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DETERMINATION OF GLYCEMIC INDICES AND GLYCEMIC LOADS OF VARIOUS TYPES OF CEREAL FOODS

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ABSTRACT

Glycemic indicies (GI) and glycemic loads (GL) of various cereal foods were determined. Forty nine male individuals of Agricultural University were recruited and were divided into seven groups, with seven students in each group. Rice, macronies were boiled in tape water before feeding to the individuals, salty biscuits, macaroni, namakparae and wonder bread were purchased from the local bakery shop. Maize and wheat bread and wheat chapatti were fed. 50g of glucose dissolved in 300 mL of water (as control diet) was given to each individual of all the groups on day first and amount of the boiled cereal foods equivalent to 50 g carbohydrate were given to each individual of the assigned group on the next day. Blood samples were collected at various time-points i.e., at 0 (fasting), 30, 60 and 120 minutes after ingestion of glucose and test foods. GI was determined from the area under curves of glucose concentration for reference and test foods. Glycemic load GL was determined by taking the percentage of the carbohydrate content in a typical serving multiplying by its GI. The GI values of rice, macaronis, wonder bread, salty biscuits, namakparae, maize bread and wheat chapatti were 66, 51, 64, 69, 45, 56 and 67, respectively. The GL values of rice, macaronis, wonder bread, salty biscuits, namakparae, maize bread and wheat chapatti were 25, 24, 9, 13, 8, 17 and 20, respectively. The results of the study indicated that cereal based foods have higher GI and GL and hence could be used with precaution in the diet of patients with hyperglycemic complications.

Keywords: glycemic load, glycemic index, cereal food.

INTRODUCTION

Estimation of dietary glycemic index (GI) and glycemic load (GL) generated a challenge in nutritional epidemiology. The wide variation of GI/GL association with health outcome may have because of methodological issues. (Lin *et al*., 2012). For describing the quality and quantity of carbohydrate the concept of GI and GL was developed. It has been established that each food has its own value of GI that individuals share common GI value for different foods, and that food GI is able to predict an individual immediate or long-term responses to a single food or a realistic mixed meal using insulinenmia, glycemia and insulin indicators (Atkinson *et al*., 2008).

The clinical application of GI/GL is still debatable topic for many scientisitc because of the confounding effect of fats, protein and other chemicals. Although several studies showed that GI of the food showed the GI of the complete meal having negligible effects of fats and protein when consumed in usual dietary amounts (Brand-miller and Wolever, 2005). Despite of these debates based on sufficient epidemiologic studies GI/GL remains interested topic for research for planning of many dietary interventions.

The most popular approaches to treat hyperglycemic complications are the drug and dietary therapy. Drug therapy is the most common approach but is costly and has numerous unavoidable side effects. The dietary therapy is the most natural, economic and more feasible. Proper dietary intake can stop the incidence of the disease and even can reduce the severity of existing cases. The food quality and diabetes mellitus has close association with each other (Khan *et al*., 1990). Although, there is no official diabetic diet (Ferri, 2004) but as a general principle, a diabetic diet is one that balances calories, exercise and medication with blood glucose levels.

The concept of glycemic index (GI) provides a way to rank carbohydrate-rich foods according to the blood glucose response following their intake. The GI calculated by measuring the incremental area under the blood glucose curve following ingestion of a test food (glucose or white bread) providing 50 g of carbohydrate, compared with the area under the blood glucose curve following an equal carbohydrate intake from the reference food. All tests are conducted after an overnight fast (Burke *et al*., 1998).

Glycemic Load (GL) refines the concept of GI to quantify the impact that a carbohydrate-containing meal or a single food eaten in a "normal" portion has on blood sugar (Ebbeling *et al*., 2001).

To the best of our knowledge, there is scarcity of research work and data on the GI and GL of our local foods. Cereal and cereal products are one of our staple foods consumed in large quantities on daily basis. In the absence of information on the blood glucose response of these foods, the physicians and dietitians find it difficult to suggest diets to patients with symptoms of hyperglycemia. This research study was designed to determine the GI of some common cereal foods. It is anticipated that the findings of the study will be of great use to the solution of this problem and health professionals will benefit from it.

