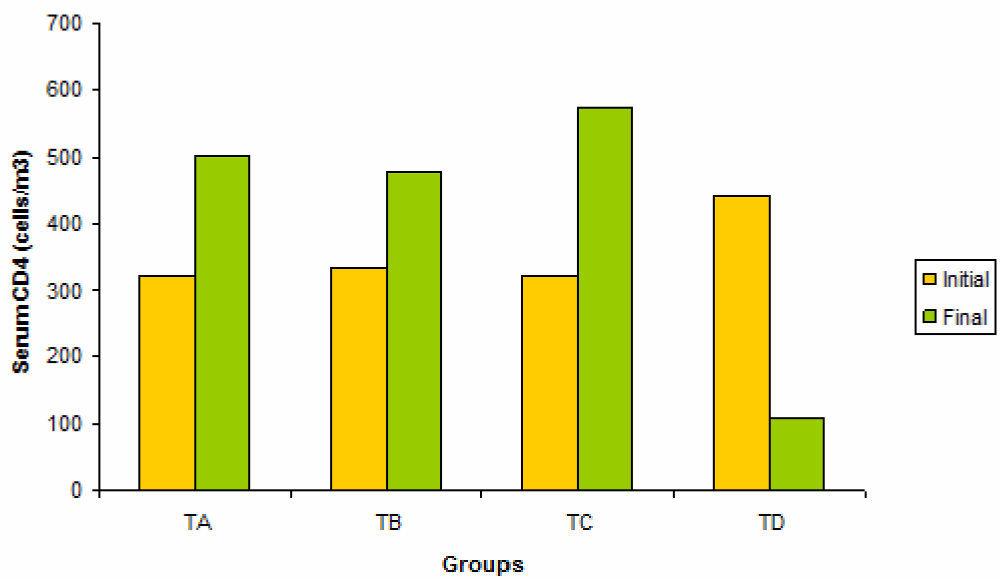


Figure 13

Changes in serum CD_4 levels

The increase in CD_4 count in all the supplemented groups showed a positive impact of supplementation. The study by Kalser (2006) reveals that as immunity builds in the body TLC count decreases with increase in CD_4 counts in low immune affected HIV subjects. Similarly in the present study, there was a decrease in the TLC count with increase in CD_4 count proving the potentials of combined supplementation of wheat germ and grass.

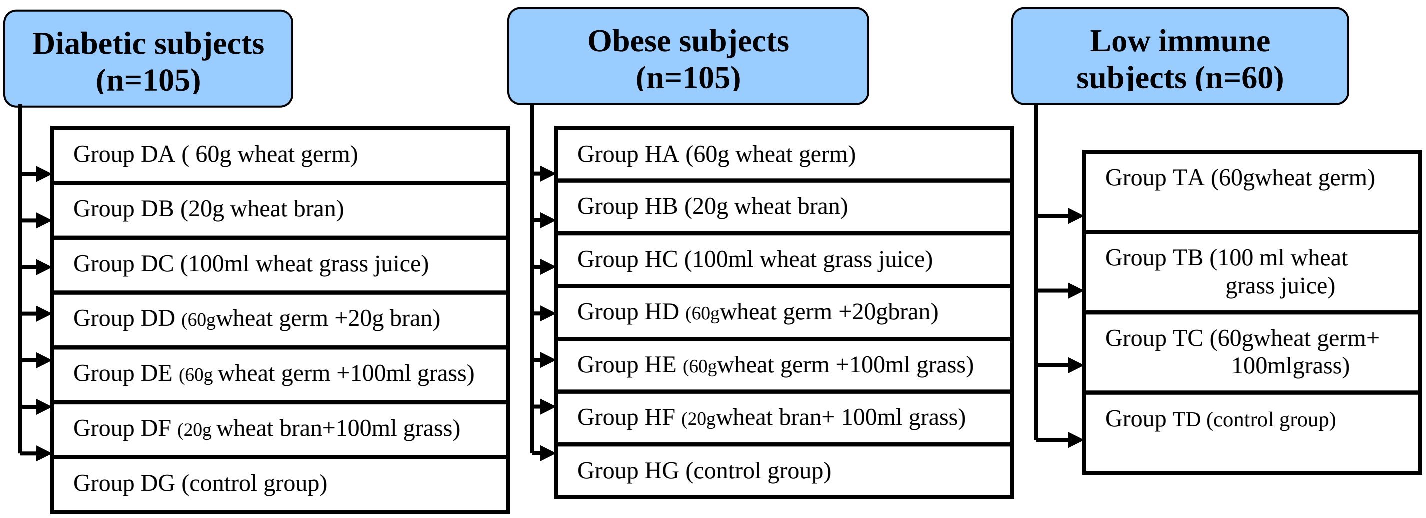
The report of this study has been hosted in the website http://www.avinuty.ac.in for receiving the feedback from the scientific community.

