ISSN 2250-3153

Evaluation of Fiber Enriched Biscuits as a Healthy Snack

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Abstract- The increase in diabetic population of the world is among the top ten causes of death, with diabetes always high on the list of causes of death. The eating habits and patterns of the diabetic patients are the main causes for pour glycemic control. It is reported in epidemiological studies that high fiber dietary intake can significantly reduce the incidence of diabetes. The study was undertaken to evaluate acceptability and glycemic response of bottle gourd pulp powder (BGPP) enriched biscuits against standard wheat biscuits. Normal healthy subjects (n=7) and prediabetic subjects (n=7) were included in the study. Blood glucose values at 0, 30, 60, 90 & 120 minutes indicated significant difference in incremental area under the curve (IAUC) of glucose and two varieties of biscuits in prediabetic subjects as well as in normal healthy subjects. The mean IAUC of BGPP enriched Biscuits (p=<0.001) was significantly lower than that of glucose and Wheat flour Biscuits (p=<0.001) in normal as well as prediabetic subjects.

Index Terms- Fiber enrichment, diabetes, glycemic response, glycemic index

I. INTRODUCTION

Diabetes mellitus describes a metabolic disorder of multiple aetiology characterized by chronic hyperglycemia with disturbance of carbohydrate, fat and protein metabolism caused by defects in insulin secretion, insulin action or both. The effects of diabetes mellitus include long–term damage, dysfunction and failure of various organs **(Liu S, 1999).**

The incidence of diabetes has been increasing, and this epidemic may continue to escalate over the next decade, especially in minorities. For >30 years, researchers have been interested in potential beneficial effects of dietary fiber intake among individuals with diabetes. Many clinical studies have investigated the effect of high-fiber diets in persons with diabetes. More recently, the role of dietary fiber in the prevention of diabetes has received attention.**(Montonen J 2003, Lairon D 2005**, **Petruzziello L 2006, Brown L 1999, Keenam 2002, Anderson JW 2004).** Fiber, particularly soluble fiber, has repeatedly been shown to decrease postprandial glucose and insulin concentrations both in individuals with diabetes and in those without diabetes **(Whelton SP 2005).**

A generous intake of dietary fiber reduces risk for developing the following diseases: coronary heart disease, stroke, **(Marangoni F 2008)** hypertension, diabetes, **(Meyer KA 2000)** obesity, and certain gastrointestinal Disorders **(Karhunen LJ 2010)** Furthermore, increased consumption of dietary fiber improves serum lipid concentrations, lowers blood pressure, improves blood glucose control in diabetes, promotes regularity, aids in weight loss, and appears to improve immune function. Dietary fiber, found in all plant-based foods, plays an essential role in human health.

Fiber has been studied in the treatment of diabetes for many years because increased fiber content decreases the glycemic index of foods. The glycemic index and glycemic load have been proposed as method of ranking of foods on the basis of the incremental blood glucose response they produce for a given amount of carbohydrate. The theory, then, is that the decreased glycemic index would lead to smaller increases in blood glucose, and thus reduced blood glucose **(Ostman EM 2006)** Although high fiber intake has been linked to a decreased risk of diabetes, the evidence on fiber intake and control of diabetes is mixed. Specifically, many of the studies focused on fiber intake and glycemic control are small and have conflicting results; some studies show an improvement in diabetes control and others show no improvement. The study was undertaken to evaluate acceptability and glycemic response of Biscuits supplemented with oven dry bottle gourd pulp powder (BGPP).

II. MATERIAL AND METHOD

In this study two products were subjected to organoleptic evaluation for various attributes like appearance, color, texture, taste and softness. Acceptibility was determine by using 9 point hedonic scale for orgenoleptic qualities .The most acceptable combination which obtained maximum score for organoleptic quality was tested against glucose to evaluate post meal glycemic response.14 subjects (7 normal and 7 prediabetic,) were selected for the study. The age group was 40-60 years. The subjects were explained the study protocol and a written consent regarding voluntary participation was obtained. The study evaluated blood glucose response after oral glucose tolerance test and administration of the test foods. In the phase I an oral glucose tolerance test (GTT) was performed with 25 gm glucose load on day 1 followed by administration of several equicarbohydrate (25gm, based on food composition tables ICMR) different test food combinations for subsequent 6 days to the selected 7 normal subjects and 7 IGT subjects.

Determination of Glycemic Index: Subjects were asked to attend the testing session after a 10-12 hour overnight fast. The subjects were instructed not to consume unusually large meals, drink alcohol or exercise vigorously on the previous day, and to avoid cycling or walking to the laboratory. On the first day subjects were given the standard or reference carbohydrate i.e. 25g glucose dissolved in 100 ml of water. Blood glucose level was measured in capillary whole blood obtained by finger prick **(Accu-Chek Roche Diagnostics India Pvt Ltd, Mumbai)** at 0 ,30, 60, 90 and 120 minutes. Blood glucose curve and the

incremental area under the curve (IAUC) was calculated by the trapezoidal rule **(Gibaldi.M and D.Perrier, 1982).**

Equicarbohydrate quantity of varieties of food combinations (25gms carbohydrates) were used for testing against the reference carbohydrate (glucose) on the following two consecutive days. The food formulations chosen were wheat biscuits and wheat biscuits supplemented with BGPP. Similar procedure was repeated to calculate IAUC.

Calculation of Glycemic Index: The Glycemic Index (GI) values were calculated by the method of (**Wolever, 1990)**. The glycemic index was calculated by dividing the IAUC for the test food by the IAUC for the reference food and multiplying by 100 for each individual. The following formula was used:

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

IAUC – Incremental Area Under the blood glucose response Curve.