METHODS AND MATERIALS

Study locale and subjects

The study was conducted in Peshawar, Khyber Pakhtunkhwa (KPK) Pakistan. All the analyses were done in the main Laboratory of Department of Human, KPK Agricultural University, Peshawar. The Adult male university's employees and students were the volunteers of the study. They were of age group from 18-42 years. The inclusion criteria were to select subjects with no present medical complaints and with no recent past history of chronic disease. Anthropometric measurements (weight and height) of all individuals were taken following the established protocols.

Research diets

A total of 7 dishes were studied for their GI values. Seven cereal-based dishes were studied for their glycemic indices and glycemic loads. They were including rice, wheat (wonder bread and sada roti), maize, macaronis, namakparae and salty biscuits. Rice (Basmati) and macaronis were prepared by boiling in water and adding 1-2 tea spoon oil, salt according to the taste. Namakparae and salty biscuits were brought from bakery wonder bread. Recepies for these dishes were calculated by keeping 50gm of carbohydrate in each one portion of dish.

Experimental protocol

Subjects grouping

The subjects were randomly divided in 7 groups, with each group having 7 individuals. However, individual reshuffling and adjustment were made between the groups to ensure that each group had subjects with relatively similar parameters of age, weight, and BMI etc.

Feeding of the dishes

The subjects of the study were instructed to report the main laboratory of Department of Human Nutrition early in the morning after a complete over-night fast (at least 8-10 hrs) one day before the start of the experiment. All participants were explained the purpose and other details of the study. They reported for two consecutive days. On day first, they were given the food assigned to the particular group. Blood was collected according to the study protocol on these two days.

Blood collection and analysis

Four blood samples were collected from each individual on each day at various time points. The first blood was taken while the individuals were fasting (0 min or fasting blood), followed by second, third and fourth blood samples at 30, 60 and 120 minutes, respectively, after the ingestion of foods. Blood serum was separated according to the standard procedure and was frozen until analyzed. Glucose was determined by the enzymatic colorimetric method of Trinder (1969). Microlab 300 and Elitech Kit were used. In this method, the enzymatic reaction is in two steps. In the first step, glucose is oxidized to gluconic acid and hydrogen peroxide in the presence of glucose oxidase enzyme. In the second step, red quinone is formed in the presence of peroxidase enzyme. Reading was given automatically by the microlab 300. All the analyses were done in single.

Calculation of glycemic index

The GI was calculated by the method of Jenkins *et al*. (1981). The values of blood glucose were plotted against time. For each person, the area under his 3hrs blood glucose response (glucose AUC) and for the food eaten was then being measured. The glycemic index value for the test food was then being calculated for each person by dividing their glucose AUC for the test food by their glucose AUC for the reference food. The final glycemic index value for the test food was the mean glycemic index value for the 7 people.

GI was calculated by the formula:

$$GI = \text{AUC for test food} \div \text{AUC for reference glucose} \times 100$$

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 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 load

GL refines the concept of GI to quantify the impact that a carbohydrate containing meal or a single food eaten in a normal portion has on blood sugar. The GL was calculated as the GI (%) multiplied by the grams of carbohydrate in the serving of food eaten. The GL for a meal would be the sum total of the GL of each food that is part of the mea
GL was calculated by the formula:

$$GL = \text{Net carbohydrates in a typical serving} \times GI \div 100$$

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Table-1. Characteristics of healthy individuals in the study.

Parameter	Group I (Mean±SD)	Group II (Mean±SD)	Group III (Mean±SD)	Group IV (Mean+ SD)	Group V (Mean± SD)	Group VI (Mean± SD)	Group VII (Mean± SD)
Age (years)	31.4±3	30± 7	25± 0.8	34±7	23± 1	23± 1	24±0.5
Height (m^2)	2.9±0.2	2.7± 0.1	2.8± 0.2	2.9± 0.3	2.8± 0.1	2.9± 0.1	2.9±0.1
Weight (kg)	67±13	65±6	62±10	72±9	66±4	73±7	74±10
BMI ($kg/m^{2)}$	23±4	25± 2	22± 2	25±3	23±1	25± 2	26±4

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

Statistical analysis

For analysis Microsoft Excel (MS-Excel), Two-way Analysis of Variance, least significance (LSD) and Randomized complete Block designs (RCBD) was used in order to know the variations between groups and also to know the variations in two directions) were used.

