Original Article

International Journal of Food, Nutrition and Dietetics
Volume 4 Number 1, January - April 2016
DOI: http://dx.doi.org/10.21088/ijfnd.2322.0775.4116.1

Clinical Evaluation of Wheat Bran Bread for Dietary Management of Diabetics Through Glycemic Index

Kamaliya Keshav B.*, Rema Subhash**

Abstract

The incidence of Diabetic Mellitus (DM) is increasing at an alarming rate especially in developing countries like India. Bakery products are highly popular and lend themselves easily for modification into therapeutic products. Therefore, the present study was planned to develop high fiber (wheat bran) bread and testing it for possible use in the dietary management. Wheat bran bread (WBB) was developed in the laboratorythrough various trials. Bread prepared with maximum 7.5 % replacement found acceptable sensorily and used for further study. A total of 25 subjects (20 type II diabetics and 5 non diabetics) of average age 53 years were fed white bread (WB) and WBB (approximately 5 slices, weighing 97.84 g for WB and 104.40 g for WBB, providing 50 g carbohydrate) on 2 different days. Blood glucose levels were determined at fasting, 60, 120 and 180 min. The glucose increments were estimated by area under the curve (AUC) and expressed as GI. The GI for non-diabetics was found to be significantly lower (69.16 $\pm$ 1.75) when compared to diabetics (77.04 $\pm$ 3.84). Similar trend was observed in females (75.05 $\pm$ 9.50) when compared to males (77.70 $\pm$ 4.24) within the diabetic group. The average GL calculated for the WBB was found to be 38.20 g for diabetics and 40.97g for non diabetics. It may be concluded that the bread prepared by supplementing 7.5% wheat bran is acceptable and could be useful in the dietary management of diabetics as well as healthy subjects.

Keyword: Glycemic Index; Glycemic Load; Diabetes; Health Food; Bakery Products; Bread; Wheat Bran; High Fiber Food; Sensory Evaluation; Blood Glucose.

Introduction

WHO reports that there are over 175 million "people with diabetes" in the world and the number is expected to increase to well over 350 million people by the year 2025 (Bailey, 2004). In India, the figure will be 57 million. At present the cases of cardiac heart diseases are nearly 15 million in our country (Bamji 2003). Anderson and Akanji (1993) examined the results of 53 studies and concluded that fiber supplements and high fiber diets improve glycemic control, increase sensitivity to insulin, lower serum lipids, decrease blood pressure and assist in weight management. Changes in the socio-economic conditions have increased the domestic demand and consumption of bakery products. The industry is presently growing at about 10 % p.a. in our country. Normally bakery products are calorie dense and bearing negligible fiber and therefore, continuous consumption of these may lead to major chronic diseases like obesity, hypercholestremia, diabetes mellitus and hypertension etc. (Kamaliya, 2005). Increasing health consciousness and easy modification of bakery products has led to their development as therapeutic products suitable to individual needs. Matz (1996) has suggested the use of bran to increase the fiber content in bakery products. The idea of classifying carbohydrates according to their effect on blood glucose concentrations, i.e. glycemic index(GI), was first proposed in 1980 (Wolver et al. 1991). This concept was developed to predict postprandial increases in blood glucose concentration in patients (Bell and Sears 2003).The glycemic load (GL) represents the qual-ity of the carbohydrate containing food (i.e. GI) and the quantity con-sumed of that food (weight). As a result,

Author's Affiliation: *Principal, Polytechnic in Food Science and Home Economics, Faculty of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand – 388110. India. **Professor, P. G. Department of Home Science, Saradar Patel University, Vallabhavidyanagar – 388 120, India.

Corresponding Author: Kamaliya Keshav B., Principal, Polytechnic in Food Science and Home Economics, Faculty of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand – 388110. India.
E-mail: kb_kamaliya@yahoo.co.in

the GL is a better predictor of the impact of a carbohydrate containing food on postpran-dial insulin secretion (Bell and Sears 2003). The present study was planned for testing high fiber bread prepared using wheat bran for its possible use in the dietary management of diabetics by estimating GI and GL.

Materials and Methods

Product Development

Wheat bran bread was developed in the laboratory. For that, various trials of bread preparation were carried out by replacing white flour with wheat bran from 3 to 15 % and evaluated using a 9 point hedonic scale (8 judges X 3 replications) followed by a composite scoring test for the bread prepared by replacing 7.5%, 9% and 10% white flour with wheat bran (by a panel of experts – 8 judges X 3 replications) on the day of preparation and after 24 hrs. White bread was prepared using the commercial formula (i.e. 0 % wheat bran) (Kamaliya and Kamaliya, 2001).The bread prepared using 7.5% replacement of WB, ranked highest in all the sensory characteristics for both the days thus it was considered as the WBB for subsequent study. The WBB contains about four and half times more fiber as compared to WB. To assess the real effect of WBB on GI, feeding trials of both the breads were carried out on human subjects as depicted out in Figure 1.