SUMMARY AND CONCLUSION

IV. SUMMARY AND CONCLUSION

Health is a fundamental human right and a worldwide social goal. It encompasses all human disregard of age. Physical aspects of diabetes, obesity and low immunity are now part of many peoples' lives and the border social dimensions affects all, even if this is not acknowledged by many. In India of the 400 people who are diagnosed with diabetes every day; of the 10.7 million deaths from cardiovascular disease every year and of 1.8 million cases of low immunity, now, many have some of the symptoms and infections and some may have received clinical diagnosis too. Yet others enjoy good health and have every chance of continuing to do so for sometime, provided they have access to care and nutritional support. It is important that nutritional interventions should begin as soon as these diseases are diagnosed.

The present study entitled" **"Impact of supplementation of wheat germ, wheat bran and wheat grass to subjects with specific health issues"** is an attempt to find out the effect of nutritious food intervention in managing the conditions like diabetes, obesity and low immunity and improving the nutritional status of the people with these problems. The locale selected for the study was Coimbatore from the State of Tamil Nadu. Based on the physicians' opinion on the clinical and biochemical picture obtained from the hospital records and the criteria framed by the investigator,105 diabetics,60 low immunity subjects and 105 obesity subjects were selected for the study. The ethical guidelines were followed and the study was approved by the Committee on Health Research Ethics, Avinashilingam University for Women, Coimbatore. As a first step in the study an interview schedule was formulated to elicit information from all the 105 diabetic, 60 low immunity and 105 obesity subjects on their socioeconomic details including age, sex, education, family type, monthly income, food habits and dietary pattern through interview cum observation method. Details on type and duration of disease and familial disposition of disease were also collected. The anthropometric measurements including height, weight, BMI and waist and hip circumferences were measured for all the diabetic, obesity and low immunity subjects. MUAC and skin fold thickness were measured for the low immunity subjects. Precise information on food consumption pattern was collected through 24 hour recall method for one tenth of the selected subjects in all the three groups studied. The raw food equivalent of the cooked food was determined and the intake of macro nutrients was computed using the values given in the 'Nutritive Value of the Indian Foods. The 105 diabetics and 105 obesity subjects were divided randomly into seven groups of 15 each respectively and low immune subjects were divided into four groups of 15 each.



Grouping of the subjects

Before starting the feeding trials, all the 225 subjects in the experimental groups were educated about the beneficial effect of the supplements in alleviating the disease conditions. Sixty grams of wheat germ and 20g of bran were supplied in sachets to the diabetic and obesity groups every fortnight at the clinic premises. For the 45 subjects each in the diabetic and the obesity group and 30 subjects in the low immunity group supplemented with wheat grass juice, 3000 ml of fresh juice was prepared daily and 100ml per selected subjects was supplemented. After supplementation for six months the impact of supplementation of wheat germ, bran and grass on selected subjects was evaluated by clinical and biochemical methods.

