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Glycemic Indices and Glycemic Loads of Various Types of Pulses

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Abstract: For preparation of diet for diabetics, glycemic indicies and glycemic loads of local pulses namely chickpea, chana dal, kidney bean, mash bean, mung bean and peas were determined. Forty two male students of Agricultural University were recruited and were divided into six groups, with seven students in each group. Glucose was fed as reference and pulses as test foods. The pulses were cooked (only boiled) in tape water before feeding to the individuals. Fifty grams glucose, dissolved in 300 mL of water, was given to each individual of all the groups on day first and amount of the boiled pulses containing 50 g carbohydrate were given to each individual of the assigned group on the next day. Blood samples were collected from each individual of the groups before (fasting) the ingestion of glucose and test foods and 30, 60 and 120 minutes after ingestion of glucose and test foods. Glycemic index was determined from the area under curves of glucose concentration for reference and test foods. Glycemic load was determined by taking the percentage of the food's carbohydrate content in a typical serving and multipling by its glycemic index. The mean glycemic index for chick pea, chana dal, kidney bean, mash bean, mung bean and peas were 36, 13, 32, 43, 42 and 25 respectively. The mean glycemic loads for these pulses were 12, 4, 8, 10, 7 and 2 respectively. The results of the study indicated that local pulses have low glycemic indices and glycemic loads, hence could be safely use in the diet of diabetic patients.

Key words: Diet for diabetic, pulses, glycemic index

Introduction

Glycemic index is a classification of the blood glucose-raising potential of the carbohydrate portion of foods. It is defined as the incremental blood glucose area under the curve following a test food, expressed as the percentage of the corresponding area following a carbohydrate equivalent load of a reference food (Bjorck *et al*., 2000).

The glycemic index concept was developed in human nutrition in an attempt to characterize foods according to their postprandial glycemic response rather than their chemical composition (Jenkins *et al*., 1981). The glycemic effect of a food in humans is influenced by the nature of the starch granules, the type of carbohydrates, the physical form of the food and processing (Wolever, 1990).

Foods that scores higher than 70 are considered to be high glycemic index foods. High glycemic index foods fill one up quickly, give a fast burst of energy, but then leave one feeling hungry and lethargic a short time later. Examples of high glycemic index foods include; glucose, bread, potato, rice, watermelon etc. Foods with scores 55-70 are regarded as moderate glycemic index foods. Examples include; sucrose, soft drinks, banana, mango etc. Foods with scores below 55 are regarded as low glycemic index foods. Low glycemic index foods raise blood sugar slowly and steadily, giving one a longer feeling of being full and continuous energy. Examples include; pulses, fructose, milk, apple, orange etc (Foster-Powell *et al*., 2002).

Glycemic index is an important tool used in treating people with diabetes and in weight loss programs. Low glycemic index foods, by virtue of the slow digestion and absorption of their carbohydrates, produce a more gradual rise in blood sugar and insulin levels and are increasingly associated with health benefits. Low glycemic index foods have thus been shown to improve the glucose tolerance in both healthy and diabetic subjects (Jenkins *et al*., 1988).

Glycemic load of a given weight of food is the weight of glucose, which would raise blood glucose by the same amount as that amount of food. Glycemic load is calculated by multiplying the glycemic index of a food by the amount of percent carbohydrates contained in a typical serving of that food (Salmeron *et al*., 1997).

Foods having glycemic load of 20 or more are called high glycemic load foods, those having glycemic load of 11-19 are called medium glycemic load foods and those having glycemic load of 10 or less are called low glycemic load foods.

Decreased postprandial glucose concentrations and diets with a low glycemic load are associated with reduced risk for cardiovascular disease, diabetes and some forms of cancer. In addition, generally, low carbohydrate or low glycemic load diets result in greater weight loss than high carbohydrate diets over periods of 3-6 months and have a favorable effect on Triglyceride, HDL and Cholesterol (Stern *et al*., 2004).

