GLYCEMIC RESPONSE TO SELECTED RICE-PULSE COMBINATIONS IN DIABETICS

BY

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THESIS

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Dedicated to

Kochachan, Chitta

Kunju

&

Molly

DECLARATION

I hereby declare that this thesis entitled "**Glycemic response to selected rice-pulse combinations in diabetics**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for associateship, fellowship or other similar title of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**Glycemic response to selected rice-pulse combinations in diabetics**" is a record of research work done independently by Miss. Suni. K., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

INTRODUCTION

The term Diabetes Mellitus is described by WHO (1999) as a metabolic disorder of multiple aetiology characterized by chronic hyperglycemia with disturbances in carbohydrate, protein and fat metabolism resulting from defects in insulin secretion, insulin action or both. It is one of the non-communicable disease occurring globally and there is substantial evidence that it is epidemic in many developing and newly industrialized nations posing a serious problem of twenty first century (Shashank 1999).

Diabetes mellitus occurs in all population but with variations in prevalence between different ethnic groups and geographical areas. (Reghuram, 1998) It is estimated that there will be 15 to 20 million person with diabetes in India. Shah (2000) reported that the millennium year 2000 brings fourth exciting innovations and hope for the diabetic population with the introduction of nasal insulin and ideal oral hypoglycemic agents and thrust on diet (Shah, 2000)

Raghuram (1998) stated that diet is the cornerstone in the management of diabetes mellitus. He is of the opinion that dietary prescription should be individualized taking into account of the dietary pattern and habitual diet of the patient. Swaran pasricha (1992) has felt that the diabetic diet is to be as close to the normal diet as possible so as to meet the nutritional needs of the patient.

During the past few decades, dietary modification in the treatment of diabetes mellitus has advanced from alternations in nutrient contribution of a meal to alternation in the whole meal itself. Shah (1999) opined that the goals of dietary management of diabetics include the normalization of blood glucose and lipid levels and maintenance of optimal body weight. According to Sheard (1995) a diet high in monounsaturated fat and low in carbohydrate can produce a more desirable plasma glucose lipid and insulin profile. Equivalent amount of carbohydrate may give different responses, since the kind of carbohydrate, food form, nature of carbohydrate and method of cooking have a marked influence on post prandial glycemia.

Miller *et al.* (1995) indicated that many foods containing sugar, whether naturally occurring or refined give glycemic and insulin responses that are similar to or lower than those of common starchy foods. According to Englyst *et al.* (1996) encapsulation of sugars and starch within plant cell walls, can delay or even prevent their digestion and absorption in the human small intestine leading to lower Rapidly Available glucose (RAG) and glycemic index values .

An ideal diet for diabetes is reported to consist predominantly of cereals like rice and wheat combined with pulses and two vegetables, providing sufficient amount of carbohydrate and fibre resulting in the reduction of blood glucose, cholesterol and triglycerides. However recent advances in the dietary management of diabetes emphasis more on the glycemic index value of the food rather than the carbohydrate content of the meals. Glycemic index indicates the extent of rise in blood glucose in response to a food in comparison with the response to an equivalent amount of glucose or any other reference foods, in other words glycemic index enable us to understand, how quickly the food ingested and how rapidly the sugar that makes up the starch or other carbohydrate in the food gets into the blood glucose. Thus a knowledge on the glycemic index of foods may be helpful for a diabetic patient to fix up the timing of meals as well as medications.

There is paucity of data regarding the glycemic response of the diet containing rice- pulse combination which is commonly used as a breakfast items among Keralites. Kavitha and Prema (1995) determined the glycemic index of selected carbohydrate rich foods served as lunch. Present study is an attempt to measure the glycemic response to various rice-pulse combination served as breakfast in non-Insulin Dependent-Diabetes Mellitus (NIDDM) patients.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Diabetes or "Madumeham" Known for centuries as a disease related to Sweetness and is described in literature as a third world disease with rates high in developing countries.

Various aspects pertaining to diabetes mellitus is reviewed carefully and informations collected are summarised in the following lines.

2.1 Prevalence of diabetes mellitus

2.2 Aetiology of Diabetes mellitus

2.3 Clinical Presentation and complications of Diabetes Mellitus

2.4 Dietary constituents and its impact on blood glucose level

2.5 Glycemic index and diabetes

2.1 Prevalence of diabetes mellitus

According to Shah (2000), Diabetes mellitus is one of the non-communicable disease globally known and there is sustained evidence that it is an epidemic in many developing and newly industrialized countries thus posting a serious threat to be met within the 21st century.

Number of studies related to the epidemiology of diabetes over last 20 years indicated that many government and public health planners are still remaining unaware of the current magnitude or more importantly the future potential of increase in diabetes and its serious complications in their own countries (Shashank, 1999).

Alberti (1996) reported that type 2 diabetes mellitus is the commonest form of diabetes characterized by a degree of insulin hypo secretion and a major contribution from insulin resistance.

As per the report of WHO (1994) Diabetes mellitus can be found in every population in the world and epidemiological evidence suggests that without effective prevention and control programme diabetes is likely to continue to rise globally. Poulose (1999) reported that by the next 25 years, the number of diabetes patients will increase from the present 2 crore to 5.7 crore with the prevalence highest among the Indian population followed by China, America and Russia.

According to Shashank (1999) the highest increase in diabetes for the period1995 to 2010 will be seen in western Asia (3.6-11.4 million) ,South Central Asia (28.8-57.5 million) south East Asia (8.6-19.5 million) and East Asia 21.7-44 million.

Shah (1999) reported that by the year 2010 the total number of people with diabetes is prejected to reach 221 million world wide, 5 million with Insulin dependent diabetes mellitus (IDDM) and 216 million with non insulin dependent diabetes mellitus (NIDDM). The regions with highest potential for increase are postulated to be Asia and Africa where diabetes could become 2-3 times more common than it is today.

Park and Park (1998) opined that the prevalence of diabetes mellitus in India is 1-2 per cent. A well organized multicentre study conducted by the Indian Council of Medical Research in Ahemadabad, Calcutta, Delhi, Puna and Thiruvananthapuram indicated that in person over 15 years of age, the over all prevalence rate for India as a whole was 1.73 per cent. The prevalence rates in urban population ranged between 0.95 per cent in Delhi and 3.8 per cent in Ahemadabad. Where as in rural population, the prevalence rate ranged between 0.6 per cent in Cuttack and 1.3 per cent in Ahemadabad.

According to Kanugo and Shaturere (1997) in Eastern India unlike in the rest of the country,the prevalence of the diabetes especially type 2 (NIDDM) is very high. Shah (2000) opined that out of the total diabetic patient over the world, 75 per cent are from the developing countries in which India contributes the maximum. Poulose (2000) is of the opinion that when compared to the rest of the world, insulin dependent juvanile diabetes in India is only one per cent.

2.2 Aetiology of Diabetes mellitus

According to Williams (1988) heredity and environmental factors enhance clinical suspicion of diabetes. On the basis of the presence or absence of various signs and symptoms and their severity levels, medical scientists have been able to predict diabetes. Davidson (1999) reported that genetic factors are more important in the aeitology of NIDDM than IDDM as shown by the studies in monozygotic twins where concordance rate for NIDDM diabetes approaches 100 per cent.

Rubin (1994) stated that genetic and lifestyle cl
fat calorie diets and decreased exercise contribute t
obesity and diabetes among native Americans.

According to the current concept, diabetes is a hereditary disease of metabolism characterized by loss of carbohydrate tolerance, glycosuria and hyperglycemia WHO (1999).

WHO study (1980) reported that heredity, high birth weight, obesity, use of oral contraceptives and mental stress are various risk factors associated with diabetes. According to Pickup and Garethmillan (1997) the energy dense 'Westernized' diet rich in fat and relatively low in carbohydrate and fibre, low physical activity and obesity are the major contributory factors to NIDDM.

According to (Davidson, 1999) type 2 diabetes is principally a disease of middle aged and elderly affecting 10 per cent of population over the age of 65.

Belfiore (2000) is of the opinion that the risk of developing disease in the off springs and siblings of type 2 diabetic patients is comparatively high. According to Ramankutty (2000) Indians have a greater genetic susceptibility to the disease, which is further compounded by stress inducing factors such as urbanization, migration and modern life style.

According to Cahill (1975) the incidence of diabetes mellitus increased markedly with ageing. Bockel et al. (1987) found that the glucose tolerance decreased with age and the decrease affects post prandial values more than glucose values than fasting plasma glucose concentrations. Majority of the epidemiological surveys revealed male preponderance in the occourance of diabetes (Ramachandran *et al.*, 1993).

Ramankutty (2000) stated that sex was found to influence the occurrence of disease and he found that in most communities males had a greater prevalence of type 2 diabetes than females. According to Sainani (2000) non-insulin dependent diabetes mellitus (NIDDM) is a heterogenous metabolic syndrome comprising variable degrees of insulin deficiency (beta cell dysfunction) and impaired insulin action.

Davidson (1999) stated that obesity acts as a diabetogenic factor in those who are genetically more prone to develop type 2 diabetes.

According to Ramachandran (1993) the occurrence of type 2 diabetes is associated with many other types of chronic conditions prominent among them are obesity and over weight. Anderson (1994) found that obese people are susceptible to diabetes because they are resistant to the effect of insulin which converts blood sugar to energy.

King and Rewers (1993) reported that the relative distribution of two major forms of diabetes viz, insulin dependent diabetes mellitus (IDDM) and non insulin dependent diabetes mellitus (NIDDM) depict show large variation between communities and ethnic groups.

2.3 Clinical presentation and complications of diabetes mellitus

According to American Diabetes Association (1987), in a diabetic, there is an increased blood sugar level, leading to passing of sugar in urine. The major symptoms of the untreated diabetes is frequent urination and thirst, general weakness and loss of body weight because of the depletion of body fat to energy purposes.

Complications of diabetes if untreated, will lead to catastrophic situations resulting in deaths due to coronary heart disease, gangrene, renal failure and blindness (Poulose 2000).

According to Loe (1993) complications of diabetes include accelerated atherosclerosis, cardiovascular and peripheral vascular diseases as well as neuropathy and nephropathy.

According to WHO (1985) complications related to diabetes are progressive changes to the eyes, kidneys, nerves and arteries, which pose a major threat to the health and life of diabetics.

Krall (1984) reported that the person with hypoglycemic or low blood sugar content experiences increased appetite, weakness, sweating, restlessness, palpitation and giddiness. Bailey (1992) stated that numerous studies have alluded to the importance of adequate glycemic control in patients with type 2 diabetes to avoid chronic complications, including blindness, renal dysfunction resulting in dialysis or transplantation and non-traumatic amputations.

In a report of American Diabetes Association (1987), it has been stated that hypertension and diabetes were commonly associated.

Zimmet *et al.* (1988) reported that there is an excess number of deaths among diabetic subjects with impaired glucose tolerance compared to normal subjects.

According to Ramussen *et al.* (1992) diabetic patients with poor glycemic control tend to have elevated serum lipoprotein levels that may well constitute a contributing factor to the high risk for atheroseclerosis.

2.4 Role of various dietary constituents in the management of diabetes mellitus

Importance of diet in diabetes can be traced back to the days of the ancient ayurvedic physician "Sushrutha". He attributed the consumption of wholesome foods besides heredity factors for the development of diabetes. Goriya *et al.* (1990) opined that the dietary recommendations vary from time to time along with social changes.