RESULTS

Table-2 shows the GI of cereal foods. The mean values of glycemic index for Rice (66), Macronies (51), Wonder bread (64), Salty biscuits (69), Namakparae (45), Maiz (56) and Wheat Chapatie (67) were recorded. The average coefficient of variation (a representation of the variability in responses between individuals) for Rice (16), Macronies (12), Wonder bread (13), Salty biscuits (6), Namakparae (21), Maiz (10) and Wheat Chapatie (4) were recorded.

Table-2. Glycemic index and GI variation between individuals.

Food items	Glycemic index	CV
Rice (boiled)	66±10	16
Macaronis (boiled	51±6	12
Wonder bread	64±8	13
Salty biscuits	69±4	6
Namakparae	45±9	21
Maize (bread)	56±5	10
Wheat (chapatti)	67±3	4

Table-3 shows the GL of pulses. The mean values of glycemic load for Rice (25), Macronies (24), Wonder bread (9), Salty biscuits (13), Namakparae (8), Maiz (17) and Wheat Chapatie (20) were recorded. The average coefficient of variation (a representation of the variability in responses between individuals) for Rice (15), Macronies (11), Wonder bread (12), Salty biscuits (5), Namakparae (21), Maiz (10) and Wheat chapatie (20) were recorded.

Table-3. Glycemic load and GL variation between individuals.

Food items	Glycemic load	CV
Rice (boiled)	25±4	15
Macaronis (boiled)	24±3	11
Wonder bread	9±1	12
Salty biscuits	13±4	5
Namakparae	8±2	21
Maize (bread)	17±2	10
Wheat (chapatti)	20±1	4

DISCUSSIONS

The concept of classification of foods according to their blood glucose response is emerging as one of the effective strategies to control the complications of hyperglycemia. Although, drug therapy is the most common approach but is costly and has side effects. The dietary therapy is the most natural, economic and more feasible. Proper dietary intake can stop the incidence of the disease and even can reduce the severity of existing cases. The food quality and diabetes mellitus has close association with each other (Khan *et al*., 1990).

People in industrialized countries base their diets on low GI and 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 theGI tables for the first time in 1995 and then a revised version in 2002. Tables of GI 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 of the present study (Tables 2-3) show the GI values of rice, macaronis, wonder bread, salty biscuits, namakparae, maize bread and wheat chapatti were 66, 51, 64, 69, 45, 56 and 67, respectively. Maximum value (69) was recorded for salty biscuits while minimum GI (45) was recorded for Namakparae. As evident, most of these foods have a medium GI value (i.e., GI=56-69) (Foster-Powell *et al*., 2002). The GL values of rice, macaronis, wonder bread, salty biscuits, namakparae, maize bread and wheat chapatti were 25, 24, 9, 13, 8, 17

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and 20, respectively. The maximum value (25) was recorded for rice while minimum glycemic load (8) was recorded for Namakparae. These data indicate that all the cereal foods investigated in current study have medium GI (Foster-Powell *et al*., 2002) and GL except Namakparae (GI=45; GL=8). The reason for relatively low value of GI may be the presence of higher amount of fat (cooking oil) added during its preparation (Khattak *et al*., 2006). Fat and protein reportedly show negative association with GI (Jenkins *et al*., 1981) on the virtue of their ability to delay gastric emptying and affect insulin secretion. Interestingly, however, their effect on GI is generally not seen unless relatively large amounts (about 30g of protein and 50g of fat per 50g carbohydrates) are added to a meal (Wolever and Bolognesi, 1996; Wolever *et al*., 1994).

The GI variation between individuals fed with these cereal foods namely rice, macaronis, wonder bread, salty biscuits, namakparae, maize bread and wheat chapatti were 16, 12, 13, 6, 21, 10 and 4, respectively while the GL variation between individuals of rice, macaronis, wonder bread, salty biscuits, namakparae, maize bread and wheat chapatti were 15, 11, 12, 5, 21, 10 and 4, respectively. The GI is influenced by the (1) type of food (including particle size, presence of intact grains, texture, and viscosity); (2) the degree of food processing and cooking; (3) the presence of fructose or lactose (both have a low GI; (4) the ratio of amylopectin and amylose in starch (amylose has a slower rate of digestion); starch-protein or starch-fat interactions; and the presence of anti nutrients such as phytates and lectins (Burke *et al*., 1998). Wolever *et al*. (2003) in a previous study stated that individuals differ significantly in their blood glucose response to the same food depending upon certain factors particularly BMI, therefore same food have different GI and GL for different individuals.