Subject Selection

To check the beneficial affect of WBB on diabetes using GI, 25 subjects were selected through purposive random sampling technique. For this local doctors were contacted and requested to provide a list of diabetic patients. They were also requested to contact and convince the patient to become volunteer for the study. The patients were than individually contacted and convinced to become volunteers. A few non-diabetic subjects were also contacted and convinced for the same purpose. In all a total of 52 persons were contacted out of which 25 adult human subjects agreed to enrolled for the study. Classification of enrolled subject is given in Table 1. Subjects aged 35-70 years from a similar socio economic status, belong to the local area and most were employees of Sardar Patel University. They had a more or less similar physical activity, patterns, lifestyle and food consumption pattern.

Feeding Trials and Blood Collection

The enrolled subjects were asked to maintain an approximately constant activity level, dietary pattern (avoidance of sweets and party meals- especially for a couple of days before GI measurements) and a general life style during the feeding period. All the enrolled subjects were requested to report to the laboratory of P. G. Department of Home Science, Sardar Patel University, Vallabh Vidhyanagar.

Collection of data on general information, general dietary pattern, daily routine schedule (life style, exercise etc.), basic medical history and present drug therapy were obtained through a simple questionnaire. The dietary information (diet on the previous evening, period of fasting etc.) were also collected at this time.

Blood samples (finger prick) of the subjects were collected in the fasting condition. Immediately after that, they were fed 5 slices of WB (weighing 97.84 g and providing 50 g carbohydrate). The blood collection were repeated after at 1, 2 and 3 hrs of WB ingestion. Within a period of 2 week, the subjects were once again requested to report to the laboratory in the same manner followed earlier. This time subjects were fed approximately 5 slices weighing 104.40 g of WBB. The blood was collected similar to earlier.

Blood samples (0.1 ml) of the subjects were collected in a test tube containing 1 ml of 0.05 M NaOH, mixed well and used for analysis using the glucose oxidase method. For each subject, blood glucose response curve was plotted. Area obtained weather above or below the fasting line were included for calculation. The area was split in to right angle triangle and than its area was calculated. On that bases the GI and GL of WBB was determined.

The standard SPSS program was run to analyse the data. All the data were tested for significance using the ANOVA / Duncan's test (Steel and Torrie, 1980).

Results

Blood Glucose Level

Results for fasting and postprandial blood glucose levels (1 hr, 2 hr and 3 hr) as well as percent change in blood glucose levels after the ingestion of WB are presented in Table 2. Both the male and female non diabetic groups showed lower fasting blood glucose levels as compared to both the diabetic (male and female) groups. These results were as expected. None of the groups showed significant differences, between each other. After 1 hr of feeding WB all the four groups showed a rise in blood glucose level. The trend in blood glucose levels remained similar, i.e. lower in non diabetics as compared to diabetics, as expected.

Both male and female diabetic groups showed more or less similar increase in percent glucose at the end of one hour. The reason for the increase is well known that after ingestion of food, by about 1 hr the blood glucose level is increased to the maximum. However, non diabetic males and females showed lower blood glucose values one hour after the ingestion of WB, females showing a slight increase compared to males. When blood glucose level was analyzed at 2 hrs postprandial period, a non significant decreasing trend was observed in all the groups. Comparing the fall in blood glucose levels between 1 hr and 2 hr values it was seen that diabetics showed an average fall of 46.50 mg while the non diabetics showed a fall of 55.23 mg. In diabetic groups the retardation was lower as compared to non diabetic groups. The 3 hr postprandial blood glucose concentrations came back to it's original fasting levels in the case of non diabetic female group. However, in the case of non diabetic males it was found to be slightly higher than the fasting value. It may be because of reduced efficiency of insulin due to older age. In both the diabetic groups the blood glucose level did not come back to their fasting concentrations. During the 3rd hr all the groups showed a similar decrease in blood glucose concentration except the non diabetic male group.