The findings of the study are summarized as follows

Nutrient content of wheat germ, bran and grass

- The moisture content of wheat germ, bran and grass were 11.1, 9.9 and 12.2g per 100g respectively. The carbohydrate content of wheat bran was 64.5g followed by 51.8g in wheat germ and 3.1g in wheat grass. The dietary fiber content was also found to be highest in wheat bran (42.8g) followed by wheat grass with 17.3g and wheat germ with 13.2g. Wheat germ contained 23.1g of protein followed by 20.5g in wheat grass and 15.5g in wheat bran. The essential amino acid to non essential amino acid ratio of wheat germ, bran and grass were 0.52, 0.43 and 0.56 respectively proving a higher ratio in wheat grass. Total fat content of wheat germ was 9.7g followed by 4. 3g in wheat bran. Wheat grass did not contain any fat. The thiamine (1.9mg), riboflavin (0.5mg), niacin (6.8 mg), vitamin B_6 (1.3 mg) and folic acid (281mcg) contents were found to be highest in wheat germ. Vitamin B_{12} (103mcg) was found to be highest in wheat bran. Calcium (242mg) was found to be highest in wheat grass followed by 73mg in wheat bran and 39mg in wheat germ .Iron content was maximum in wheat bran (10.6mg), whereas the iron content of wheat germ was 6.3mg and of wheat grass was 0.61mg.Wheat bran provided highest content of magnesium (611mg).

Background details of the subjects

- Of all the diabetic subjects 35.2 per cent were in the age group of 40-45 years, 32.4 per cent in the age group of 46-50 years and 32.4 per cent were in the age group of 51-55 years. Of the selected obesity subjects 26.7 per cent were in the age group of 40-45 years, 38.1 per cent in the age group of 46-50 years and 35.2 per cent in the age group of 51-55 years. In the low immunity group 20 per cent were in the age group of 40-45 years, 36.67 per cent were in the age group of 46-50 years and 43.4 per cent were in the age group of 51-55 years.

- In the diabetic group there were 42.9 per cent women and 57.1 per cent men. In the obesity group 70.5 and 63.3 per cent were male and female subjects respectively and in the low immunity group 63.3 per cent were male and only 36.7 per cent were females.
- Around 70 to 80 per cent of the families in the three groups studied belonged to nuclear family system and the remaining families belonged to joint families.
- Among the selected diabetics 40 per cent had primary education, 28.58 per cent had completed high school / higher secondary education and only 28.6 per cent were degree holders. In the obesity group, 26.67 per cent had completed primary education, 34.3 per cent had completed high school / higher secondary education and only 5.71 per cent were degree holders. Among the low immunity subjects 15 per cent had primary school education, 26.70 per cent had high school / higher secondary education and none of them were degree holders. In the diabetic, obesity and the low immunity groups 22.9, 33.3 and 58.3 per cent respectively were found to be illiterates.
- In the diabetic group, 40 per cent were agricultural landlords and only 1.9 per cent were doing business. Further 21.91 per cent were either in government or private jobs. In the obesity group 85.7 per cent were government /private job holders and only 10.5 per cent constituted the agriculture group. In the low immunity group 58.33 per cent were agriculturists and only 13.3 per cent were either in government or private jobs
- It was found in the diabetic group 27.6 per cent belonged to low income group, 17.1 per cent belonged to high income group and a majority of 55.2 per cent belonged to the middle income group. In the obesity group 60.0 per cent of the subjects belonged to middle income group and 29.5 per cent belonged to the high income group. Only 10.5 per cent of the subjects belonged to the low income group. In the low immunity group 75 per cent belonged to the low income group, 18.3 per cent belonged to the middle income group and only 6.7 per cent belonged to the high income group.