According to Axen *et al.* (1994) the most important element in the therapeutic plan of patients with non-insulin dependent diabetes mellitus is dietary modification. Cassirola *et al.* (1994) reported that diet is the cornerstone of diabetes management but nutritional intervention of diabetes is to be developed, hence it is important to understand the effect of diet on nutrient metabolism.

According to Hubbard *et al.* (1994) diabetes mellitus or type 2 diabetes is a related disease where diet is a possible casual or a strong contributing factor. Vijayalekshmi (2000) stated that rigorous adherence to a fixed diet becomes more important, since the body's endogeneous insulin reserve is limited and the therapeutic modality should fetch long term results.

Agarwal (2000) viewed that diet therapy of diabetes remains an integral part of diabetes management. Evidence for a new approach in the dietetic prescription for non insulin dependent diabetes mellitus act as an important component in the treatment of the disorder.

Steven (1998) reported that the most fundamental component of the diabetes treatment of patients with type 2 diabetes is Medical Nutrition Therapy (MNT).

Gerristen *et al.* (1981) reported that data derived from animal models with spontaneous diabetes suggests that diet plays a very important role in the aetiology and control of the disease. According to Bantle (1992) diabetic patients should be consistant with calorie and carbohydrate intake, and the body weight should be strictly controlled by energy intake and energy expenditure.

Dietary constituents and its impact on blood glucose level

2.4.1.1 Carbohydrate

Vijayalekshmi (2000) stated that carbohydrate should constitute around 60-70 per cent of the total calories. This is to be supplied in the form of complex polysaccharides (Starch) and contain adequate amount of fibers. However carbohydrate in the form of simple sugars need restriction.

Many factors influence carbohydrate absorption. Slower rates of absorption may have advantages in reduced post prandial glycemia and insulinaemia and in turn reduce serum low density lipoprotein (LDL) cholestrol and apolipoprotein B concentration (Jenkins *et al.*, 1994).

Vessby (1994) reported that the intake of carbohydrate rich food stuffs contribute to an improved metabolic profile. Lerman *et al.* (1994) stated that not only the type of food but also its structure is of importance for the blood glucose and hormone responses after a meal. Partial replacement of complex digestable carbohydrate with monounsaturated fatty acids in the diet of patients with non insulin dependent diabetes mellitus improves the lipid profile favourably, maintains an adequate glycemic control and offers a good management control.

Kelly and Wing (1997) reported that individuals consuming greater percentage of energy from refined grains and simple carbohydrates are more prone to develop type 2 diabetes than those who are consuming whole grains.

Garg *et al.* (1993) opined that for patients with mild NIDDM, diet high in carbohydrate neither improve glycemic control nor insulin sensitivity. Kurup and Krishnamurthy (1993) found that glycemic response of carbohydrate diet composed of ragi, rice or tapioca was not different from that of wheat based diet. The effects of high carbohydrate on blood glucose control in NIDDM patients differ according to severity of glucose intolerance. They were also of the opinion that the inhibition of intestinal carbohydrate splitting enzymes also decreases the post meal rise of blood glucose in non insulin dependent diabetic. According to Antia (2000) the ingested carbohydrate are deposited as glycogen in the muscles and liver by the action of insulin.

Antia (2000) opined that an occasional helping of rice is allowed to diabetic of normal body weight while a lean diabetic can have rice everyday. Those who are particularly fond of rice can exchange their ration of wheat chappathi for one slice of bread, for four table spoon of rice which provide 100 Kcal.

2.4.1.2 Energy

Jenkins *et al.* (1992) reported that in non insulin dependent diabetes, increased frequency of meals add more to the total calories consumed per day. According to Alberti (1996) very low calorie diets (VLCD) containing 400-800 Kcal/day may effectively reduce body weight, hyperglycemia, hyperlipaedemia and hyperinsulinaemia in obese patients with type 2 diabetes.

Henry *et al.* (1997) reported that moderate energy restriction reduces blood glucose concentration in most of the diabetic subjects and leads to symptomatic improvement within days or weeks. According to Davidson (1999) starches in cereal foods (wheat, rice) root foods (potato, cassava) and legumes are the constituents which provide the largest proportion of calories in most diets around the world.

According to Saramma (1989) a modified diet which provide 60 to 65 per cent calories from carbohydrates 15 to 20 per cent calories from protein and 15 to 25 per cent calories from fats helps to improve the diabetic patients metabolic rate.

According to Vijayalekshmi (2000) a prescribed diet for diabetics should contain 30 kcal/kg for optimal body weight subjects 20 kcal/kg for over weight subjects and 40 kcal /kg for under weight subjects.

2.4.1.3 Fibre

Davidson (1998) stated that fibre rich foods decreased stomach emptying and delay intestinal transit, and so reduce the rate of glucose absorption, lower blood sugar rise, and decrease urinary glucose excretion.

According to Vinik and Jenkins (1998) in patients with non insulin dependent diabetes mellitus (NIDDM) viscous (soluble) dietary fibre has a modest hypoglycemic effect and also improves blood lipid profile, reducing LDL and VLDL cholesterol concentration.

According to Vijayalekshmi (2000) high fibre intake of 25g/ 1000 kcal or 40 g soluble fibre help to control blood sugar and satiety.

According to Davidson (1999) the consumption of 15 g of soluble fibre present in beans, peas, pulses, oats, fruits and vegetables can produce a 10 per cent reduction in fasting blood glucose glycated hemoglobin and low density lipoprotein cholesterol.

According to Eggum (1991) fibres will generally stimulate microbial activity in the digestive tract and reduce rate of digestion rather than carbohydrate malabsorption. Recently the soluble fibre content of foods was thought to be the last predictor of glycemic response. Soluble fibres decreases the rate of glucose absorption from gut and reduce the rate of glucose diffusion into the small intestine (Wolever 1992).

According to American Dietetic Association (1987) the inclusion of high fibre foods in diets has improved control of both blood glucose and lipids. Antia (2000) opined that an obese diabetic who requires much bulk with few calories should be advised to take good quantity of vegetables rich in fibre.

2.4.1.4 Protein

According to Sreelekshmi and Antia (2000) a diet high in protein is good for the health of diabetics because it supplies the essential amino acids needed for tissue repair. Protein does not raise blood sugar during absorption as do carbohydrates and it does not supply as many calories as fats. Protein also promotes satiety and helps both types of diabetic patients to adhere to the carbohydrate allowance.

According to United Kingdom Prospective Diabetes Study Group (UKPDS) (1998) high dietary protein intake increases the risk of both nephropathy and the progression to end stage renal disease. They also found that among patients with type I diabetes who had a lower protein intake had a lower prevalence of micro albuminuria.

Biesenbach *et al.* (1994) reported that patients with type 2 diabetes with smoking have a greater risk of microalbuminuria than patients who do not smoke and the rate of progression to end stage renal disease is about twice as rapid. According to Vijayalekshmi (2000) 10-15 per cent of total calories can be supplied in the form of protein. It is approximately 1 gm/ kg body weight in a cereal based diet or 0.8 g/kg when high quantity protein is consumed.

2.4.1.5 Fat

According to Feuersten and Weinstock (1997) obesity, more specifically android distribution of abdominal body fat has been shown to be an independent risk factor for the development of type 2 diabetes as well as an impedement to adequate glycemic control. Pickup (1997) indicated that isocaloric diet rich in monounsaturated fats and low in saturated fats may provide a useful alternation to a high carbohydrate diet for people with NIDDM.

Pekkanen *et al.* (1990) stated that an excessive intake of dietary fat is considered to be a factor for ishaemic heart disease in diabetic patients. According to Sheard (1995) a diet high in monounsaturated fat and low in carbohydrate can produce a more desirable plasma glucose, lipid and insulin profile.

Davidson (1999) reported that weight loss in obese patients with type 2 diabetes helps in lowering plasma lipids but many patients find the reduction of dietary fat intake very difficult to achieve. Antia (2000) stated the ketone bodies are the intermediate products of normal fat metabolism, accumulation of which result in diabetic coma.

Vijayalekshmi (2000) reported that the fatty acid intake should be equally distributed among saturated, monounsaturated and polyunsaturated types and patients with dyslipaedemia, fat intake needs further restriction. The total intake of cholesterol should be restricted to less than 300 mg/day she also expressed that food preparation by steaming or grilling is preferred to frying for diabetic patients.

2.5 Glycemic index and diabetes

Wolever (1996) stated that the ability of the food item to raise the blood sugar is measured in terms of glycemic index. Many factors contribute to glycemic index, including carbohydrate structure, fibre content, cooking, food processing, storage, presence of enzyme inhibitors and coingestion of other nutrients.

According to Mohan (1997) in a severe diabetic the plasma glucose is likely to be high at any time of the day and therefore a random plasma glucose is often enough for diagnosis.

According to Antia (2000) acarbose, a starch blocker in dosage of 50 mg with each meal decreases the post meal rise of blood glucose in a non insulin dependent diabetic.

Frontviellie *et al.* (1992) stated that the inclusion of low glycemic index foods in the diet of diabetic patients may be an additional measure which slightly but favourably influences carbohydrate and lipid metabolism.

According to Jenkins *et al* (1983) lower glycemic response was found in parboiled rice, whereas higher response was obtained with regular rice. Studies suggest the glycemic response to different mixed meals cannot be predicted from the glycemic index of individual carbohydrate foods (Collier *et al.*, 1986).

Wolever (1990) has stated that the reduced glycemic responses seen after the intake of soluble fibres, enriched meals and low glycemic index foods can be explained by slower absorption and reduction of insulin levels. The rise of blood sugar after a meal does not depend only on the amount of carbohydrate ingested but also on the rapidity of absorption. Bell *et al.* (1995) reported that diet especially total energy is an important contributer to glycemic control.

The study by Wolever and Nyguen (1998) on the relationship between blood glucose and lipid revealed that carbohydrate and fibre intake with low glycemic index diet improve the blood glucose levels. Simpson *et al.* (1985) have brought out an empirical relationship between dietary fibre and both type 1 and type 2 diabetes (insulin dependent and non-insulin dependent) as evidenced by reduced requirement of insulin and increased peripheral insulin sensitivity.

According to Swaran (1992) many foods containing sugar whether naturally occurring or refined give glycemic and insulin responses that are similar to or lower than those of common starchy foods.

According to Collier *et al.* (1986) the relative glycemic effects of mixed meals can be predicted from the glycemic index than carbohydrate components, again stressing the importance of the type of carbohydrate in regulating post prandial blood glucose levels.

The diet prescription for obese diabetic patients should be implemented in stages with calorie restriction as the first priority, since weight loss itself diminishes hyperglycemia to normal combinations of foods and different processing or cooking of the same food are also reported to produce different glycemic responses (Wheeler *et al.*, 1987).

Mani *et al* (1994) the glycemic index and triglyceride responses of NIDDM patients above 40 were estimated after giving 50g portion of rice as flakes or puffed or wheat bhakri alone or stuffed with fenugreek or spinach. Results showed that wheat bhakri alone and puffed rice gave the highest glycemic index where as bhakri stuffed with vegetable gave the lowest.

Kavitha (1995)had measured the glycemic index of lunches in which rice, wheat, ragi and tapioca were included as staple food. Based on this study glycemic index of ragi was the lowest followed by wheat, rice and tapioca. Bell (1998) reported that total energy is an important contributor to glycemic control, than the diet as a whole.