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

Glycemic Index range:

Foods with low GI (GI= 55% or less), foods with medium GI (GI= 69%) and foods with high GI (GI=70% or more) **(Foster-Powell, 2002).**

The GTT curve obtained for the test food combination showing significant reduction in mean peak rise was considered as dietary therapy/medical nutrition therapy.

Statistical Analysis: The data was analyzed using sigma stats package (3.5).

III. Results (Table & Graphs)

Table 1 Blood glucose responses in normal subjects following glucose and products

Test & reference food	Time intervals						
	0	30	60	90	120	IAUC	GI
Glucose	99.3	167.0	187.1	144.1	105.1	338.6	-
BGPP enriched Biscuits (wh 80% + Bgpp20%)	100.3	112.7	120.7	110.1	103.6	73.75	21.7
Wheat Biscuits (wh 100%)	99.6	114.0	125.0	112.4	103.9	91.33	26.97

Note: - Values given mg/dl

Wh=Wheat Flour

Bgpp= Bottel Gourd pulp Fiber

Table 2 Blood glucose responses in prediabetic subjects following glucose or products

Test & reference food	Time intervals						
	0	30	60	90	120	IAUC	GI
Glucose	116.7	187.1	196.6	170.4	137.7	357.5	-
BGPP enriched Biscuits (wh 80%+ bgpp20%)	118.4	130.3	139.0	133.3	120.4	80.6	22.5
Wheat Biscuits (wh 100%)	118	133.6	143.6	135.3	128.6	106.3	29.7

Note: - Values given mg/dl

Wh=Wheat Flour

Bgpp= Bottel Gourd pulp Fiber

Table 3 Percent Reduction in baseline to peak

Test & reference foods	Normal healthy subjects		Prediabetic subjects	
	Baseline to peak	Peak to endpoint	Baseline to peak	Peak to endpoint
Glucose	46.9	43.8	40.6	29.9
BGPP enriched Biscuits (wh 80%+ bgpp20%)	16.9	14.2	14.8	13.4
Wheat biscuits (wh 100%)	20.3	16.9	17.8	10.4

Wh=Wheat Flour
Bgpp= Bottel Gourd pulp Fiber

IV. RESULT

The blood glucose curves of normal healthy subjects & prediabetic subjects after intake of 25 g glucose increased in the time period 0 to 60 minute and reached a peak value at 60 minute and then decreased progressively till the end of the observation period of 2 hours. Whereas the curve plotted for the products indicated the peak at 60 minutes there after gradually decreased in 2 hours period.

Products were observed for their peak value i.e. increment from baseline values, as well as decrement from peak value in normal and prediabetic subjects. In normal subjects increment of 46.9% at peak was seen and decrease of 43.8% was indicated from peak value in case of glucose. BGPP enriched Biscuits and Wheat Flour Biscuits indicated respective increment of 16.9%, and 20.3% at peak followed by decrement of 14.2% and 16.9%.

In pridiabetic subjects glucose was seen to have 40.6% increment and 29.9% decrement. Administration of , BGPP enriched Biscuits and Wheat Flour Biscuits exhibited 14.8% and 17.8% increment respectively from their baseline values and 13.4% and 10.4% decrease from their peak values.

The mean plasma glucose responses after the consumption of glucose and the test foods in normal subjects are shown in Table 1. The mean IAUC of glucose was found to be 338.6 mg/dl. Mean IAUC of BGPP enriched Biscuits was noted to be 73.75 mg/dl and Wheat Flour Biscuits 91.33 mg/dl respectively. The mean IAUC of BGPP enriched Biscuits ($p=<0.001$) was significantly lower then that of glucose and Wheat flour Biscuits ($p=<0.001$)

The mean plasma glucose responses after the consumption of glucose and the test foods in prediabetic subjects are shown in Table 2. The mean IAUC of glucose was 357.5 mg/dl. IAUC of BGPP enriched Biscuits was 80.6 mg/dl followed by 106.3 mg/dl of Wheat flour Biscuit. The mean IAUC of BGPP enriched Biscuits ($p=<0.001$) was significantly lower then that of glucose and Wheat flour Biscuits ($p=<0.001$).

V. DISCUSION

The present study demonstrated that the highly BGPP added to biscuits had benefits to its consumers. It increased dietary fiber intake and reduced the glycemic index value of the snack to a similar extent in both healthy and diabetic participants. Soluble dietary fibers have been shown to alter food texture, structure, and viscosity, and, therefore, the rate of starch degradation and digestion **(Brennan CS. 2005),** which is related to the regulation of postprandial glucose levels. BGPP is likely to be a mixture of soluble and insoluble fiber thus the effect on glycemic level could be attributed more to soluble fiber in it. Using the classification of Brand-Miller**.** Three types of the biscuits were found to have a low glycemic index but BGPP enriched biscuit indicating lowest glycemic index among all. BGPP enriched biscuits could be classified as a "low glycemic index" food (glycemic index ≤55), snack. The decreased glycemic index would lead to smaller increases in blood glucose, and thus reduced blood glucose and HbA1c levels. Although high fiber intake has been linked to a decreased risk of diabetes has been reported by **(Meyer KA, 2000, Wannamethee SG, 2009)** Results obtained from the present study indicate that BGPP supplemented biscuits may serve as health improving snack.

VI. CONCLUSION

BGPP is a very palatable fiber when added to a snack, which is able to reduce the glycemic response to a similar extent in both healthy participants and individuals with impaired glucose tolerance. Biscuits with low GI may potentially be a useful replacement of high GI snack foods in the diet.

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