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Sweet Potato Glycemic Index in Relation to Serum Glucose Level in Human Participants

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ABSTRACT

The glycemic index (GI) is a useful method to educate the diabetics in better managing the disease. Several researchers identified its shortcomings of it being overly pessimistic and or optimistic. Despite GI weaknesses, the method faired better in explaining the rise and fall of blood glucose level with the intake of high or low glycemic carbohydrates. Thus, in this article, GI of sweet potato cultivars namely white star (Pakistan) and Beauregard (US) were estimated in a study enrolled 40 subjects (20 each normal & Diabetic) from Pakistan. The GI's were compared with that of glucose as control and Caiapo. Mean glycemic response for normal subjects was 100.28, 98.64, 98.12 and 101.32 for dehydrated white star, Glucose+Caiapo, Whit Star skin and dehydrated Beauregard, respectively. In case of diabetic subjects, the mean response of white star; Glucose+Caiapo; white star skin and Beauregard varied from 72.84; 68.03; 67.10 and 77.67, respectively. The white star skin index was lowest followed by glucose + Caiapo, dehydrated white star and Beauregard, respectively In summary, white star and its skin followed by Beauregard indicated blood glucose lowering effect on diabetic subjects. White star skin followed by Caiapo showed blood glucose reduction in normal subjects. Both metabolic and epidemiologic data indicated that substitution of high GI with low GI carbohydrates can reduce the risk of type-2 diabetes. This in turn will improve glycemic control and reduce hypoglycemic episodes among those treated with insulin.

Key Words: Glycemic index; Blood glucose level; Caiapo; White star; Beauregard

INTRODUCTION

The wide spread epidemic of diabetes mellitus (DM) has challenged physicians and nutritionists to explore ways and means to better manage this disease. The concept of glycemic index (GI) was established by Jenkins *et al.* (1988) to classify carbohydrate containing foods, depending on how fast they raise blood glucose level in the body. The GI was defined as the incremental area under the blood glucose response curve of a 50 g carbohydrate portion of a test food expressed as a percent of the response to the same amount of carbohydrate from a standard food taken by the same person (Jenkins *et al.*, 1981). A high response means that a person gets a massive increase in blood sugar level in contrary to small increase in sugar level due to low GI food (Patel et al., 2004). The index is a percent comparison against pure glucose which has the index of 100 (Jenkins *et al.*, 1981; Wolever *et al.*, 1987).

The relation among glycemic diets, low fiber intake and risk of non-insulin-dependent DM was observed by Salmeron *et al.* (1997). Later, Meyer *et al.* (2000) examined the relationship of intake of dietary fiber, dietary magnesium and the GI with the incidence of diabetes. For example, dietary carbohydrates may influence the development of type-2 (non-insulin-dependent) diabetes through effects on blood glucose and insulin concentrations.

The carbohydrate data were used as a basis for food exchange in controlling glycemia, but this system is not entirely appropriate because the same quantity of available carbohydrate in different foods can induce very different degrees of glycemic response. Therefore, an additional aid to food selection, the GI was introduced and has become the benchmark for classifying carbohydrates. The GI is a measure of how rapidly a particular food cause's blood sugar to rise compared with that of glucose. Although other aspects of diet may add to variation in glucose and insulin responses, the effect of these other sources of variation does not appear to seriously affect the validity of calculated GI values for mixed meals under real conditions. However, it is difficult to use in all situation because most foods do not consist solely of carbohydrate and being a ratio, GI does not refer directly to food quantity (Monro, 1999).

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The GI concept is an extension of the fiber hypothesis, suggesting that fiber consumption reduces the rate of nutrient influx from the gut. The GI has particular relevance to those chronic western diseases associated with central obesity and insulin resistance. Early studies showed that starchy carbohydrate foods have very different effects on postprandial blood glucose and insulin responses in healthy and diabetic subjects, depending on the rate of gastric emptying as well as digestion and absorption of carbohydrates from small intestine (Jenkins *et al*., 1987). The food factors affecting the GI of food and meal are texture, cellular structure, starch, gel, organic acids, amylase inhibitor and fructose/glucose ratio (Bjorck and Elmstahl, 2000).