- Among the diabetic subjects 58.6 per cent had the condition over the past four to six years, 42.9 per cent of the subjects had diagnosed within the past 1-3 years and only 12.4 per cent of them had diagnosed the condition during the past one year. In the obesity group 58.1 per cent had diagnosed the condition before four to six years while 33.3 per cent of the subjects had the condition over one to three years and only 8.6 per cent of the obesity subjects had diagnosed the condition during the past one year. All the 60 low immunity subjects had diagnosed the infection within one year.
- Among the selected 105 diabetic subjects 41 per cent of the mothers of the subjects were diabetic, 81 per cent of the fathers were diabetic. Also 12.4 and 11.4 per cent of the grand mothers and grand fathers respectively were found to be diabetic. In the obesity group 61 and 91.4 per cent of the mothers and fathers respectively had heart disease, 21.9 and 33.3 per cent of the grand mothers and grand fathers respectively had heart disease.

Anthropometric measurements of the subjects

- The mean weight of the diabetic male and female subjects were 69.98 and 68.55kg respectively. In the obesity group the mean weight of the male and female subjects were 71.25 and 65.99 kg respectively and in the low immunity group the male and female subjects weighed only 41.23 and 40.37kg respectively indicating muscle wasting.
- The mean Body Mass Index of male and female diabetic subjects were 24.81 and 26.21 respectively, obesity subjects were 25.35 and 26.85 respectively and low immunity subjects were 17.62 and 17.92 respectively. The diabetic and obesity male and female subjects were in the Grade I obesity (25-30) and the low immunity male and female subjects were in mild Chronic Energy Deficiency (CED)-grade I.

- The Waist Hip Ratio (WHR) of the male and female diabetic subjects were 0.94 and 0.92 respectively, obesity subjects were 0.95 and 0.93 respectively and low immunity group were 0.62 and 0.71 respectively.
- Mid Upper Arm Circumference and skin fold thickness were measured on low immunity subjects only. The MUAC of male and female subjects were 23.22 and 22.38 cm respectively and the skin fold thickness of the male and female subjects were 1.7 and 1.6 cm respectively.

Food and nutrient intake of subjects

- Consumption of cereals, milk and milk products and fats and oils in the diabetic group were found to be excess and the percentage adequacy of these foodstuffs included +132.9, +138.7 and +260 respectively. The consumption of pulses, green leafy vegetables and fruits were found to be deficient to the extent of 76.7, 80, 39.5 and 48 per cent respectively.
- The mean energy intake of the diabetic subjects was 1688 kcal as against the suggested allowance of 1800kcal. The carbohydrate and fat intake of the diabetic subjects was 251 and 51g respectively. The protein intake of the diabetic subjects was 56.8g as against the suggested allowance of 59.5g and the dietary fiber content of their diet was 39.4g as against the suggested allowance of 34g.
- Consumption of cereals, milk and milk products, fats and oils were found to be 178.6, 147.5, 225 and 450 per cent of RDA respectively in the obesity group. The consumption of green leafy vegetables (13.3%), other vegetables (45%) and fruits (25%) were found to be deficit when compared with the suggested allowance. The mean energy intake of the obesity subjects was 2153 kcal as against the suggested values of 1800 kcal. Similarly carbohydrate (65g) was also found to be in excess.
- In the low immunity group consumption of protein and dietary fiber was only 53.3 and 31.6g when compared with the suggested allowance of 59.5 and 34g. Consumption of all food stuffs including cereals, pulses, green leafy vegetables, other vegetables, fruits, milk and milk products and fats

and oils were found to be deficient in their diets. The mean energy intake of the low immunity subjects was 1756 kcal. The low energy value of diets of low immunity was mainly due to low intake of fat and carbohydrate which was only 20 and 159g respectively.