According to American Diabetes Association (1995), the glycemic response of fruits and milk has been found to be lower than the response to most starches and sucrose has been found to produce the glycemic response similar to that of bread, rice and potato. Kavitha and Prema (1995) reported a negative relationship between the protein content and glycemic response.

According to Goriya *et al.* (1990) ingestion of low glycemic index meal revealed excellent inhibitory effects upon post prandial glycemic elevation in the elderly diabetics. This implies the clinical usefulness of a low glycemic index meal for post prandial glycemic regulation in elderly diabetes mellitus subjects. Crofford (1995) reported that the vast majority of patients with NIDDM are over weight and their glycemic control can be greatly improved by reducing food intake.

Glycemic response of different foods is influenced by physical form and nature of cooking for example consumption of ground rice raises the blood sugar level to a greater extent than of unground rice (Antia 1989). Neeraja and Rajalekshmi (1996) reported that the incorporation of germinated fenugreek in to a receipe significantly decrease post prandial blood glucose concentration in all subjects compared to control receipes.

The glycemic response to wheat products is affected by the processing condition used. The more severe is the processing conditions, the more rapid is the digestion of the starches. In this connection the degree of starch gelatinization is one of the important factor (Holm *et al.*, 1986).

Giri *et al.* (1986) reported that red gram juice is hypoglycemic, hypocholesteremic and it may help in the control of diabetes. It can be used daily in diabetic diets. Jenkins *et al.* (1983) identified potentially and clinically useful starchy foods producing relatively flat glycemic responses and included legumes pasta, grain such as barley, parboiled rice and bulgar (cracked) wheat and whole grain breads, which were associated with reduction in low density lipoprotein, cholestrol and triglyceride levels in hyperglycemia and with improved blood glucose control in insulin dependent patients.

2.5.1 Hypoglycemic foods and diabetes

Sharma (1987) reported that fenugreek seeds a common condiment in India decreased hyperglycemia, serum cholestrol and serum triglyceride in diabetics. Treatment with decoction of fenugreek seed has been reported to suppress glycosuria in mild diabetics and bring about improvement in severe diabetic condition. This is due to the water soluble alkaloid " trigonelline" which is present in fenugreek seeds.

According to National Institute of Nutrition (1990), the fenugreek diet increased the metabolic clearance rate and as a result, area under the curve (AUC) and half life of glucose were significantly reduced and there was an increase in the molar insulin binding sites of fenugreek diet.

The hypoglycemic effect of selected sorghum recipes revealed that the consumption of whole sorghum recipes resulted in significantly lower plasma glucose levels in diabetic subjects when compared with the consumption of dehulled sorghum recipes and wheat recipes. (Lekshmi and Vimala 1996).

William *et al.* (1993) studied the effects of some Indian vegetables on the glucose and insulin response in diabetic subjects. The vegetables tested were bittergourd, curry leaves and drumstick leaves. The effects of feeding different levels of vegetable fibre to normal and non insulin dependent diabetics was studied by Sreedevi and Chathurvedi (1993). They found that the fasting and post prandial values for the diabetics were higher than the normal subjects; incorporation of fibre in the diet of diabetics significantly reduced the post prandial blood glucose compared to the two leafy vegetables (ponnanganni and colacasia leaves), bittergourd was found to be more effective in reducing the blood glucose levels at lower fibre levels possibly due to the combined effect of fibre and the bitter principle.

Sumathi *et al.* (1995) revealed that the effect of processing difference in carbohydrates of cereal legume blend on blood glucose response in an individual with impaired glucose tolerance. Among the cereal legume blends, of malted, popped and roller dried wheat, chick pea, green gram and moth bean, the malted cereal legume blend showed the higher glycemic response in subjects with impaired glucose tolerance.

MATERIALS AND METHODS

MATERIALS AND METHODS

A study was conducted to assess the glycemic response to selected cereal-pulse combinations such as rice, green gram, bengalgram, blackgram, redgram and soyabean which can be used as breakfast items. Methodology adopted for the study is described below.

3.1 Selection of subjects for the study

Twenty Non Insulin Dependent Diabetes mellitus (NIDDM) or type 2 diabetes subjects were selected for the study. Criteria for the selection of subjects for the study are detailed below.

1. Only men in the age group of 40-51 years
2. Subjects who have undergoing a Glucose Tolerance Test (GTT) with a fasting blood sugar level greater than 140 mg/dl and less than 200 mg/dl after two hour of glucose ingestion.
3. Subjects free from other complications but using oral drugs were selected.

3.2 Conduct of pilot study

A pilot study was conducted on the out patients attending Government Hospital, Peroorkada, Thiruvananthapuram with the incidence of diabetes. Among them 100 patients who satisfied with criteria of selection were identified. In order to assess their diabetic condition, glucose tolerance test was administered on 80 patients. Based on the blood glucose levels, 20 subjects were selected at random for further study.

3.2.1 Conduct of Glucose Tolerance Test among the selected subjects

The subjects were asked to avoid drugs for 24 hours, fast over night (12 hours) and were asked to report at the medical out-patient clinic of Peroorkada Hospital at 7.30 a.m. without taking any food. They were allowed to take one cup of tea or coffee without sugar before administering the glucose load. Blood samples were collected from the finger tip, for determining their fasting blood glucose level. In order to get the glucose tolerance, the subsequent blood picture was analysed at half an hour interval for two hours (i.e., ½ h, 1 h, 1 ½ h and 2 hour) procedure followed in appended (Appendix I).

3.2.2 Assessment of personal characteristics of the subjects

To assess the personal characteristics of the subjects, a questionnaire was formulated incorporating variables such as age, location of residence, height, weight, duration of disease, obesity, familial predisposition, the type of oral hypoglycemic agents used by the subjects, presence of other diabetic patients in the family, type of family, family income and total number of family members. The questionnaire developed was pre-tested and administered among the subjects. Questionnaire used for the purpose is appended (2)

3.2.3 Formulation of test meals

Test meals proposed were breakfast items comprising different rice-pulse combinations. All the experimental breakfast items planned for the subjects were almost isocaloric (500 kilo calories) and contained 75g equivalent of carbohydrate in the form of rice with different pulses such as greengram, bengalgram, blackgram, redgram and soyabean. Each combination was to supply 40 per cent of daily calorie requirement of an individual weighing 60 kg of body weight. Each test meal was prepared independently for 20 subjects based on the calorie requirement of the subject. Five such test meals were prepared and administered to the subjects under study within a gap of one to two weeks interval after each test meal.

Test meal combinations

Ingredients	Food combinations
Rice + greengram (T_1)	Kanji with greengram poriyal
Rice + bengal gram (T_2)	Puttu with bengalgram curry
Rice + blackgram (T_3)	Dosai with chutney
Rice + blackgram + red gram (T_4)	Iddli with redgram dhal curry
Rice + soyabean (T_5)	Rice +curry

3.2.3.1 Method of preparation of rice-pulse combinations

Rice + greengram (Kanji with greengram poriyal)

The parboiled rice was washed and then boiled until it was well cooked.

The greengram was soaked in water over night and then washed and cooked under pressure till it was well cooked. Five grams of ground coconut was added along with a pinch of salt to taste.

Rice + Bengalgram (puttu with Bengal gram curry)

Parboiled rice was soaked for an hour and ground to a powder and then roasted. This flour was sprinkled with little salted water and kept for sometime. Lumps were broken and mixed with scrapped coconut. This mixture was steamed in the mould (Puttukutti) added with little coconut scrapings in between.

Bengal gram was soaked over night and then washed and cooked under pressure. Ground coconut was roasted till golden brown, adding chilli powder and corriander powder. This was ground into a paste and mixed with the cooked bengal gram and boiled. A little of tamarind pulp was added and cooked till gravy thickened.

Rice + blackgram (Dosai with chutney)

Rice and blackgram were taken in the proportion of 3:1 and soaked in water for eight hours. It was ground in a wet grinder and kept over night for fermentation. The next morning little amount of water and salt was added to the batter. This batter was used to make dosai smeared with little oil.

Coconut was ground in to a paste with small onion, chillies, curry leaves and salt. It was then seasoned with mustard and curry leaves.

Rice + blackgram + redgram (Iddli with redgram dhal curry)

Rice and blackgram were taken in the proportion of 3:1 and soaked in water for eight hours. It was ground in a wet grinder and kept over night for fermentation. Next morning sufficient salt was added and the batter was mixed thoroughly. Iddlies were prepared using this batter.

Redgram dhal was soaked and cooked under pressure adding little small onion and salt. Chilli powder and coriander powder and was made into a paste adding water. This was then mixed with the cooked dhal and boiled for sometime, till the gravy thickened . Curry was seasoned with mustard and curry leaves.

Rice + soyabean (Rice with soyabean curry)

The parboiled rice was washed and then boiled until it was cooked and strained.

Soyabean was soaked overnight, washed with water and then cooked under pressure. Heat a frying pan adding two grams of onion, chilli powder and coriander leaves. To this added cooked soyabean. Added $1/4^{th}$ cup of coconut milk, simmered for 2 –3 minutes and served along with rice.

3.2.4 Assessment of blood glucose level of the subjects

Blood samples were taken from the finger tip before the administration of test meals to assess the fasting blood sugar level of the subjects. After the administration of each test meal, blood glucose level of the subjects were analysed independently at half hour interval upto two hours (½ hr, 1 hr, 1 ½, 2 hrs).

Blood glucose concentration of the subjects were determined by using a glucometer adopting the procedure given below.

Blood glucometer provides a management system for diabetes control. With this equipment blood glucose level can be accurately measured from 20 mg to 500 mg/dl. Glucose oxidase method was adopted for estimation. This system helps the subjects to monitor blood glucose levels accurately without much difficulty. The glucometer system contains the following parts.

1) Glucometer (blood glucose meter)

2) Glucofilm (test strips)

3) Glucolet (automatic lancing device with end cap and lancet)

4) Wiping material (this is any common facial tissue or absorbent paper towel)

Procedure

The instrument was kept ready for the analysis on the table. Load the glucolet device ready for pricking. Patient was asked to wash hands in fresh, warm soapy water. Rinse and dry thoroughly. Remove the test strip from the glucofilm test strip container and place on the clean surface next to the folded wiping material. Close the bottle cap thoroughly. The procedure involves the following steps.

1. Press the button to ON the meter. The full display of the programme number appears on the screen. Match the programme number on the glucofilm test strip container. Programme number was adjusted as 888. Open the test slide. A number 60 will appear on the display.

2. Prick patients finger tip with glucolet device and gently squeezed the finger to form a drop of blood.

3. Hold the strip by the handle and applied blood to the pad (cover the test area). Immediately press the button for ‘count down’ to begin. At 25 seconds, picked up the folded wiping material and lay the strip (pad side up) in the middle. Fold the wiping material over the handle.

4. At 20 seconds quickly wiped the blood from the test pad, by applying firm pressure.

5. Inserted the test strip immediately and fully into the test slot and made sure that the test pad is facing the display screen. Closed the test slide immediately before count down reaches 1 and waited for test result to be displayed. The result will be displayed immediately on the screen and it was recorded.

3.2.5 Computation of glycemic response of the subjects

The response of the reference food mainly glucose and also of the various test foods administered on the subjects were plotted, for each of the test foods against time 't'. As the observations on these responses at each time interval for each test foods administered were found to have a sharp response at beginning intervals and sharp declining trend at later intervals and slower responses at mid intervals, it was adjudged that in the quadratic response curve of the form $y = a + bt + ct^2$, where y is glucose level, t is the time and a, b and c are the regression coefficient.