Pulses are the seeds of plants belonging to the family

Leguminosae. Pulse is a general term applied to all dried, edible legume seeds. Pulses are inexpensive, nutrient-dense sources of plant protein that can be substituted for dietary animal protein. While sources of animal protein are often rich in saturated fats, the small quantities of fats in pulses are mostly unsaturated fats. Pulses are excellent sources of essential minerals and are rich in dietary fiber (Anderson *et al*., 1999).

One of the easy and possible approch to control diabetes is food. Those foods which have low glycemic index and glycemic load are appropriate for diabetes. However glycemic index and glycemic load of the locally available foods are not known. It is a general belief that pulses are good for control of diabetes, therefore it was initiated that glycemic index and glycemic load of pulses may be determined that it could be effectively used in the diet of diabetes.

Materials and Methods

Location and subjects of the study: The study was conducted in the department of Human Nutrition, NWFP Agricultural University Peshawar. The adult male university students were the volunteer participants of the study. They were of age 20-30 years. The inclusion criterion was to select subjects with no recent history of chronic disease.

Sample size and sample collection: The numbers of subjects recruited for the study were determined on the basis of number of foods. A total of six foods were studied for their glycemic index and glycemic load values. For each food seven individuals were selected. In this way a total of forty two individuals participated in the study.

Experimental protocol: The subjects were divided in six groups randomly; each group was having seven individuals. Weight and height of all individuals were taken and their Body Mass Indices (BMI) were calculated.

Six pulses namely chickpea, chana dal, kidney bean, mash bean, mung bean and pea were studied for their glycemic index and glycemic load values. These pulses were assigned to group I, II, III, IV, V and VI respectively. These pulses were simply boiled and only salt was added for taste. The amount of a pulse to be consumed by an individual was on the basis that it should provide 50 g carbohydrates.

All participants were explained the purpose and details of the study. The subjects of the study were asked for a complete overnight fast one day before the experiment. They came for two consecutive days to the department of Human Nutrition. On day first, they were given a 50 g glucose dose (reference food) dissolved in 300 mL of water. On day second, they were given the food assigned to the particular group.

Blood collection and analysis: Four blood samples (3 mL each) were taken from each individual on day first i.e. at fasting, after 30, 60 and 120 minutes of glucose drink. Similarly on day second four blood samples (3 mL each) were collected from the individuals of the same group i.e. at fasting, 30, 60 and 120 minutes intervals after consumption of the food assigned to that group. Blood samples were transferred to sterilized centrifuge tubes and allowed for clotting at room temperature. The blood samples were centrifuged for 10 minutes in a centrifuge at 4000 rpm for serum separation. Separated serums were transferred to eppendorf tubes and were stored in freezer at 0°C for later analysis.

Determination of serum glucose: Glucose was determined by the method of Barham and Trinder (1972). GENESYS 10 Spectrophotometer and Randox kit (CAT No GL 2586/s) were used. In this method glucose is determined after enzymatic oxidation in the presence of glucose oxidase. The hydrogen peroxide formed reacts, under catalysis of peroxidase, with phenol and 4-aminophenazone to form a red-violet quinoneimine dye as indicator. The absorbance of this coloured substance is taken and concentration of glucose is calculated.

$$\text{Glucose} + O_2 + H_2O \xrightarrow{\text{Glucose Oxidase}} \text{Gluconic acid} + H_2O_2$$

$$2H_2O_2 + \text{4-aminophenazone} + \text{phenol} \xrightarrow{\text{Peroxidase}} \text{quinoeimine} + 4\,H_2O$$

Sample: Serum free of hemolysis.

Procedure: Wavelenght of the spectrophotometer was adjusted at 500 nm and 1 cm light path cuvette was used. Ten (10) µL of sample and 1000 µL of reagent were pipetted into test tube and mixed. After 10 minutes of incubation at 37°C in water bath, the absorbance against reagent blank was recorded.

Calculation

$$\text{Glucose concentration (mg/dl)} = \frac{A_{\text{Sample}}}{A_{\text{Standard}}} \times 100$$

A = Absorbance.