Impact of supplementation on diabetic subjects

- Initially polyuria, polydypsia, polyphagia, nocturia and constipation were found to be the most frequently occurring symptoms in all the diabetic subjects studied. After six months of supplementation with wheat germ, bran and grass individually and in combination there was a drastic reduction in the physiological symptoms expect for one or two subjects in whom symptoms like polyuria, polyphagia, nocturia and polydypsia did not reduce. Further it was found out that the subjects who expressed constipation as a problem expressed relief of constipation after taking the supplements.
- It is inferred that there was a gradual reduction in fasting glucose levels on supplementation with wheat germ, bran and grass individually and in combination. Group DA supplemented with wheat germ and group DC supplemented with wheat grass had a minimal decrease of 22.07mg/dl. Group DB supplemented with wheat bran had a reduction of serum fasting glucose of 22.80mg/dl while group DF supplemented with wheat bran and grass had a reduction of 23.46mg/dl. Group DD supplemented with wheat germ and bran had a decrease of 23.27mg/dl while group DE supplemented with wheat germ and grass had a maximal decrease of 28.33mg/dl. The final values of the serum fasting glucose was significantly lower than the initial values ($P<0.01$) in all the experimental groups. The difference observed between the initial and final values of the control group DG was not found to be significant.
- The serum postprandial glucose levels in the experimental groups after the supplementation ranged from 113.07 to 123.93 mg/dl. Among the supplemented groups, maximum reduction of 52.87mg/dl was noted in

group DE supplemented with wheat germ and grass and the minimum reduction of 39.80mg/dl was noted in group DB supplemented with wheat bran. The decreases observed in serum postprandial glucose levels in all the experimental groups were found to be significant at one per cent level and also significantly greater than group DG proving the potential of supplementation. The mean decrease observed in groups DC, DD and DF supplemented with wheat grass, wheat germ and bran and wheat bran and grass were significantly higher than that of groups DB and DA supplemented with wheat bran and wheat germ respectively. Group DE supplemented with wheat germ and grass pictured increased reduction and was significant over groups DB, DC, DA and DD.

- The HbA_1C had lowered by the individual as well as combined supplementation over a period of six months. Group DA supplemented with wheat germ had a reduction of 2.07 per cent with the final values at 6.35 per cent which was considered as 'good control'. A similar effect was noted in groups DB and DC which had a reduction of 1.96 and 1.99 per cent respectively with the final values at 6.41 (good control). In all the three combined supplementation groups including groups DD, DE and DF the final values were 5.49, 5.26 and 5.34 per cent respectively. Further maximum reduction of the HbA_1C was noted in group DE supplemented with wheat germ and grass. The reductions between the mean initial and final values of HbA1C in all the supplemented groups were significant at one per cent level and all the reductions were found to be significant over that of the control group.

Impact of supplementation on obesity subjects

- Six months of supplementation of wheat products brought about a marked reduction in the serum total cholesterol values in all the supplemented groups. While group HB supplemented with wheat bran had a maximum reduction of 44mg/dl, group HC supplemented with wheat germ and grass had a minimal decrease of 22.47mg/dl among the individual supplements.

Group HD supplemented with wheat germ and bran had the maximum reduction of 48.87mg/dl among the combination of supplements and group HE supplemented with wheat germ and grass had a minimum decrease of 28.26mg/dl. Group HG which served as the control group had an increase of 0.73mg/dl over a period of six months. The final values of the serum total cholesterol were found to be significantly lower than the initial values ($P<0.01$) in all the experimental groups. The mean difference in the serum total cholesterol of the experimental groups registered significance over the control group. Groups HB and HD supplemented with wheat bran and wheat germ and bran respectively had shown a statistically significant decrease in the mean total cholesterol when compared against the groups HC and HE which were supplemented with wheat grass and wheat germ and grass respectively.

- The serum triglyceride and combined levels reduced after individual supplementation with wheat germ, bran and grass. The final values of the mean serum triglyceride levels in the experimental groups ranged from 132.60 to 155.33mg/dl. Maximum reduction of 52.07mg/dl was noted in group HD and the minimum reduction of 32.80mg/dl was noted in group HC. Decrease in serum triglyceride levels in the experimental groups were found to be significant at one per cent level whereas the change observed in the control group was not statistically significant. The mean differences of serum triglyceride in all the supplemented groups were significantly greater than that of the control group.
- The serum LDL – cholesterol had lowered by the individual as well as combined supplementation of wheat germ, bran and grass. Among the individual supplementation groups a maximum reduction of 40.53mg/dl was recorded by group HA while group HC supplemented with wheat grass had a minimal decrease of 16.87mg/dl. In the group HD supplemented with wheat germ and bran had a maximum reduction of 41.40mg/dl followed by groups HF and HE with a decrease of 36.67mg/dl and 27.47mg/dl respectively. The reductions in the serum LDL-cholesterol