The area under curve (AUC) thus obtained was found out for each test food as well as the reference food (glucose). The Glycemic Response (GR) of each test food is computed as the ratio of AUC of test food and AUC of reference food.

$$GR = \frac{\text{AUC of test food}}{\text{AUC of reference food (glucose)}}$$

Statistical analysis

Results of the study were subjected to analysis of variance (ANOVA) to compare the plasma glucose concentrations at different time intervals after each breakfast.

Correlation analysis was applied to find out the relationship between glycemic response and blood plasma glucose concentrations after each breakfast.

Relationship between glycemic response (y) and plasma glucose concentration (x) were analysed using the simple linear regression equation y= a + bt + ct where 'b' is the change y for unit change 't'.

RESULTS

RESULTS

The study entitled "Glycemic response to selected rice-pulse combinations in diabetics" was conducted to assess the glycemic response to various rice-pulse preparations, which can be consumed as breakfast items for the diabetic patients. The data collected was analysed and the findings of the study are presented under the following headings.

4.1 Personal characteristics of the selected subjects and the assessment of oral glucose tolerance test (OGTT) administered.

4.2 Formulation of experimental breakfast items for the subjects.

4.3 Effect of experimental breakfast items on plasma glucose response

4.4 Impact of test foods on 'glucose build up' of subjects

4.5 Relationship of glycemic response to plasma glucose concentrations

4.6 Glycemic response of experimental meals

4.1 Personal characteristics of the selected subjects and Oral Glucose Tolerance Test (OGTT)

Personal characteristics of the study subjects as depicted in Table 1 revealed that 80 per cent of the subjects were in the age group of 46-51 years, while the rest were in the age group of 40-45 years.

Rural- urban variations in the disease occurrence noted among the subjects indicated that 60 per cent of the subjects were from the urban population while 40 per cent from the rural areas.

Table 1 Personal characteristics of the selected NIDDM subjects

Characteristics of the subjects	Per cent of the respondents
Age (years)	
40-45	20 (4)
46-51	80 (16)
Total	100 (20)
Place of residence	
Urban	60 (12)
Rural	40 (8)
Total	100 (20)
Type of family	Per cent of subjects
Nuclear	75 (15)
Joint	25(5)
Total	100(20)
Total number of family members	Per cent of subjects
1-4	35 (7)
4-6	50 (10)
More than 7	15 (15)
Family income per month	Per cent of subjects
< Rs. 1000	15 (3)
1001-5000	50 (10)
Above 5000	35 (7)
Total	100 (20)

Anthropometric measurement	Range	Mean
Body weight of the respondents (in kg)	55-77	64.30
Body height of the respondents (in cm)	150-189	167.35

Body mass index	
Less than 25	85 (17)
Greater than 25	15 (3)
Total	100 (20)

Table 2 Disease characteristics of the subjects

Hereditary predisposition in the family	
Present	40 (8)
Absent	60 (12)
Total	100 (20)
Duration of the disease (year)	
Less than 1	20 (4)
1-3	40 (8)
4-6	15 (3)
7-10	10 (2)
More than 10	15 (3)
Total	100 (20)
Number of diabetic patients in the family	Per cent of subjects
1	40 (8)
>1	60 (12)

The type of family of the subjects under study was assessed and found that seventy five per cent of the subjects were from the nuclear families and rest were from joint families.

The family size of the selected subjects when assessed indicated that thirty five per cent had 1-4 members in their family, 50 per cent had 4-6 members and 15 per cent had more than seven members in their family.

The economic status of the subjects was assessed and it was found that fifteen per cent had a monthly income up to Rs. 1000 while half of them fall in the income range of Rs. 1001-5000. Another 35 per cent had a monthly income of Rs. 5000 and above.

Body height and weight of the selected subjects were measured. Results indicated that the body weight of the subjects ranged from 55-77 kg with a mean body weight of 64.30 kg. Body height ranged from 150-189 cm with the mean body height of 167.35cm. Body mass index $(wt/ht)^2$ helps to diagnose whether a diabetic is obese or not. Data pertaining to the body mass index revealed that body mass index of 15 per cent of subjects was found to be greater than 25 which is considered to be an indication of obesity. Body mass index of 85 per cent subjects were below 25.

Diabetes mellitus is considered as a genetically transmitted disease, hence hereditary factor associated with the occurrence of the disease was analyzed with respect to each respondent. Results indicated that 40 per cent of the subjects had genetic predisposition to disease occurrence while 60 per cent showed no such genetic predisposition.

Nature of onset of the disease assessed in the subjects revealed that 25 per cent had the disease for more than 7- years while for 20 per cent, the onset was within a year. Fifty five per cent of the subjects were suffering from this disease for the past two to six years.

Number of diabetic subjects in the family was also recorded. Sixty per cent of the subjects had one to two diabetic patients in their family while forty per cent had only one diabetic subject.

Table 3 Oral hypoglycemic agents used by the subjects

Name of the drug	Chemical nature	Per cent of subjects
Daonyl Glynase Glide	Sulphonyl urea	80
Glycigon (Metformin)	Biguanides	20
Total		100

Table 3 gives the nature of the oral hypoglycemic agents used by the subjects. Majority of the subjects (80 per cent) were using sulphonyl urea compounds as oral hypoglycemic agents while the remaining 20 per cent were using combination of sulphonyl urea and biguanides. The sulphonyl ureas increases the insulin secretion from functioning pancreas. The extra pancreatic action sensitizes the target production of insulin. Sulphonyl ureas is valuable in the treatment of patients with type 2 diabetic who fail to respond to simple dietary restriction and who are not over weight. Metformin is used for obese diabetic patients. As its hypoglycemic effect appears to be synergistic with that of sulphonyl ureas, these can be combined with sulphonyl ureas when these alone are proved inadequate.

4.1.1 Assessment of Glucose Tolerance Test administered among the subjects

Glucose Tolerance Test was conducted in the subjects to assess their glycemic response and to analyse their glycemic response to selected test diet combination. Oral glucose tolerance test was conducted for all the subjects to assess their metabolic response to glucose load and for comparison with the glycemic response to the test diets under study.

From the table 4 it is revealed that the fasting blood sugar level before the oral glucose tolerance test ranged from 143-184 mg/dl with a mean fasting blood sugar level of 158.3 mg/dl. After half an hour, the blood sugar level was between 208-320 mg/dl with a mean blood sugar level of 251.4 mg/dl. There was a sudden increase in the blood sugar level after one hour, which ranged from 214-484 mg/dl with a mean blood sugar level of 368.7 mg/dl. After 1 ½ hours the blood sugar level decreased with a variation of 208-436 mg/dl and the mean blood sugar level of the subjects was 319.6 mg/dl. After two hours the blood sugar level lowered further between 203-411 mg/dl with a mean blood sugar level of 281.1 mg/dl. The peak rise of blood sugar over the fasting blood sugar level was in the range of 82-320 mg/dl with a mean peak rise of 216.6 mg/dl.

Table 4 Mean plasma glucose values of the subjects after oral glucose tolerance test (GTT)

Interval (hrs)	Range of blood sugar level (mg/dl)	Mean blood sugar level (mg/dl)
Fasting blood sugar level		
143-184		
Blood sugar levels at intervals (hrs)		
½ hr	208-320	251.4
1hr	214-484	368.7
1 ½ hr	208-436	319.6
2 hr	203-411	281.1
Peak rise over the fasting level		
82-320		210.5

4.2 Formulation of experimental breakfast item

Five experimental breakfast combinations were planned for the study with greater emphasis on cereal-pulse combinations. All the breakfast items prepared were almost isocaloric and supplied 75g glucose load in the form of rice with greengram, bengal gram, blackgram, redgram and soyabean. Composition and nutritive value of the experimental breakfast administered are given in Appendix (3a-e). All the five breakfast combinations provided approximately 500 kilo calories of energy, while the protein level ranged between 14.5 g to 27.8 g. Carbohydrate content of the test meals were 82.7, 75.2, 88.1, 97.8 and 59.7g respectively, in T_1, T_2, T_3, T_4 and T_5 (Test meals) while fat content of the test meals ranged between 3.32-15.0g.

The data on blood sugar level of the subjects who had been administered the various calorigenic test food combinations after different time intervals were recorded and subjected to detailed statistical analysis. Anova was worked out separately with the data on each time interval. The average blood sugar level before the administration of test foods (fasting time) are given in Table 5. Analysis indicated that the blood sugar level of the subjects before the administration of test meals were found to vary between 142.2 to 160.8 mg/dl. From this, it can be assumed that the pretreatment state of the blood sugar level of the subjects was not uniform and hence the buildup glucose level would be a more accurate measurement for testing the response to various test foods.

Table 5 Mean plasma glucose values of the subjects at the fasting level (mg/dl)

Food combination	Plasma glucose values
Glucose	158.3
Rice + Green gram	154.5
Rice + Bengal gram	148.2
Rice + Blackgram	142.2
Rice + Blackgram + Redgram	132.7
Rice + Soyabean	160.8

F= 6.28, CD= 14.30

The blood sugar level of the subjects who had been given the various test foods was not exactly same. Therefore it was found imperative that these significant variability of the subjects in blood glucose profile should also be accounted for, when the response to the administration of these test foods after fixed intervals of time were analysed. The technique of analysis of co-variance was applied which will also take into account a rough estimate of the initial variability among the subjects. The mean plasma glucose levels after adjusting for the regression of the data on plasma glucose levels on the initial plasma glucose levels after half an hour of administration of test foods are presented in Table 6.

The mean blood sugar level after the administration of glucose was found to be 239.46 mg/dl. Among the test diets, rice + blackgram + redgram combination had the least glucose value of 236.65 mg/dl whereas, rice + green gram combination had the highest blood glucose value of 291.21 mg/dl after half an hour administration of the test foods. CD value 25.38 reflects that there is significant difference between the test diets with respect to the blood sugar level within half an hour interval.

Table 6 Response (adjusted) different isocalorigenic test foods on the blood glucose profile of the subjects after half an hour

Test food	Blood sugar level (mg/dl) at half an hour interval
Glucose	239.46
Rice + Green gram	291.21
Rice + Bengal gram	283.77
Rice + Blackgram	277.38
Rice + Blackgram + Redgram	236.65
Rice + Soyabean	250.18

$F_{5, 113} = 7.19$, CD = 25.38 mg/dl

Table 7 depicts the blood glucose response of the subjects after one hour of administration after adjusting for the regression of the data on the initial plasma glucose levels. Among the test meals, rice + bengalgram combination had the highest blood glucose level of 358. 26 mg/dl whereas the lowest blood glucose of 276.81 mg/dl was observed in rice + blackgram + redgram combination. CD value 33.89 reflects that, there is significant difference between the test diets with respect to blood sugar level within one hour interval.

Table 7 Response (adjusted) of different isocalorigenic test foods on the blood glucose profile of the subjects after one hour

Test food	Blood sugar level (mg/dl) at half an hour interval
Glucose	355.20
Rice + Greengram	349.75
Rice + Bengalgram	358.26
Rice + Blackgram	344.81
Rice + Blackgram + Red gram	276.81
Rice + Soyabean	313.79

F_5 113 = 6.21, CD = 33.89 mg/dl

Table 8 showed the plasma glucose levels of the subjects after one and half hour of administration of the test food combination after adjusting for the regression of the data on plasma glucose levels on the initial plasma glucose levels. Compared to other test food combinations, rice + blackgram had the highest plasma glucose value of 392.19 mg/dl whereas, the rice + blackgram + redgram showed the lowest plasma glucose of 297.92 mg/dl. CD value 33.89 reflects that, there is significant difference between the test diets with respect to the blood sugar level within one and half hour interval of administration of test food.