Despite inconsistencies in the data, sufficient, positive findings have emerged to suggest that the dietary GI is of potential importance in the treatment and prevention of chronic diseases. Dietary GI is an indicator of the ability of the carbohydrate to raise blood glucose level and glycemic load (Cathrine *et al*., 2005). The product of GI and carbohydrate intake, have been positively related to risk of coronary heart disease. The findings from a nationally representative sample of US adults suggest that high dietary GI and high glycemic load are associated with a lower concentration of plasma HDL (Ford & Liu, 2001). Different researchers have used varying blood sampling methods, time for measuring glucose response area and control food. The divergence in methodologies restricts the comparison of results across studies. Nevertheless the definition and methodology recently used by (FAO/WHO, 1998) have been considered as internationally recognized standards.

The dietary GI concept suggests a possible role for the rate of carbohydrate digestion in the prevention and treatment of chronic disease, including those diseases that have been highlighted in the dietary fiber hypothesis and are now associated with insulin resistance. In order to take a closer look at high carbohydrate foods and glycemic response the objective of this study was to compare GI of sweet potato cultivars Caiapo coupled with glucose (as control) in diabetic and normal subjects in Pakistan in order to achieve the conclusive approach against the disease.

MATERIALS AND METHODS

The participatory rapid appraisal (PRA) was conducted on 20 each of diabetic and normal participants from the city and suburbs of Faisalabad. The subjects were briefed about the objectives of the study and also apprised about the process of blood sampling and intake of various treatments of sweet potato. The participants were also briefed about the protocol of the experiments, time involved and other pertinent reasons. The researcher obtained prior approval from the University institutional review board for human subject for research. Dehydrated whole sweet potato cultivars namely Beauregard from United States and white star from Pakistan were used in the study; however, skin of white star alone was also used as a separate treatment in the efficacy studies. Five treatments including glucose as control were given to 40 subjects (20 each normal & diabetic subjects). The treatments were: glucose (T_1) as control, dehydrated white star (T_2), glucose+Caiapo (T_3); white star skin (T_4) and dehydrated Beauregard (T_5) Each participant consumed one of their assigned samples (50 g carbohydrates per serving) on every alternate day. This study provides information's on Pakistani and US cultivars and showed comparison with caiapo (Ludvik *et al*., 2003) from Japanese cultivar.

A number of different methods have been used to calculate the area under the blood glucose curve. For most cases, GI data were the area under the curve that has been calculated as the incremental area under the blood glucose response curve (IAUC), ignoring the area beneath the fasting concentration. This can be calculated geometrically by applying the trapezoid rule. When a blood glucose value falls below the baseline, only the area above the fasting level is included. The FAO/WHO, 1998 methodology to estimate the GI is as follows:

$$GI = IAUC_t \div IAUC_c * 100$$

Where $IAUC_t$: Incremental area under the postprandial glucose response curve due to treatment (T); $IAUC_c$: Incremental area under the postprandial glucose response curve due to control (c).

The portion of food tested should contain 50 g of available carbohydrate. In practice, glycemic carbohydrate is often measured as total carbohydrate minus dietary fiber, as determined by the AOAC method. Although a valuable tool, especially for diabetics, the GI confines itself to measuring a standard amount of carbohydrate (50 g). The GI of a food is not based on commonly consumed portion-sizes of foods. Instead, GI is measured by giving volunteers a portion size sufficient to contain 50 g of useable carbohydrate. Therefore, the portion size of each GI tested food varies according to how much carbohydrate it contains but ultimately 50 g of carbohydrate equivalent was used.

The GI index of a food is measured under strict conditions (Luscombe *et al.*, 1999). Portions of a carbohydrate food are fed to a group of volunteers whose blood is then tested at regular intervals, over 2 h, in order to check blood glucose levels (Jenkins *et al*., 1981, 2002; Wolever *et al.*, 1991; FAO/WHO, 1998).

The area under the curve (AUC) can be established by the Mann-Whitney-U-test, but due to limitation of data and interpretational ease, (FAO/WHO, 1998) commonly used methodology was applied here. Basically a polynomial curve was drawn from the data. The area can be drawn through estimation of the integral or is estimated geometrically through the triangle and trapezoidal rule. The later was used to derive the area under the curve in this study. Excel spreadsheet analysis was developed to estimate the area under the curve for individual subjects. The method is illustrated in Fig. 1. The spreadsheet assay provides the