level of all the experimental groups except the control group were significant at one per cent level. In all the supplemented groups the mean serum LDL-cholesterol reduced significantly than the control group. Group HE supplemented with wheat germ and grass showed a significant betterment in the reduction of LDL- cholesterol over group HC supplemented with wheat grass. Group HF supplemented with wheat bran and grass showed a significant reduction over the groups HC and HE which were supplemented groups with wheat grass and wheat germ and grass respectively.

- There was an increase in the HDL-cholesterol levels on supplementation. Maximum increase of 9.53 mg/dl was observed in group HD while the least increase of 5.53mg/dl was noted in group HF. The increments in the HDL-cholesterol were found to be significant ($P<0.01$) in the experimental groups. It was noted that the mean differences of serum HDL- cholesterol of the supplemented groups were significantly greater than the control group.
- There was a reduction in VLDL-cholesterol levels in all the experimental groups. Groups HA, HB and HC treated with individual supplements had a reduction of 6.64mg/dl. Maximum reduction of 10.35mg/dl was observed in group HD supplemented with wheat germ and bran followed by groups HE and HF with mean reduction of 8.67 and 8.26 mg/dl respectively. One per cent level of significance in the reduction was observed in all the experimental groups. The mean difference of serum LDL cholesterol in all the experimental groups registered significance over the control group.

Impact of supplementation on low immunity subjects

- Of the various clinical parameters indicative of low immunity, cough with sputum was present initially in 13 subjects in group TA supplemented with wheat germ and 15 subjects each in groups TB, TC and TD. After the supplementation, groups TA, TB and TC had only two, five and three subjects with cough and sputum respectively. Dry cough was prevalent among 12, 13 and 15 subjects in groups TA, TB and TC initially whereas after the supplementation period it was noted only among five, three and five subjects respectively. Loss of weight greatly reduced at the end of the study among all the experimental subjects.

- On supplementation with wheat products there was an improvement in the serum albumin levels after six months. Group TC supplemented with wheat germ and grass had a maximum increase of 4.74g/l and group TB supplemented with wheat grass had a mean increase of 2.60g/l. The changes observed in the mean serum albumin levels in the experimental and the control groups were found to be significant at one per cent level.
- There was an increase in the serum total protein levels on supplementation. Maximum increase of 10.74 g/l was observed in group TC supplemented with wheat germ and grass while an increase of 7.6g/l was noted in group TA supplemented with wheat germ only. Group TB supplemented with wheat bran had registered an increase of 6.42g/l. The final values of the serum total protein when compared with the initial values were found to be significantly greater ($P<0.01$) in the experimental and control groups. Only the mean difference of serum total protein of group TC supplemented with wheat germ and grass was significantly greater than that of the control group.
- There was a marked reduction in the serum TLC values in all the supplemented groups. Group TC supplemented with wheat germ and grass had a maximal decrease of 1088.60 cells/m^3 while group TB supplemented with wheat grass had a reduction of 565.07 cells/m^3. Group TD which served as the control group had a decrease of 224.20 cells/m^3 over a period of six months. The final values of the serum TLC was significantly lower than the initial values ($P<0.01$) in the experimental and control groups.
- The CD_4 levels increased after individual as well as combined supplementation with wheat germ and grass. The final values of the mean CD_4 levels in the experimental groups ranged from 441.40 to 573.93

cells/m^3. Among the supplemented groups, maximum increase of 251 cells/m^3 was noted in group TC supplemented with wheat germ and grass and the minimum increase of 143.33 cells/m^3 was noted in group TB supplemented with wheat grass. Increase in the final values of CD_4 count in the experimental and control groups were found to be significant at one per cent level. The mean difference of CD_4 levels of the groups TB, TA and TC were significantly higher than the control group TD.