Table 8 Response (adjusted) of different isocalorigenic test foods on the blood glucose profile of the subjects after one and half an hour

Test food	Blood sugar level (mg/dl) at half an hour interval
Glucose	311.91
Rice + Greengram	361.89
Rice + Bengal gram	379.52
Rice + Blackgram	392.19
Rice + Blackgram + Redgram	297.92
Rice + Soyabean	373.06

F_5 113 = 13.25, CD = 30.09 mg/dl

Table 9 represents the plasma glucose levels of the subjects after two hour of administration of the test food combinations after adjusting for the regression of the data on plasma glucose levels on the initial plasma glucose levels. After two hours, rice + blackgram had the highest plasma glucose value of 369.03 mg/dl while rice + blackgram + redgram showed the lowest glucose value of 280.31 mg/dl. CD value 34.30 reflects that, there is significant difference between the test diets with respect to blood sugar level within two hour interval of test food administration.

However, a comprehensive analysis of the blood sugar levels of the samples at different time intervals would be more reliable in the context of the varying response pattern of the different food combinations. Therefore, analysis of variance was conducted on the whole set of data on plasma glucose levels of the subjects corresponding to all the time intervals and the food combinations in a two factor split plot fashion in completely randomized block design with food as the main plot and period as the sub plot.

Table 9 Response (adjusted) of different isocalorigenic test foods on the blood glucose profile of the subjects after two hours

Test food	Blood sugar level (mg/dl) at half an hour interval
Glucose	272.39
Rice + Greengram	327.90
Rice + Bengalgram	355.78
Rice + Blackgram	369.03
Rice + Blackgram + Redgram	280.31
Rice + soyabean F_5, 113 = 12.68, CD = 34.30 mg/dl	365.03

Results clearly confirm that (Table 10) the food combinations had a varying rate of response on the blood sugar level of the subjects ($F_{20, 456}$ = 8.94**) and the test foods as such were different from each other as far as their blood sugar level response ($F_{51, 114}$ = 9.83 **) is concerned.

Table 10 ANOVA table (pooled over different time intervals) of plasma glucose levels of the subjects

Source	df	MSS	F
Food combination (A)	5	96975.21	9.83**
Within foods	114	9868.667	
Periods (B)	4	819774	736.10**
A x B	20	9962.8	8.94**
Error	456	1113.675	-

** significant at five per cent level

4.4 Impact of test foods on glucose build up of the subjects

The analysis of variance established that the different test foods responded differently at different time intervals of observation ($F_{15, 392}$ = 107.44) Table 11. The standard glucose administration gave a glucose buildup of 60 per cent after half an hour interval and reached its peak (121.44 per cent) in another half an hour (Table 12). After two hours, the percentage glucose buildup was plummeter to 78.3 per cent from the initial glucose level. As against this, the rice-blackgram combination effected the highest buildup of glucose (161.89 per cent) after two hours of administration. It was maximum at 1½ hours after administration (177.41 per cent). The rate of glucose buildup was found to recede after 1 ½ hours up to which the percentage glucose buildup was steadily galloping upward. Test foods had a comparable glucose buildup after two hours of its administration. To that of rice + blackgram combination in the percentage buildup glucose after two hours, the test foods just follow rice + blackgram combination were rice + bengalgram and rice + soyabean combination. Rice + bengalgram combination effected a percentage glucose buildup of 141.95 while rice + soyabean combination had caused a glucose buildup of 138.09 per cent over their initial glucose levels.

The resultant mean table is given below with their respective CD values (Table 11).

Table 11 ANOVA table (pooled over different time intervals of blood sugar levels adjusted by using abott's formula

Source	df	MSS	F
Between foods (A)	5	37916.8	10.22**
Within foods	114	3712.132	
Periods (B)	3	87879.5	178.19**
A x B	15	3623.933	107.44**
Error	392	487.546	
Total	479		

** Significant at five per cent level

Table 12 Mean glucose build up (%) of various food combinations after different time intervals

Test food	½ hour	1 hour	½ hour	2 hour	Mean
Glucose	61.04	121.44	104.28	78.31	91.27
Rice+Greengram	92.89	131.85	139.61	116.73	120.27
Rice+bengalgram	90.52	140.32	157.49	141.95	132.57
Rice+Blackgram	88.76	139.62	177.41	161.89	141.92
Rice+Blackgram+redgram	86.09	86.35	109.69	98.61	87.70
Rice+ soyabean	67.09	107.89	143.45	138.09	114.14
Mean	76.07	121.25	138.66	122.60	

CD values (mg/dl): Food = 19.074, Interval = 5.587, Interaction = 13.685

The general conclusion that could be arrived on the basis of the results of these analysis is that all the test foods took about 90 minutes to find its peak glucose buildup percentage over the initial values and it started to dissipate (recede) afterwards. Except for the test foods of rice + soyabean and rice + blackgram + redgram combinations, all other test foods caused a significantly reduced glucose buildup percentage in the last lap of observation duration (1 ½ hours to 2hours).

The mean glucose buildup was higher for rice + blackgram combination which was but on a'par with other test foods, barring glucose and rice + blackgram + redgram combination. The lowest buildup recorded was for rice + blackgram + redgram combination (87.70 per cent) which was comparable to that of glucose (91.26 per cent).

As pointed out earlier, since the initial blood sugar level of the subject was not similar, the plasma buildup of the subjects clearly depict the exact impact of the test diets on the plasma glucose level of the subjects. In order to find out the plasma buildup of the subjects both initial blood sugar level and the actual blood sugar after a given period of time is to be accounted. The glucose build up of each of the subjects were found using the Abbott's formula $\frac{gt - g_0}{g_0} \times 100$ where g_0 is the initial sugar level and gt is the observed sugar level after t-length of time. Data on plasma build up of subjects were analysed through split plot (CRD) fashion and is presented in Table 13.

FIG. 1. TWO HOUR PLASMA GLUCOSE TOLERANCE CURVE OF RICE+GREEN GRAM, RICE+BENGAL GRAM, RICE+BLACK GRAM, RICE+BLACK GRAM+REDGRAM, RICE+SOYABEAN AND GLUCOSE

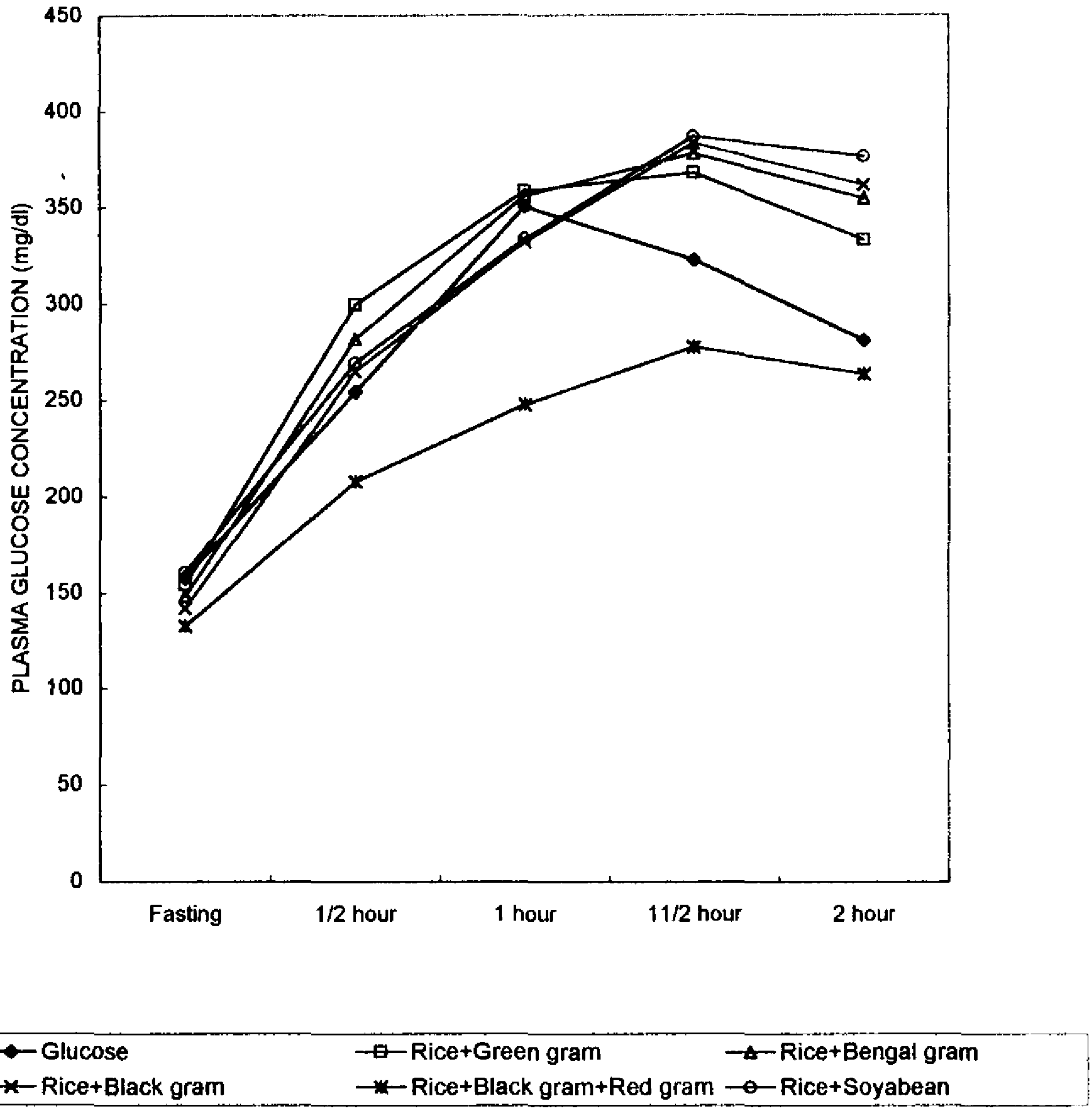


Table 13 Mean plasma glucose levels at different time intervals after the administration of test foods (mg/dl)

Test food	Fasting	½ hour	1 hour	½ hour	2 hour	Mean
Glucose	158.30	254.45	350.55	322.65	281.15	273.42
Rice + Greengram	154.50	299.75	358.50	368.00	332.95	302.74
Rice + Bengalgram	148.25	281.70	356.15	378.05	354.55	303.74
Rice + Blackgram	142.20	265.05	332.20	383.35	361.75	296.91
Rice+Blackgram+Redgram	132.70	208.20	247.70	277.55	263.50	225.93
Rice + Soyabean	160.85	269.50	333.55	386.90	376.45	305.45

CD (mg/dl) CD- Food = 27,817, Interval = 38.444, Interaction = 20,684

The mean blood glucose value of the subjects at each half hour of administration of the test diets as shown in Table 13 and Fig. 1 indicated that among the test diets, rice + blackgram + redgram showed least value of blood sugar levels (225.93 mg/dl) at all time intervals whereas the rice + soyabean combination showed the highest value (305.45 mg/dl) for blood sugar level among the test diet administered.

4.5 Relationship of glycemic response to plasma glucose concentration

Table 14 indicates that the relationship between blood sugar level at various time intervals after the consumption of the experimental breakfast and glucose.