Table I. Glycemic Response of normal participants of various Treatments

Subjects	White star	Glucose +Caiapo	White star Skin	Beauregard
N13	102.66	105.07	98.90	105.08
N15	112.22	103.27	97.89	104.18
N16	100.95	101.27	99.16	102.80
N17	107.20	100.27	96.93	105.10
N18	101.82	99.40	99.93	106.18
N19	100.00	105.18	105.86	97.22
N111	100.94	87.21	110.81	91.10
N113	101.13	98.52	99.93	101.20
N114	103.61	101.69	95.90	108.04
N115	106.34	90.50	92.46	115.01
N116	94.02	109.31	99.00	94.97
N119	110.79	106.27	80.69	102.24
N120	103.49	97.23	102.64	100.83
N122	90.89	79.89	103.99	87.41
N123	98.37	92.81	100.86	97.53
N125	101.30	100.38	91.45	110.78
N126	84.72	78.01	98.32	86.17
N127	98.51	100.81	84.90	116.04
N128	86.38	101.86	100.93	85.58
N129	106.34	80.90	100.37	106.18
Mean	100.28	98.64	98.12	101.32
SD	7.22	9.09	6.81	9.14
CV	0.07	0.09	0.07	0.09

Table II. Glycemic Response of Diabetic subjects for various Treatments in Faisalabad

Subjects	White star	Glucose +Caiapo	White star Skin	Beauregard
D11	81.10	114.05	88.85	91.28
D12	72.20	94.67	93.57	77.16
D13	79.42	50.98	43.36	65.62
D14	91.61	51.26	69.32	64.62
D17	52.95	59.81	38.62	65.27
D112	79.48	58.16	43.29	65.56
D113	56.28	56.12	63.00	89.34
D114	54.88	94.81	77.55	70.77
D115	97.00	53.35	62.53	94.30
D116	83.19	105.95	77.00	91.40
D117	103.16	63.96	61.37	63.15
D118	63.28	43.42	103.44	61.18
D119	102.39	63.25	30.20	61.22
D120	59.33	69.98	54.50	108.86
D121	64.09	63.48	87.77	73.02
D122	74.00	63.01	89.29	84.40
D123	44.31	62.53	60.43	73.32
D124	74.74	62.07	56.45	88.81
D125	50.58	61.61	76.03	86.50
D126	50.57	61.80	76.45	86.80
Mean	72.84	68.03	67.19	77.67
SD	17.72	19.55	20.27	13.87
CV	0.24	0.29	0.30	0.18

GI of both diabetic and normal subjects.

RESULTS AND DISCUSSION

Analytical results of glycemic response. The glycemic response of normal subjects was explored (Table I) and further explicated in Fig. 2. The mean values of GI were 100.28, 98.64, 98.12 and 101.32 for dehydrated white star, glucose+Caiapo, whit Star skin and dehydrated Beauregard, respectively. The GI of normal subjects was close to the scale 100 and provides inconclusive evidence. The figure

Fig. 1. Polynomial curve from the experimental data

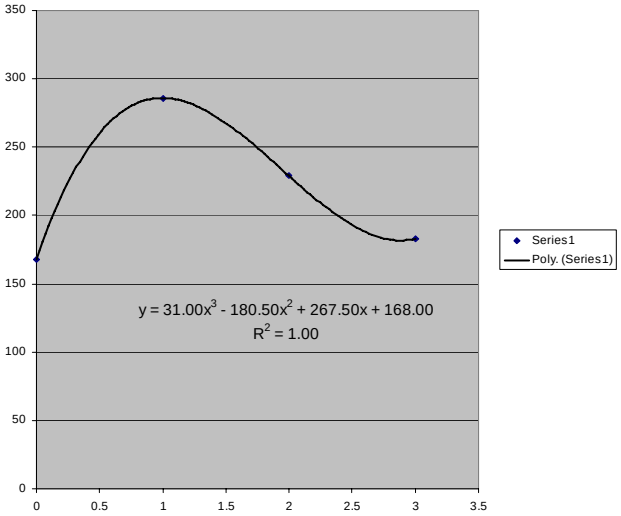


Fig. 2. Glycedmic index of blood glucose with various treatment in normal subjects in Faisalabad