Construction of blood glucose response curves: Blood glucose curves were constructed from blood glucose values for each individual at time 0, after 30, 60 and 120 minutes intervals after consumption of the reference food and test food of each group. The Incremental Area Under the Curve (IAUC) was calculated for reference food (glucose) by the trapezoidal rule (Gibaldi and Perrier, 1982) in every individual separately as the sum of the surface of trapezoids between the blood glucose

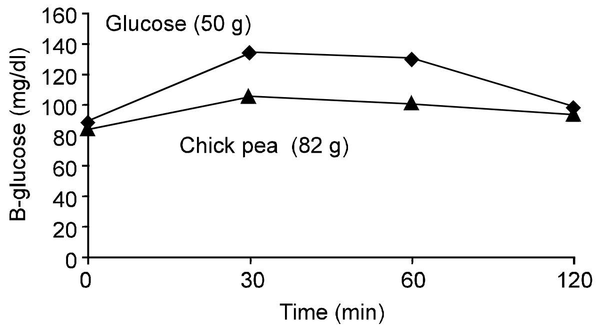

Fig. 1: Mean B-glucose curves of group-I (7 individuals) after consumption of 50g glucose and 82g chick pea which contain 50g carbohydrates

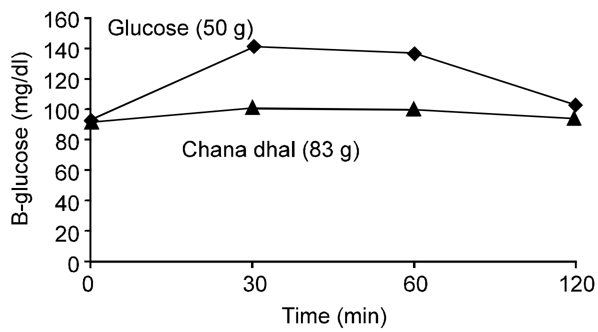

Fig. 2: Mean B-glucose curves of group-II (7 individuals) after consumption of 50g glucose and 83g chana dal which contain 50g carbohydrates

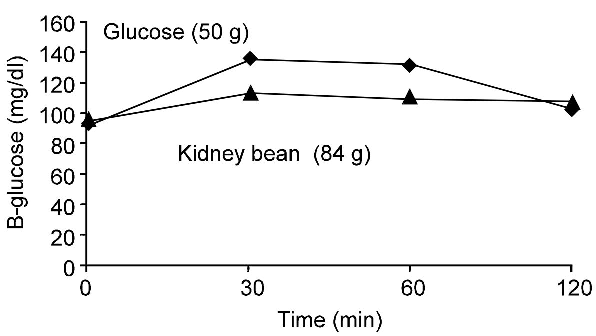

Fig. 3: Mean B-glucose curves of group-III (7 individuals) after consumption of 50g glucose and 84g kidney bean which contain 50g carbohydrates

curve and horizontal baseline going parallel to x-axis from the beginning of blood glucose curve at time 0 to the point at time 120 min to reflect the total rise in blood glucose concentration after eating the reference food (glucose). The Incremental Area Under the Curve (IAUC) for the test food of the same individual was obtained similarly.

Calculation of Glycemic Index: The Glycemic Index (GI) values were calculated by the method of Jenkins *et al*. (1981). In each individual, the glycemic index was calculated by dividing the IAUC for the test food by the IAUC for the reference food and multiplying by 100. The following formula was used:

$$GI = \frac{\text{IAUC for tested Food}}{\text{IAUC for Reference Food}} \times 100$$

IAUC-Incremental Area Under the blood glucose response Curve.

The final glycemic index for each test food was calculated as the mean from the respective average GI's of the 7 individuals.

Calculation of Glycemic Load: Glycemic Load (GL) for each food was determined by the method of Salmeron *et al*. (1997). In each individual glycemic load was calculated by taking the percentage of the food's carbohydrate content in a typical serving and multiplying it by its glycemic index value. The following formula was used:

$$GL = \frac{\text{Net Carbs (g)} \times GI}{100}$$

Net Carbs = Total Carbohydrates - Dietary Fiber

Serving in this study is 150 g for all the pulses.