There are certain limitations of the present study: the main limitation is that female subjects could not be included due to technical reasons. There may be gender-based differences in GI and therefore, in future a separate study including both male and female individuals may add interesting results. Nevertheless, the results of the results of the current study show that cereal foods have high GI and GL, Hence could not be safely used in the diet of diabetic and obese patients.

REFERENCES

Burke L.M., G. R. Collier and M. Hargreaves M. 1998. The glycemic index - a new tool in sport nutrition. Int. J. Sport. Nutr. 8: 401-415.

Bruns W., D. Wagner and F.P. Taubert. 1989. Glycemic index and obesity. Am. J. Clin. Nutr. 76: 2815-2855.

Ebbeling C.B and D. S. Ludwig. 2001. Treating obesity in youth: should dietary glycemic load be a consideration. Adv. Pediatr. 48: 179-212.

Foster-Powell K., J. Miller, S. H. Holt and J. C. Brnad-Miller. 2002. International tables of glycemic index and glycemic loads values. Am. J. Clin. Nutr. 76: 5-56.

Ferri F.F. 2004. Diabetes mellitus. In: Ferri F.F. Practical guide to the care of the medical patient. St. Louis, MO: Mosby, Inc. 6: 267-268.

Gannon M.C., F.Q. Nuttall, P.A. Krezowski and C.J.S. Parker. 1986. The serum insulin and plasma glucose responses to milk and fruit products in type-2 (non-insulin-dependent) diabetic patients. Diabetologia. 29: 784-791.

Gibladi M and D. Perrier. 1982. Pharamacokinetics. 2nd Rev. Ed. Marcel Dekker, New York, USA. 24: 102-112.

Jenkins D.J.A., T. M. S. Wolever and R. T. Talyer. 1981. Glycemic index of foods: a physiological basis of carbohydrates exchange. Am. J. of Clin. Nutr. 34: 362-367.

Khan A., I. Ahmad and Z. M. Wazir. 1993. Epidemiological studies of diabetes mellitus in the North West Frontier Province of Pakistan-1. J. Med. Sci. 3, 3: 35-44.

Khan A., N.A. Bryden, M. M. Polansky and R. A. Anderson. 1990. Insulin potentiating factor and chromium content of selected foods and spices. Bio. Trace. Element. Res. 24: 183-188.

McCarty and P. Zimmet. 1997. Diabetes 1994-2010: global estimate and projections. Diabetes Care. 20: 1785-1790.

Raben A. 2002. Should obese patients be counseled to follow a low-glycemic diet? No. Obesity Reviews. 3: 245-256.

Robinson C.H., M. R. Lawler, W. L. Chenoweth and A. E. Cawick. 1986. Diabetes mellitus. In: Normal and theraputic nutrition..McMillan publishing Co. New York, USA. 17: 504-519.

Salmeron J., J.E. Manson, M.J. Stampfer, G.A. Colditz, A.L. Wing and W.C. Willett. 1997. Dietary fiber, glycemic load and risk of non-insulin-dependent diabetes mellitus in women. JAMA. 277: 472-477.

Trinder P. 1969. Ann. Clin., Biochem. 16: 24.

Wolever T.M., H.M. Vorster, I. Bjorck, J. Brand-Miller, F. Brighenti, J.I. Mann, D.D. Ramdath, Y. Granfeldt, S. Holt, T.L. Perry, C. Venter and W. Xiaomei. 2003. Determination of the glycemic index of foods: interlaboratory study. Eu J. Clin. Nutr. 57: 475-482.

Wolever TM and C. Bolognesi C. 1996. Prediction of glucose and insulin responses of normal subjects after consuming mixed meals varying in energy, protein, fat, carbohydrate and glycemic index. J. Nutr. 126(11): 2807-12.

Wolever T. M., P. M. Nguyen, J. L. Chiasson, J. A. Hunt, R. G. Josse and C. Palmason. 1994. Determinants of diet glycemic index calculated retrospectively from diet records of 342 individuals with non-insulin-dependent diabetes mellitus. Am J. Clin Nutr. 59(6): 1265-1269.

F.S. Atkinson, K. Foster-Powell and J.C. Brand-Miller. 2008. International tables of glycemic index and glycemic load values. Diabetes Care. 31(12): 2281-2283

J.C. Brand-Miller and T.M. Wolever. 2005. The use of glycaemic index tables to predict glycaemic index of breakfast meals. Br J. Nutr. 94(1): 133-134.