The relationship between the blood sugar level (y) at various time intervals (t) has been explained by the quadratic regression equation

Table 14 Relationship between the blood sugar level (y) at various time intervals (t)

Food	Regression equation	For regression	Coefficient of determination (per cent)	Optimum time (minutes
Glucose	$Y = 153.59 + 290.95\,t - 114.08t^2$	68.15	58	76.51
Rice + greengram	$Y = 159.16 + 319.23\,t - 117.10\,t^2$	130.58	72	81.79
Rice + Bengal gram	$Y = 149.60 + 311.19\,t - 104.70t^2$	151.17	75	89.17
Rice + blackgram	$Y = 141.87 + 285.70\,t - 87.11t^2$	79.46	62	98.39
Rice + blackgram + redgram	$Y = 132.77 + 174.0\,t - 53.92\,t^2$	114.60	70	96.82
Rice + soyabean	$Y = 160.17 + 251.94\,t - 71.11\,t^2$	76.29	61	106.28

$y = 159.16 + 319.23 - 17.10\ t^2$ which was found to be highly significant and gave an optimum time of 81.79 minutes, beyond which the blood sugar level decreased in rice + greengram combination. Seventy two per cent of the variation in blood sugar level was attributed to the above fitted regression.

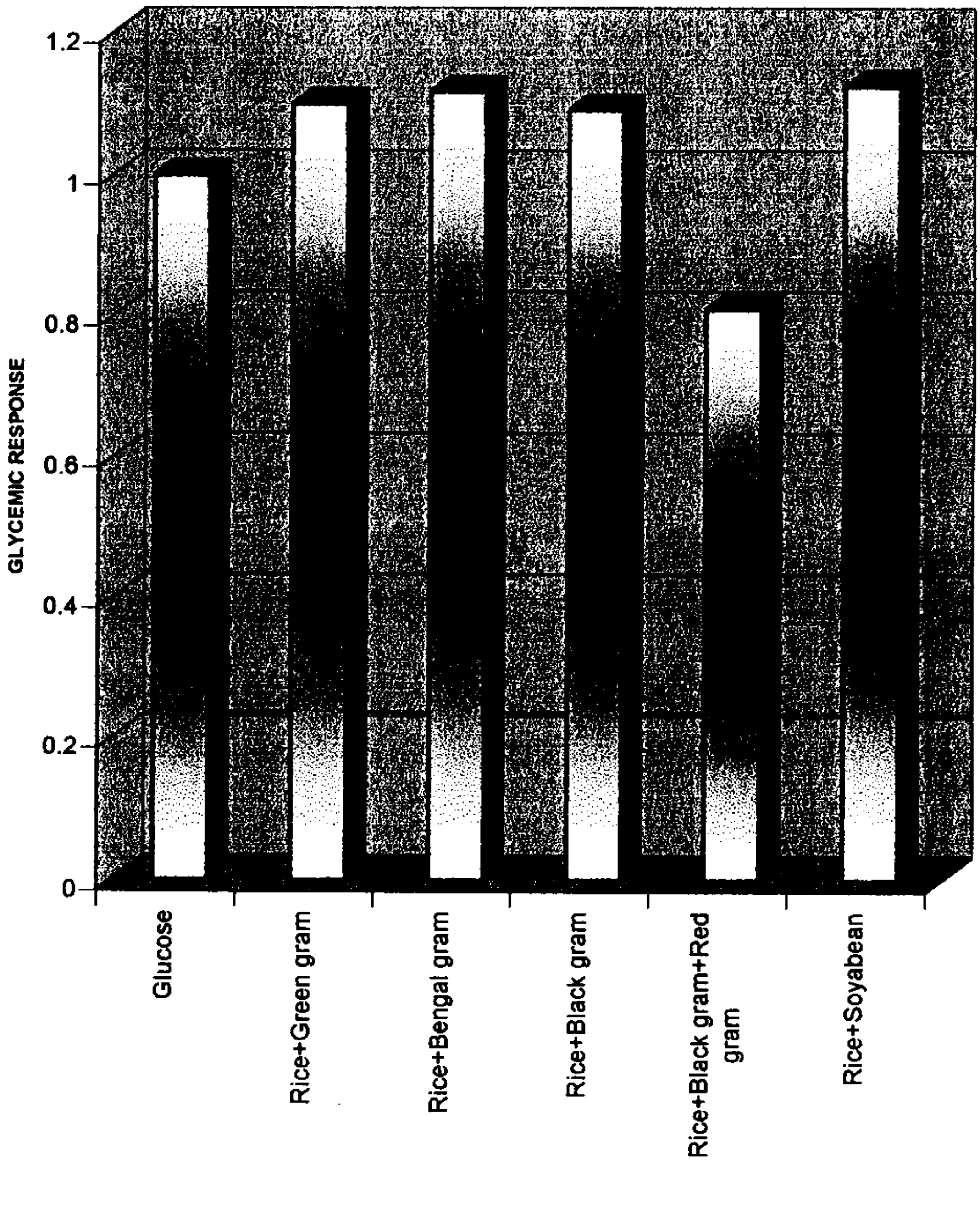
In the case of rice + bengalgram, the relationship between the blood sugar level (y) at various time intervals (t) has been explained by the quadratic regression equation $y = 149.60 + 311.9\ t - 104.70\ t^2$ which was found to be highly significant and gave an optimum time of 89.17 minutes beyond which the blood sugar level decreased. 75 per cent of the variation in blood sugar level was attributed to the above fitted regression.

In rice + blackgram food combination, the relationship between the blood sugar level (y) at various time intervals (t) has been explained by the quadratic regression equation $y = 141.87 + 285.7\ t - 87.11\ t^2$ which was found to be highly significant and gave an optimum time of 98.39 minutes, beyond which the blood sugar level decreased. 62 per cent of the variation in blood sugar level was a attributed to the above fitted regression.

In the case of Rice + blackgram + redgram food combination, the relationship between the blood sugar level (y) at various time intervals (t) has been explained by the quadratic regression equation $y = 132.77 + 174.04\ t - 53.92\ t^2$ which was found to be highly significant and gave an optimum time of 96.82 minutes, beyond which the blood sugar level decreased. 72 per cent variation in blood sugar level was attributed to the above fitted regression.

In rice + soyabean combination, the relationship between the blood sugar level (y) at various time intervals (t) has been explained by the

FIG. 2. MEAN GLYCEMIC RESPONSE OF THE BREAK FASTS



quadratic regression equation $y = 160.17 + 251.94t - 71.11\,t^2$ which was found to be highly significant and gave an optimum time of 106.28 minutes beyond which the blood sugar level decreased. Sixty one per cent of the variation in blood sugar level was attributed to the above fitted regression.

4.6 Glycemic response of experimental meals

Table 15 shows the mean area under the plasma glucose response curve (AUC) for the five experimental break fast meals. As indicated in table (15) figure (1) rice + soyabean had the highest area under the curve (855 mm^2) followed by rice + bengalgram (850 mm^2) + rice + green gram (845 mm^2) followed by rice + Bengal gram (850 mm^2) + rice + green gram (845 mm^2), rice + blackgram (830 mm^2) and rice + blackgram + redgram (615 mm^2). Rice + blackgram + redgram combination was found to have the least area under the curve.

Table 15 Mean area under the curve of experimental breakfast

Food	Area under the curve (mm^2)
Glucose	760.00
Rice + greengram	845.00
Rice + Bengalgram	850.00
Rice + blackgram	830.00
Rice + black gram + redgram	615.00
Rice + Soyabean	855.00

Based on area under curve (AUC) and applying the formula given below the glycemic index of the test meals was determined which is depicted in Table 16. mean glycemic response of the test meals was determined using the formula. AUC was plotted using the equation.

$$GR = \frac{\text{AUC of test food}}{\text{AUC of reference food (glucose)}}$$

As indicated in Table 16 (figure 2) rice + soyabean was found to record the highest glycemic response (1.12) followed by rice + Bengal gram (1.10); rice + green gram (1.10) and rice + blackgram (1.09). Rice + blackgram + redgram showed the lowest glycemic response (0.81) which was 20 per cent less than that of glucose.

Table 16 Mean glycemic response of the breakfast

Food	Glycemic response
Glucose	1.00
Rice +greengram	1.101
Rice + bengalgram	1.118
Rice + blackgram	1.092
Rice + blackgram +redgram	0.810
Rice + soyabean	1.125

DISCUSSION

DISCUSSION

The dynamic rise in the incidence and prevalence of diabetes mellitus is a great challenge in all nations especially in developing countries like India. Recent studies have suggested that not just the carbohydrate ingested but the biological equivalents is quantities of food yielding the same effect of blood glucose or the glycemic response to food should also be considered while planning a diet for diabetes. Present study was aimed at assessing glycemic response of various rice-pulse combinations given as break fast to non-insulin dependent diabetes subjects (NIDDM). The results obtained are discussed below.

5.1 Personal Characteristics of the Selected Subjects

Personal Characteristics of the respondents assessed indicated that all the selected subjects were males and majority were in the age group of 46-51 years. Ramankutty (2000) reported that in most communities males had a greater prevalence of type 2 diabetes than females. Studies conducted in western regions indicated that 70 per cent of all cases occur after the age of 50 years. Maximum incidence of non- insulin-dependent type of diabetes occur above the age 35 years. High proportion of Indians develop NIDDM at much younger age and therefore, the prevalence of maturity onset diabetes of young is higher in India (Davidsen,1999).

Incidence of diabetes in rural and urban sector indicated that 60 per cent of the subjects under study were from the urban populations. Poulose (1999) reported that prevalence of diabetes is more among urban population due to the sedentary habits, change in life style and lack of exercise. A survey conducted in the early seventies in India indicated that the prevalence of diabetes was 2.3 per cent in the urban population as against 1.5 per cent in the rural population. The same research group when conducted a repeat survey after five years found a dramatic increase in the occurrence of diabetes among urban population (11.6 per cent).

Type and size of the family of the subjects under study revealed that the majority of the subjects belonged to nuclear type families and 35 per cent were found to adopt small family norm. The rest were found to be comparatively large sized families.

On assessing the economic level of the surveyed subjects, It was found that more than half of the subjects had a monthly income ranging from Rs. 1000 to 5000 while for the remaining 35 per cent monthly income was found to be above Rs. 5000.

Body weight is one of the major contributing factor in the aetiology of diabetes mellitus. Body weight of the selected subjects, ranged between 55 to 77kg with the mean body weight of 64.30 kg while the mean body height was found to be 167.35 cm. Body mass index (BMI) (wt/ht^2), which is a valuable tool for identifying excess body weight indicated that 15 per cent of the subjects under study were obese. Ian (1994) found that obese people were more prone to diabetes because they are resistant to the effect of insulin, which converts blood sugar to energy. According to Keen *et al.* (1979) body mass and blood glucose levels were universally correlated with energy intake.

Hereditary predisposition in the disease occurrence was examined. Results indicated that among the surveyed subjects 40 per cent showed hereditary pre disposition in the disease occurrence. Ramankutty (2000) reported that Indians have a greater genetic susceptibility to the disease, which is further compounded by stress inducing factors such as urbanization, migration and modern lifestyle.

Assessing the duration of occurrence of disease among the subjects, it was found that in majority of the subjects the disease was manifested during the previous six years where as for the rest clinical manifestation was for more than 7-10 years. National level preventive programme functioning in the state facilitates early detection of diabetes even in the primary health centre and at district hospital levels (Beegum, 2000). This might have contributed to the early detection and control of diabetes among the selected subjects.