Results

Blood glucose concentration of individuals: The blood glucose values (88 and 85 mg/dl) at time 0 min in Fig. 1 indicate the fasting blood glucose concentration of group-I individuals before glucose and food (chickpea) intake, respectively on two consecutive days. When glucose was given as a reference and chickpea as a test food, the mean postprandial blood glucose concentration were 130 and 104 mg/dl at time 30 min, 128 and 101 mg/dl at time 60 min and 96 and 93 mg/dl at time 120 min respectively. Similarly blood glucose concentrations of other groups at fasting and after glucose and foods intake are given in Fig. 2-6.

Blood glucose curves of groups

Glycemic Index of Pulses and Glycemic Index Variation Between Individuals: Data presented in Table 2 shows the glycemic indices of pulses. The mean values of glycemic index for chickpea (36), chana dal (13), kidney bean (32), mash bean (43), mung bean (42) and peas (25) were recorded. The average coefficient of variation (a representation of the variability in responses between individuals) for chickpea (13), chana dal (14), kidney bean (9), mash bean (5), mung bean (9) and peas (15) were recorded.

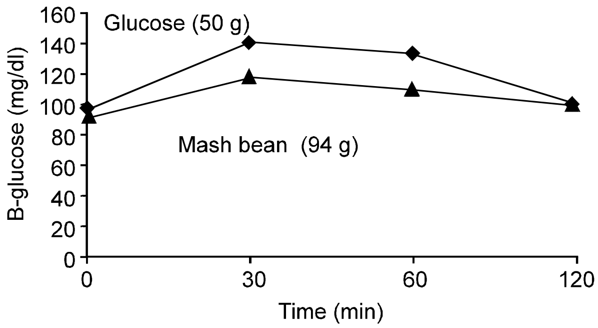

Fig. 4: Mean B-glucose curves of group-IV (7 individuals) after consumption of 50g glucose and 94g mash bean which contain 50g carbohydrates

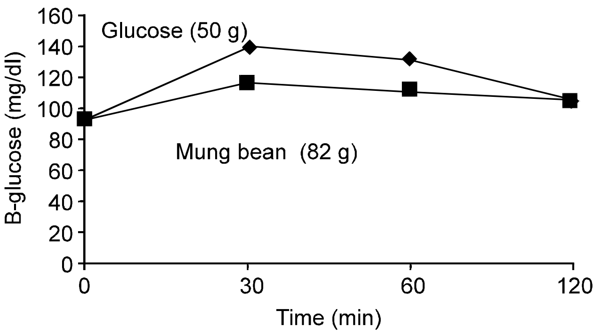

Fig. 5: Mean B-glucose curves of group-V (7 individuals) after consumption of 50g glucose and 82g mung bean which contain 50g carbohydrates

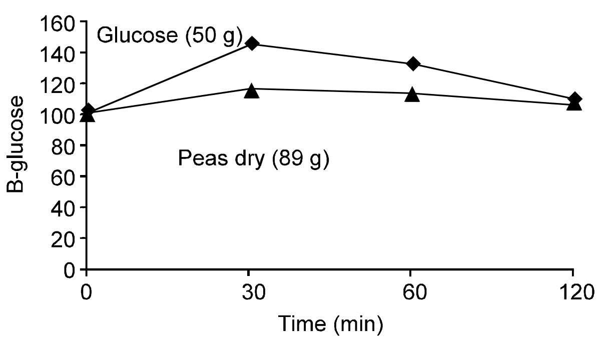

Fig. 6: Mean B-glucose curves of group-VI (7 individuals) after consumption of 50g glucose and 89g peas which contain 50g carbohydrates

Glycemic load of pulses and glycemic load variation between individuals: Data in Table 3 shows the glycemic loads of pulses. The mean values of glycemic load for chickpea (11), chana dhal (4), kidney bean (8), mash bean (11), mung bean (7) and peas (2) were recorded. The average coefficient of variation (a representation of the variability in responses between individuals) for chickpea (9), chana dal (25), kidney bean (12), mash bean (9), mung bean (14) and peas (47) were recorded.