The report of this study has been hosted in the website http://www.avinuty.ac.in for receiving the feedback from the scientific community.

From the foregoing discussions, it could be concluded that wheat germ, bran and grass are effective contrivance fight against degenerative and infectious diseases like low immunity and could be used as an adjunct intervention in ensuring better health for diabetic, obesity and low immunity subjects; if not completely cure them of the disease. It would be a boon to the diabetic, obesity and low immunity population, if all the hidden, health promoting properties of wheat like alleviation of co-morbidities are explored for the fullest use of this nature's gift.

It could be concluded from the study that wheat germ, bran and grass are having beneficial effect in alleviating specific health issues like diabetes obesity and could be used as an immune booster in low immunity. In this ever changing scenario of emerging varieties of disease, existence of medical assistance without any side effect is much sought after remedy. In this context, the result of the present investigation assumes significance and a small step in such innovative findings on the hitherto –**"Wheat – A treasure to treasure".**

Recommendations

The study emerged with the following recommendations

- The utility of wheat apart from the form in which it is consumed generally has been unraveled empirically; it becomes necessary that the findings of the study move to another level whereby the information is disseminated to the community at large, for which a nutrition education campaign may be conducted.
- The dietary departments of hospitals may be encouraged to use wheat byproducts namely wheat germ, bran and grass in the preparation of therapeutic diets wherever it is applicable.
- Further studies should be conducted to improve the shelf life of wheat germ and bran.
- Ways of incorporating wheat products in the recipes in most acceptable forms need to be explored.
- A comparative study on the efficacy of fresh wheat grass and wheat grass juice will throw light on the regular consumption.
- Above all, a state sponsored campaign; subsidized harnessing of the bran, germ and wheat grass juice can do a remarkable impact to the nutritional status of the nation as a whole, because every finding at ivory towered laboratories, especially as the present study, get their fullest meaning only if they are pointed towards the benefit of the common man.

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APPENDICES

APPENDIX I

AVINASHILINGAM INTSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION FOR WOMEN, DEEMED UNIVERSITY, COIMBATORE-641043

INTERVIEW SCHEDULE TO ASSESS SOCIO ECONOMIC BACKGROUND, DIETARY AND HEALTH STATUS

Name of the Interviewer :

Name of the Interviewee :

Address :

Age in years :

Sex :

Religion :

☐ Hindu ☐ Muslim ☐ Christian ☐ Others

Marital Status :

☐ Unmarried ☐ Married ☐ Divorced ☐ Widow

Education :

☐ Illiterate ☐ Primary School ☐ High School

☐ Higher Secondary ☐ Graduate

Occupation :

☐ Labourer ☐ Office- going ☐ House wife

☐ Business ☐ self- employed ☐ others

Type of family : Joint /Nuclear/Extended

Economic status :

Source of income :

☐ Salaried ☐ Pension ☐ Investment

☐ Agriculture ☐ Others

Monthly Income (Rs.) of the subject :

☐ <1000 ☐ 1000-2000 ☐ 2000-3000 ☐ 3000-4000

☐ >4000

Dietary Pattern:

Type of meal taken :

☐ Vegetarian ☐ Ovo- vegetarian ☐ Non – vegetarian ☐ Pisco vegetarian

Frequency of consumption :

☐ Daily ☐ Weekly ☐ Fortnightly ☐ Monthly

No of meals consumed per day :

☐ One ☐ two ☐ three ☐ others

Do you avoid any foods? :

☐ Yes ☐ No

If yes, indicate the reasons

☐ Allergy ☐ Flatulence ☐ Indigestion ☐ Chewing ☐ Others

Mention the food avoided:

Meal pattern for 3 days :

Meal Pattern	Day 1	Day 2	Day 3
Early morning			
Breakfast			
Mid morning			
Lunch			
Tea			
Dinner			
Bed time			