Among the selected subjects, 60 per cent had one to two diabetic subjects in their family while 40 per cent had only one member as diabetic.

On assessing the nature of oral hypoglycemic agents used by the subjects indicated that majority use sulphonyl ureas as oral hypoglycemic agents. Antia (2000) reported that the sulphonyl ureas are found to lower blood sugar by stimulating pancreatic insulin receptors on cells. Metformin monotherapy and combination therapy with Metformin and suplhonyl ureas are well tolerated; they improve glycemic control and lipid concentration in patients with NIDDM where diabetes is poorly controlled with diet or sulphonyl urea therapy alone.

5.2 Assessment of Glucose Tolerate Test (GTT) among the subjects

Glucose tolerate test (GTT) is the determinant of diabetic characteristics of the subjects. Results of the glucose tolerance test conducted among the subjects under study indicated that the fasting blood glucose levels ranged from 143-184 mg/ dl with a mean blood sugar level of 158.3 mg/dl. According to Mohan (1997) in a serve diabetic, the plasma glucose is likely to be high at any time of the day and therefore a random plasma glucose is often enough for diagnosis. However this is not very much helpful in identifying the mild diabetes and hence Glucose Tolerance Test (GTT) is a must. The glucose tolerance test helps to diagnose diabetes early and also helps in assessing the severity of the case.

5.3 Formulation of experimental breakfast items for the subjects

Rice-pulse combination is the integral part of traditional South Indian diets. This combination helps to achieve supplementary effect on cereal-pulse protein. According to Elizebeth (1998), a proportion of 3:1 (three parts of rice with one part of pulse) is enough for the supplementary effect. Grain legumes are important source of protein, minerals and vitamins for millions of people in the world particularly in the developing countries (Singh and Singh, 1992). As per wolever (1996), the ability of the food item to raise the blood sugar is measured in terms of glycemic index. According to Umesh (1993) many factors contribute to the glycemic index, including carbohydrate structure, fibre content, method of cooking, food processing, storage and coingestion of other nutrients.

The processing methods involved in the preparation of experimental breakfast items for the subjects under study include overnight soaking and boiling, soaking and powdering, boiling and pressure cooking, overnight soaking and fermentation.

All these processes facilitates gelatinization of starch thereby increasing the digestibility and eliciting the maximum response. Bishnoi *et al* (1993) studied the effect of domestic processing and cooking methods on phytic acid and polyphenol content of pea cultivars. Soaking as well as dehulling of soaked seeds contributed significantly towards lowering down the phytic acid content in field and vegetable pea cultivars.

All the experimental breakfast items were almost isocaloric with 75 g of glucose in the form of rice-pulse combination. Commonly followed rice-pulse combinations were administered among the subjects. This include rice gruel with greengram poriyal, puttu with bengalgram curry, dosai with chutney, iddli with dhal curry and rice with soyabean curry. Principles of meal planning suggested by National Institute of Nutrition were strictly adhered to, while formulating the test meals. All the test meals administered were found to be well tolerated by the subjects.

5.4 Effect of experimental breakfast on plasma glucose response

The results of the study revealed that the plasma glucose concentration of the subjects before the administration of the meals vary differently from the initial values of each half an hour intervals of the time. In the case of reference food ie glucose the highest mean value in the post prandial curves were observed at 60 minutes after the administration of glucose.

An attempt is also made to compare the plasma glucose response of experimental breakfast items with glucose load administered at different time intervals. Even though the food item were rice-pulse combination and isocaloric significant variations were noted in plasma glucose levels at different time intervals.

The results indicated that all the subjects reached a peak plasma glucose value at different time intervals after the consumption of test meals which is assumed to be due to the effect of consumption of different breakfast items served. Assessing the plasma glucose concentration of the subjects after the administration of the test meals at half an hour intervals indicated that the combination of rice + greengram served as Kanji and greengram poriyal showed the highest mean glucose value of 291,21 mg/dl. This may be due to the method of preparation of rice gruel and serving along with rice water which will facilities easy absorption of food item. According to O'Dea *et al.*(1980) the physical form of rice is of great importance in determining the post prandial glucose and insulin response to rice and that the fibre in greengram per se played a relatively minor role in this instance. Even though the breakfast item of Kanji and poriyal is favourite dish for Keralites, it is not advisable for the diabetic patients at is triggers rise in blood sugar level.

During the second half an hour i.e., one hour, rice + bengalgram combination depicted the highest mean glucose value (358.26 mg/dl) while at one and half hour the rice + blackgram combination showed the highest mean plasma glucose value (392,19 mg/dl). In 1994 Jenkins *et al.* found that various carbohydrate foods have different absorption pattern and these are reflected by difference in glycemic response. Rice- bengalgram combination was served as puttu and curry which is very much relished by Keralites. The processing method followed in this combination include soaking, grinding and roasting the rice flour and then steaming for puttu preparation. Where as, for bengalgram, pressure cooking is followed. According to Osei *et al.* (1987) cooked whole rice gives a lower blood sugar raise when compared to rice flour. Bengalgram had good amount of fibre which helps to reduce blood sugar levels. Leonara *et al.* (1991) reported that amylose content of rice alone is not a good predictor of starch digestibility and glycemic response. Antia (1989) reported that fibre rich foods cause slower stomach emptying, delay in intestinal transit time, reduce the rate of glucose absorption, lower blood sugar rise and decrease glucose excretion.

Rice-blackgram combination showed comparatively low peak rise over the fasting level in the subjects under study. This combination was served as dosai and coconut chutney. The processing method involved in the preparation of this breakfast item include soaking and grinding followed by fermentation. These process facilities complete gelatinization there by increasing the digestibility and eliciting the maximum glycemic response. According to Vinik and Jenkins (1998), in patients with non-insulin dependent diabetes mellitus (NIDDM) viscous (soluble dietary fibre) has a modest hypoglycemic effect and also improves blood lipid profile, reducing LDL and VLDL cholesterol concentration. Crapo *et al.* (1976) showed that the complex carbohydrates from the two mixed meals are digested slowly and therefore induces lower glucose response.

The combination of rice- blackgram + redgram which was served as iddli and dhal curry depicted the least glucose value throughout the different time intervals. The striking point noted in the result is that the combination of rice + blackgram + redgram served as iddli and curry continued to be contribute low plasma glucose value throughout the period. These combination include or contained two different pulses and one cereal base. The processing method involved in this combination include soaking, grinding, fermentation and steaming for the preparation for iddli and pressure cooking for dhal. According to Elizebeth (1998), a proportion of three parts of rice with one part of pulse will be the ideal rice-pulse combination to obtain the mutual supplementary effects of amino acids. Jenkins *et al.* (1986) reported that various carbohydrate foods have different absorption pattern and these are reflected by difference in glycemic response. According to Giri *et al.* (1986) redgram juice is hypoglycemic and hypocholesterimic which may control diabetes.

At two hours of administration, blood glucose level was found to be slightly lowered and at this period also rice-blackgram-redgram showed the lowest value and rice + blackgram combination depicted the highest value of 369.03 mg/dl. Statistical analysis of the data at different time intervals confirmed that significant differences exist between the test diets and blood sugar levels.

Since the blood sugar level of the subjects under study was not similar and in order to understand the exact response of the test meals on the blood glucose levels. Glucose build up of the subjects was accounted using the Abott's formula

$$\frac{gt-g_0}{g_0} \times 100$$

were g_0 is the initial sugar level and gt is the observed sugar level after 't' length of time. The data on plasma buildup of the subjects were analysed on split plot CRD fashion. The results of the mean plasma buildup (percentage) of various experimental test meals indicated that rice- blackgram food combination effected the highest buildup of glucose (177,41 mg/dl) during one and half hour interval which is the expected time interval for acquiring the peak level of plasma glucose.

While that of rice-blackgram- redgram combination showed the least glucose buildup of 109.69 mg/dl at the same time interval. The rate of glucose buildup was found to decrease after one and half hours. The test meals were found to depict a comparable decrease in glucose buildup after two hour of its administration following the lowest with rice-blackgram-redgram combination (98.61) and highest with rice + blackgram (161.89 mg/dl).

From the above results it can be concluded that all the test meals took approximately 90 minutes to attain peak maximum glucose buildup percentage over the initial values and then started to dissipiate. The rice- blackgram-redgram combination and rice-soyabean combination were found to maintain the glucose buildup per cent which was decreased in the last lap of observation (one and half to two hours). Dibildose *et al.* (1985) reported that proteins in food may also alter the glycemic response. According to Beegum (1994) soyabean is a miracle bean because it is a store house of protein, fat and other vitamins. Unless it is not processed properly it will not be digested.

5.5 Relationship of glycemic response at different time intervals

The relationship of glycemic response of test meals at different time intervals was studied in detail . The relationship was explained by quadratic regression equations and found to be highly significant. In the case of rice-greengram combination the maximum glucose response was attained at 81.79 minutes while in the case of rice + bengalgram the maximum response was attained at 89.17 minutes and after the equation was fitted at 75 per cent level. In the case of rice + blackgram the optimum time for attaining maximum glucose response was 98.39 minutes while that of rice + blackgram + redgram combination, it took 96.82 minutes. Rice + soyabean combination utilised maximum time of 106.28 minutes to attain the maximum glucose response. According to Antia and Abraham (2000) the phytic acid usually contained in cereals and pulses may have a more dominant role in decreasing the blood sugar rise than fibre. The blood glucose response becomes less with increasing content of phytic acid in food. A highly significant and negative correlation was observed between the protein digestibility and the concentration of phytic acid (Singh *et al.*, 1992).

5.6 Glycemic response of the experimental meals

Glycemic response of the test meal was calculated as per Jenkins (1982). The area under the curve of each of the experimental breakfast calculated by quadratic regression equation. According to Gannon and Nuttal (1987), the methodologic factors may influence the glycemic response data. The highest area under the curve was depicted by the rice- soyabean combination (845 mm2) followed by rice + bengalgram (850mm2) and rice + greengram (845 mm2) and rice + blackgram (830mm2). The least area under the curve was shown in rice + blackgram combination (615 mm2). Wolever *et al.* (1992) reported that the long glycemic index starchy foods may be beneficial in the treatment of type 2 diabetes. According to Thompson *et al.* (1991 b) the area under the glycemic response curve for each food is expressed as the percentage of mean response to the standard food taken by the same subjects and the resulting values are arranged to obtain the glycemic index value of the food.

Glycemic index of the test meals calculated based on the area under curve indicated that rice-blackgram- redgram combination showed the lowest glycemic response (0.81) indicating that this combinations is an ideal food for diabetic patients. The glycemic index value obtained for rice-blackgram-redgram combination was found to be 20 per cent less than that of the standard glucose. The next ideal food combination as per the glycemic index was found to be rice-blackgram combination (1.09). Rice-soyabean depicted the maximum glycemic index (1.125). The higher protein content per se in the soyabean and the form in which it has been given might have contributed the higher glycemic index values.

SUMMARY

SUMMARY

A study was conducted to assess the glycemic response of various rice - pulse combinations served as breakfast to twenty non- insulin -dependent diabetic subjects. The selected subjects were males with a fasting blood sugar greater than 140 mg/dl to 200mg/dl after 2hours of glucose ingestion and who were using only oral hypoglycemic agents.