Discussion

Control of diabetes through diet is a more appropriate approach in terms of applicability and cost in developing countries. Identification of foods that have low glycemic effect are important for diabetes. A fundamental assumption regarding low glycemic index and glycemic load foods is that, these foods produce a lesser increase in the plasma glucose concentration as a result of slower rates of gastric emptying and digestion of carbohydrate in the intestinal lumen and subsequently, a slower rate of absorption of glucose into the portal and systemic circulation (Jenkins *et al*., 1981; Wolever *et al*., 1991).

People in industrialized countries base their diets on low-GI and low-GL foods in order to prevent the most common diseases such as coronary heart disease, diabetes and obesity (Burns *et al*., 1989; Gannon *et al*., 1986; Raben, 2002).

The American Journal of Clinical Nutrition published the glycemic index tables first in 1995 and then in 2002. Tables of glycemic index contain about 600 different foods. According to GI, foods may be divided into three groups: foods with low GI (GI = 55% or less), foods with medium GI (GI = 56-69%) and foods with high GI (GI = 70% or more) (Foster-Powell *et al*., 2002).

The results in Table 2 and 3 shows the glycemic index and glycemic load of pulses respectively. The mean glycemic index of pulses namely chickpea, chana dal, kidney bean, mash bean, mung bean and peas were 36, 13, 32, 43, 42 and 25 respectively. Maximum glycemic index (43) was recorded for mash bean while minimum glycemic index (13) was recoded for chana dhal. Similarly the mean glycemic loads of these pulses were 11, 4, 8, 11, 7 and 2 respectively. Maximum value (11) was recorded for both chickpea and mash bean while minimum glycemic load (2) was recorded for peas dry. The results of the study agree with a previous study conducted by Foster-Powell *et al*. (2002).

The data indicated that all the pulses studied have low glycemic indices and glycemic loads i.e. below 55. Jenkins *et al*. (1980) and Holt *et al*. (1979) proposed that physical factors like dietary fiber and its viscosity, high unabsorbable carbohydrate contents and delay gastric empting are responsible for the low glycemic indices and glycemic loads of pulses.

The glycemic index variation between individuals fed with these pulses namely chickpea, chana dal, kidney bean, mash bean, mung bean and peas were 13, 14, 9, 5, 9 and 15 percents respectively while the glycemic load variation between individuals were 9, 25, 12, 9, 14 and 47 percents respectively. Wolever *et al*. (2003) in a previous study stated that individuals differ significantly

Table 1: Anthropometry of the participants

Parameter	Group I	Group II	Group III	Group I	Group V	Group VI
Age (years)	22±1	22±2	22±2	24±2	21±2	23±2
Height (cm)	172±2	170±3	172±2	172±1	168±2	168±1
Weight (kg)	68±6	64±11	65±4	67±7	60±8	64±4
BMI (kg/m^2)	24±2	23±2	23±2	23±2	22±2	24±1

Figures in the column 2-6 are the means and standard deviations of 7 individuals

Table 2: Glycemic Index and GI Variation Between Individuals

Pulses	Glycemic Index	CV
Chick pea	36±5	13
Chana dal	13±2	14
Kidney bean	32±3	9
Mash bean	43±2	5
Mung bean	42±4	9
Peas	25±4	15

Table 3: Glycemic Load and GL Variation Between Individuals

Pulses	Glycemic Load	CV
Chick pea	11±1	9
Chana dal	4±1	25
Kidney bean	8±1	12
Mash bean	11±1	9
Mung bean	7±1	14
Peas	2±1	47

in their blood glucose response to the same food depending upon certain factors particularly BMI, therefore same food have different glycemic index and glycemic load for different individuals.

From the results of the study it was concluded that pulses have low glycemic index and glycemic load, hence could be safely used in the diet of diabetic and obese patients.

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