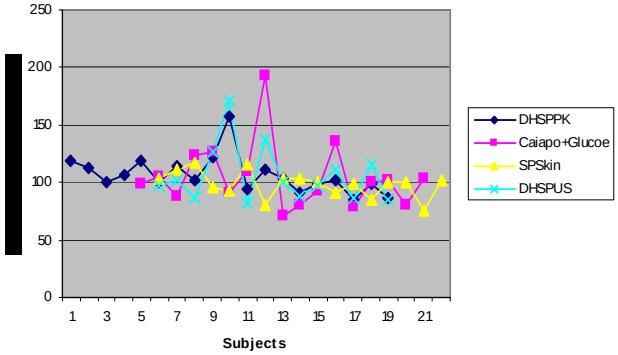
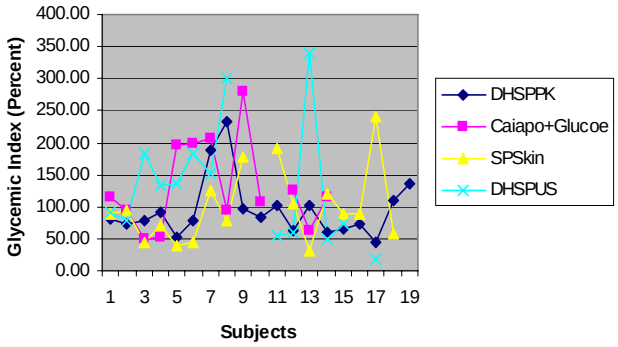


Fig. 3. Glycedmic index of various treatments of Diabetic subjects in Faisalabad



showed that white star skin and glucose+Caiapo showed similar lowering trends and the other two treatments were higher than these treatments. The mean difference was insignificant and coefficient of variation was very small (7-9%). The usefulness of GI for normal subjects was unclear and needs further research. The results of the study are consistent with Arvidsson-Lerner *et al.* (2004). In a group study, Kiens and Richter (1996) did not find an increase in

insulin resistance in 7 healthy, lean young men after the subjects had consumed a high GI diet. In addition to the small sample size, the low underlying degree of insulin resistance in this group of lean young men may have contributed to the lack of an observed effect. However, another explanation for the abundance of inconclusive studies is that recruitment of volunteers for nutrition studies is notoriously difficult and many studies draw a young or a highly health-oriented population. These groups are likely to be physically active was noted in studies. Given the strength of the positive influence of physical exertion on insulin sensitivity, such persons are likely to be resistant to the negative effects of diet (Daly *et al*., 2003; Andreas et al., 2004). However, this does suggest that the promotion of physical activity may have a greater influence on insulin sensitivity than does diet (Andreas *et al*., 2004). The estimation of GI needs further refinements at shorter time intervals i.e. 30, 60, 90 and for a longer period 180 min to give a clearer picture.

The Glycemic response of diabetic subjects is shown in Table II and also depicted in Fig. 3. The mean indices of white star; Glucose+Caiapo; white star Skin and Beauregard varied from 72.84; 68.03; 67.10 and 77.67, respectively. The white star skin index was lowest followed by glucose+Caiapo, dehydrated white star and Beauregard, respectively. The GI showed that white star skin had a greater lowering response on the glucose level and treatment T_3 (Glucose+Caiapo) trailed behind the skin followed by white star and Beauregard (Fig. 2). Because the skin of sweet potato is more fibrous, contains glycoproteins as identified by electrophoresis and is abundant in dietary fiber, it showed better performance in lowering blood glucose levels. The current results are supported by Ludvik *et al*. (2002) who found the acidic Glycoprotein (Caiapo) in sweet potato skin and reported the first results. The current results were consistent with a number of studies (Ludvik *et al*., 2002, 2003 & 2004; Bjorck and Elmstahl, 2003).

CONCLUSION

The prevalence and exponential increase of diabetes across the globe has intrigued the scientific community to look into novel ways to manage diabetes. The GI is a useful tool in showing impact of foods on blood glucose response. The GI method of classifying carbohydrates according to their effect on blood-glucose, replaces the older method of classifying carbohydrates according to their chemical structure. In this study GI of various sweet potato cultivars (white star, Beauregard & white star skin) were developed and compared with Caiapo and glucose as control on 40 participants (20 each normal & diabetic).

It was shown that, white star skin and white star followed by Beauregard have blood glucose lowering effect on diabetic's subjects while in normal subjects only Whit Star skin followed by Caiapo had an effect. The results of the present study corroborated with most of the aforementioned studies. However the evidence on healthy subjects remained inconclusive and demands further study. There is also a need to conduct long term trials on both the cultivars and its skin to determine. It is also suggested that the blood should be drawn at 30, 60, 90 and 180 min intervals to determine a clearer picture of the effects.

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