Food Frequency Pattern

Food Items	Daily	Thrice a week	Twice a week	Weekly once	Fortnight	Monthly	Not at all
Cereals							
Rice							
Ragi							
Wheat							
Bajra							
Barley							
Others							
Pulses							
Horse gram							
Rajmah							
Soya Beans							
Bengal gram							
Black gram							
Red gram							
Others							
Leafy vegetables							
Agathi							
Amaranthus spinosis							
Kuppameni							
Ponnaganni							
Manathakkali							
Others							
Roots and Tubers							
Carrot							
Radish							
Tapioca							
Onion							
Others							
Other Vegetables							
Sundakai							
Cluster beans							
Ladies finger							
Broad beans							
Beans							
Others							

Fruits							
Lemon							
Gauva							
Amla							
Apple							
Orange							
Grapes							
Pomegranate							
Others							
Non – vegetarian foods							
Fish							
Mutton							
Fowl							
Egg							
Others							
Milk and milk products							
Milk (Cow's / Buffalo's/ Skimmed)							
Curd							
Buttermilk							
Others							
Sugars							
Jaggery							
Sugar							
Others							
Fats and oils							
Refined oil							
Butter							
Vanaspathi							
Others							

Health Status and Life Style pattern

What type of activity do you perform?

☐ Light ☐ Medium ☐ Heavy

Do you have the habits like smoking, chewing, tobacco and alcoholism?

☐ Yes ☐ No

If yes

Habits	Frequency	Duration
Smoking		
Tobacco		
Alcoholism		
Bubble gum		
Pan		

Do you have the habit of exercising?

☐ Yes ☐ No

Type Frequency

Do you take any supplements?

☐ Yes ☐ No

Do you suffer from any of the following?

Anaemia	Hypertension
Cardiovascular disease	Osteoarthritis
Dementia	Osteoporosis
Diabetes mellitus	Rheumatoid arthritis
Hyperlipidemia	Others

Type of Beverage consumed

Beverages	Quantity	Frequency
Tea		
Coffee		
Aerated Drinks		
Others		

Cooking methods

Foods	Boiling	Steaming	Pressure cooking	Roasting	Deep fat Frying	Shallow fat frying
Cereals						
Pulses						
Vegetables						
Leafy vegetables						
Meat						
Fish						
Egg						

Convenience /Processed foods consumed

Item	Quantity used	Frequency
Biscuits		
Chips		
Pickles		
Pappads		
Sauces		
Squashes		
Canned foods		
Sweets and chocolates		
Savories		

Fats/Oil consumption:

Types of fat/oil used	Frequency and amount used (in litre)				
	2-3 times	A week	Weekly	Fortnightly	Monthly
Butter					
Ghee					
Groundnut oil					
Gingelly oil					
Refined Oil					
Palm oil					
Coconut oil					
Others Specify					

Personal Habits:

Do you consume alcohol Yes No

Types	quantity	Frequency
Toddy		
Arrack		
Beer		
Rum		
Whisky		
Gin		
Others		

APPENDIX III
CLINICAL ASSESSMENT SCHEDULE

Name of the Interviewer:

Name of the Interviewee:

a. Healthy and free from deficiency symptoms

b. Face	:	Nasolabial seborrhoea paleness
c. Eyes	:	Pale conjunctiva, conjunctival xerois
	:	Nightblindness
	:	Bitots spot
	:	Corneal xerosis
	:	Keratomalcia
d. Lips	:	Angular stomatitis, cheilosis
e. Tongue	:	Scarlet tongue
	:	Magenta tongue
f. Teeth	:	Molted enamel carries
	:	Spongy bleeding gums
g. Hair	:	loss of luster
	:	Discoloured hair
	:	Dry and brittle hair
h. Skin	:	Follicular hyperkeratosis
	:	Dermaitis
	:	Pallor of hair
i. Nail	:	Brightness
	:	Koilonychias

j. Muscular and skeletal system	: Calf muscle tenderness, muscular skeletal osteoporosis
L. Cardiovascular system	: Cardiomegaly