Personal characteristics of the selected subjects assessed revealed that majority of the respondents were in the age group of 46-51 years. Examining the incidence of diabetes among the surveyed subjects indicated that 60 percent belonged to urban population

Type and size of the family of the respondents revealed that majority belong to nuclear type families and 35 percent of them were found to adopt small family norms .The economic status of the subjects under study indicated that half of the subjects had a monthly income ranging from Rs-1000 to 5000 while 35 percent had a monthly income above Rs 5000.

The body weight and height of the subjects assessed indicated that 15 percent of the subjects were obese. Hereditary predisposition in the disease occurrence was examined among the selected subjects and found that 40 percent showed familial predisposition in the disease occurrence. Assessing the duration of occurrence of disease among the subjects revealed that the majority had the disease for the last six years and the rest had the disease for more than 7-10 years.

In majority of the families (60 per cent) of the subjects under study had one or two diabetic subjects while 40 per cent had only one member as diabetic. On assessing the nature of oral hypoglycemic agents used by the subjects revealed that a combination of sulphonyl ureas (80 per cent) and metformin (Biguanides) (20 per cent) were used as oral hypoglycemic agents by the respondents.

In order to analyse the diabetic condition of the subjects Glucose Tolerance Test (GTT) was conducted and the results showed that the fasting blood sugar levels of the subjects ranged between 143 to 184 mg/dl with a mean blood sugar level of 158.3 mg/dl.

Five experimental breakfast preparations were administered to the subjects understudy which supplied 75g carbohydrate in the form of staple foods such as rice along with green gram/ bengalgram/ blackgram/ redgram and soyabean.

Impact of experimental breakfast on plasma glucose response was studied in detail. The breakfast preparation consisting rice+green gram served as Kanji and green gram poriyal showed the highest mean glucose value of 291.21 mg/dl in the first half an hour. While during the second half an hour, rice + bengalgram combination served as puttu and bengalgram curry had the highest mean glucose value of 358.26 mg/dl. The combination of rice with blackgram showed the highest mean plasma glucose value (392.19 mg/dl) at one and half an hour compared to other combinations and this combination depicted the low peak rise over the fasting level. Combination of rice + blackgram + redgram which was served as iddli and dhal curry depicted the

Since the blood sugar level of the subjects under study was not similar, the exact response of the test meals was assessed accounting the glucose build up of the subjects. The results of the mean plasma buildup of various experimental test meals assessed indicated that rice + blackgram combination effected the highest buildup of glucose (177.41 mg/dl) during one and half hour interval. While rice + blackgram + redgram showed the least glucose buildup of 109.69 mg/dl at the same time interval. The test meals were found to depict a comparable decrease in glucose buildup after two hour of its administration following the lowest with rice + blackgram + redgram combination and highest with rice + black gram.

The relationship of glycemic response of test meals at different time intervals was assessed, which was explained by quadratic equation. Results indicated that among the five experimental breakfast preparations, majority of the subjects reached the peak at $1_{1/2}$ hour post prandially or more accurately 81.79 minutes for rice + green gram, 89.17 minutes for rice + bengal gram, 98.39 minutes for rice + blackgram, 96.8 minutes for rice + blackgram + red gram and 106.28 minutes for rice + soyabean.

Area under the curve (Auc) of the experimental breakfast preparation were calculated by using the quadratic regression equation $Y= a + bt + ct^2$ and glycemic response was worked out using the ratio of Auc of test food: Auc of reference food (glucose).

The mean area under 2-hour glucose stimulation curve revealed that rice + soyabean has got the highest area under the curve (855 mm^2) followed by rice+ bengal gram (850 mm^2) and rice + green gram (830 mm^2. The least area under the curve was shown by rice + blackgram + redgram combination (615 mm^2).

Glycemic index of the test meals calculated based on area under curve indicated that rice + black gram + red gram combination depicted the lowest glycemic response (0.81) indicating this combination was found to be most ideal for diabetics among the test meals administered. The next ideal food combination was found to be rice + black gram with the glycemic index of (1.09) followed by rice + greengram (1.10) and rice + bengal gram combination was (1.11). Rice+ soyabean combination depicted the maximum glycemic index of (1.125)

Based on the results obtained it can be concluded that a breakfast which include cereal with two pulse combination is found to be more suited to a diabetic patient, than cereal with one pulse combination.

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APPENDICES

APPENDIX I

Oral glucose tolerance test (GTT)

Oral glucose tolerance test is carried out after 12 hours of over night fasting Glucose 75gm in adults 1.75g/kg of body weight in children is orally administered. Before the glucose load and 30 minutes for 120 minutes after the administration of glucose blood samples were collected and glucose levels were estimated.

The diagnostic criteria for diabetes and impaired glucose tolerance are given in the table. Generally in normal person without diabetes or impaired glucose, the fasting blood sugar levels vary between 80-110 mg/100ml. The blood sugar levels increase after the glucose load and come down to basel level within 2 hours.

WHO criteria with glucose load 75 gm water for adult or 1.75gm/kg body weight (To a maximum of 75 gm)

	Glucose concentration		
	Venous whole blood	Capillary whole blood (mg/dl)	Venous plasma (mg/dl)
	Normal	Diabetes mellitus	Confirmed
Fasting	120	120	140
2 hours after glucose load	180	200	200
	Impaired glucose tolerance		
Fasting	120	120	140
2 hours after glucose load	120-180	140-200	140-200

WHO (1980)

APPENDIX II

Questionnaire eliciting the personal characteristics of the subjects

1. Name and address of the respondent

2. Age

3. Type of family

Nuclear	Joint

4. Family composition of the respondents

Name	Relationship with the respondent	Age	Sex

5. Total monthly income of the family

6. Number of family members having diabetes

7. Duration of the disease

8. Type of oral hypoglycemic agents used by the subjects

9. Anthropometric measurements of the respondents

Height	Weight

APPENDIX III a

Composition and nutritive value of the ingredients of experimental breakfast 1-Rice+greengram

Preparation	Ingredients	Quantity (g)	Energy (Kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
Kanji	Rice	67.00	238.82	47.4	4.28	0.268
Greengram poriyal	Greengram	60.00	200.4	34.02	14.4	0.78
	Coconut	5	22.2	1.3	0.45	4.16
	Oil	5.00	45.00	-	-	5.00
	Total		499.42	82.72	19.33	10.29

APPENDIX III b

Composition and nutritive value of the ingredients of experimental breakfast 2- Rice + Bengalgram

Preparation	Ingredients	Quantity (g)	Energy (Kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
Rice (pittu)	Rice	60.00	207.6	47.4	3.84	0.24
Bengalgram curry	Bengalgram	60.00	216.0	36.54	10.26	3.18
	Coconut	10.00	44.4	1.3	0.45	4.16
	Oil	4.00	36.0	-	-	4.00
	Total		504.0	75.24	14.55	11.58

APPENDIX III c

Composition and nutritive value of the ingredients of experimental breakfast 3-Rice + Blackgram

Preparation	Ingredients	Quantity (g)	Energy (Kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
Dosai 3 Numbers	Rice parboiled	40.00	138.00	31.28	2.72	0.20
	Rice raw	40.00	138.40	31.60	2.56	0.16
	Blackgram	40.00	138.80	23.84	9.60	0.56
Chutney	Coconut	8.00	35.52	1.04	0.36	3.32
	Onion	3.00	1.77	0.37	0.054	0.30
	Oil	4.00	36.00	-	-	4.00
	Total		488.49	88.13	15.29	8.54

APPENDIX III d

Composition and nutritive value of the ingredients of experimental breakfast 4 – Rice + Blackgram + Redgram

Preparation	Ingredients	Quantity (g)	Energy (Kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
Iddli 3 Numbers	Parboiled Rice	40.00	138.40	31.60	2.56	0.16
	Raw rice	40.00	138.00	31.28	2.72	0.20
	Blackgram	20.00	69.40	11.92	3.42	0.28
Curry	Red gram	40.00	134.00	23.04	8.92	0.68
	Oil	2.00	18.00		-	2.00
	Total		497.80	97.84	17.62	3.32

APPENDIX III e

Composition and nutritive value of the ingredients of experimental breakfast 5- Rice + soyabean

Preparation	Ingredients	Quantity (g)	Energy (Kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
Rice cooked	Rice - parboiled	60.00	207.6	47.40	3.84	0.24
Curry	Soyabean	55.00	237.6	11.49	23.70	10.7
	Coconut	5	22.2	0.65	0.225	2.08
	Onion	2.00	1.18	0.252	0.036	0.002
	Oil	3.00	27.00	-	-	2.00
	Total		495.58	59.70	27.801	15.022

GLYCEMIC RESPONSE TO SELECTED RICE-PULSE COMBINATIONS IN DIABETICS

BY

SUNI.K

ABSTRACT

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ABSTRACT

A study was conducted to assess the glycemic response of various rice-pulse combination served as breakfast to twenty (non-insulin dependent diabetes mellitus) NIDDM subjects. The selected subjects were adult males in the age group of 40 to 51 years, having a fasting blood sugar level of 140 mg/dl to 200 mg/dl at 2 hour after the consumption of food and who were using only oral hypoglycemic agents.

Personal characteristics of the selected subjects revealed that majority were in the age group of 46-51 years, of which 60 per cent belonged to urban population. 35 per cent respondents were found to adopt small family norms. The economic status of the subjects showed, half of the subjects had a family monthly income ranging from Rs. 1000 to 5000.

The anthropometric measurements of the subjects assessed indicated that 15 per cent respondents were found to obese and 40 per cent depicted hereditary predisposition in the disease occurrence.

Majority of the families were found to have more than one member as diabetic. All of them depend on sulphonyl urea and biguanides or a combination of these two drugs as oral hypoglycemic agents.

An Oral Glucose Tolerance test was conducted among the respondents indicated that a fasting blood sugar level ranged between 143 to 184 mg /dl with a mean blood sugar level of 158.3 mg/dl.

Five experimental breakfast preparations were administered to the subjects understudy which supplied 75g carbohydrate in the form of staple foods such as rice along with green gram/ bengalgram/ blackgram/ redgram and soyabean.

Impact of experimental breakfast on plasma glucose response was studied in detail. The breakfast preparation consisting rice + green gram served as Kanji and green gram poriyal showed the highest mean glucose value of 291.21 mg/dl in the first half an hour. While during the second half an hour, rice + bengalgram combination served as puttu and bengalgram curry had the highest mean glucose value of 358.26 mg/dl. The combination of rice with blackgram showed the highest mean plasma glucose value (392.19 mg/dl) at one and half an hour compared to other combinations and this combination depicted the low peak rise over the fasting level. Combination of rice + blackgram + redgram which was served as iddli and dhal curry depicted the least glucose value throughout the different time intervals.

Among the five experimental breakfast items majority of the subjects reached the peak at 1 ½ hour post prandially or more accurately 81.79 minutes for rice + greengram, 89.17 minutes for rice + bengalgram, 98.39 minutes for rice + bengalgram, 98.8 minutes for rice+ blackgram + redgram and 106.28 minutes for rice + soyabean.

From the results the area under 2 hour glucose stimulation curve, it was found that rice + blackgram + redgram combination had the least area under the curve while the rice + soyabean had the highest area under the curve.

Glycemic Index of test meals computed based on area under curve indicated that rice + blackgram + redgram combination depicted the lowest glycemic response (0.81) indicating this combination was ideal for diabetics-followed by rice + blackgram (1.09) while the maximum glycemic response was depicted by rice + soyabean combination (1.125).