Results for fasting and postprandial blood glucose concentrations as wellas percent change in blood glucose concentrations at 1, 2 and 3 hrs after ingestion of WBB are presented in Table 3. Percent change in blood glucose is also presented in Fig. 2. Fasting blood glucose levels of all the 4 groups were similar to levels observed for the testing of WB previously. The reason is that the subjects again came back for the feeding trial within a period of one week. After 1 hr, the same trend was observed as that obtained after feeding WB. However, the percent increase was lower for WBB as compared to WB in diabetics indicating the beneficial effect of wheat bran supplementation. Similar trend was observed in non diabetics also. The 2 hr postprandial blood glucose level were reduced with an average percent decrease of 14.95% for diabetics and 24.78 % for non diabetics. The highest decrease was found in non diabetic males followed by non diabetic females. Both the diabetic groups showed a lower decrease in blood glucose concentration as compared to the non diabetic groups. However the difference was non significant. The 3 hr blood glucose concentrations fell close to that of the fasting blood glucose concentrations. However, in both the diabetic groups, the blood glucose levels did not come down to fasting values. Low levels of insulin and their inefficiency invariably attribute for the slower fall in diabetics.

A change in blood glucose concentration of combined diabetics groups after feeding control and experimental bread is presented graphically in Figure 3.

Glycemic Index and Glycemic Load

Values obtained for blood glucose concentrations of each individual were plotted on a graph and the AUC was calculated separately for both the breads. On the basis of this data GI as well as GL were calculated. The results obtained are presented in Table 4. Area under the curve for WBB was observed to be low in all the groups as compared to the respective AUC obtained for WB. It clearly indicates that when wheat bran was added to the bread it reduced the blood glucose absorption which resulted in lowering of the AUC. Area under the curve for WB and WBB showed no significant differences. GI for WBB ranged from 77.04 to 81.25% within an average of 77.04% for diabetics and 81.93% for non diabetics. The average GL calculated for the WBB was found to be 38.20 g for diabetics and 40.97g for non diabetics. However, it ranged from 37.53 to 38.85 g for diabetics and 40.62 to 41.20 g for non diabetics.

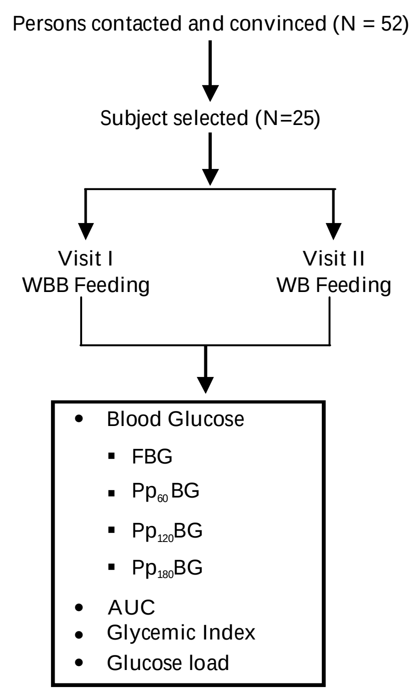

Fig. 1: Experimental Design for Clinical Trials for Bread Evaluation

WBB= Wheat Bran Bread, WB= White Bread, FBG = Fasting Blood Glucose
$PP_{60}BG$= Postprandial blood glucose after 1 hr of bread ingestion
$PP_{120}BG$ = Postprandial blood glucose after 2 hr of bread ingestion
$PP_{180}BG$ = Postprandial blood glucose after 3 hr of bread ingestion

Table 1: Classification of subjects enrolled for glycemic index measurements

	Type II Diabetes			Normal			Total		
	No.	Age (Yrs.)		No.	Age (Yrs.)		No.	Age (Yrs.)	
		Range	Avg.		Range	Avg.		Range	Avg.
Male	15	41-66	54	03	42-66	50	18	41-66	52
Female	05	49-70	55	02	35-58	47	07	35-70	51
Total	20	41-70	55	05	42-58	49	25	35-70	53

Table 2: Fasting and postprandial as well as percent change in blood glucose levels after feeding white bread

Group	Fasting	1 hr	% ch (1 hr)	2 hr	% ch (2 hr)	3 hr	% ch (3 hr)
Diabetic male	161.07 [a]	302.31 [a]	102.30 [a]	264.35 [a]	-15.71 [a]	194.00 [a]	-29.43 [a]
(15)	± 20.16	± 21.80	±10.72	± 31.96	± 4.97	± 29.52	± 3.15
Diabetic female	167.52 [a]	317.43 [a]	100.78 [a]	262.84 [a]	-18.44 [a]	190.72 [a]	-27.29 [a]
(5)	± 32.70	± 35.32	± 19.20	± 41.20	± 5.00	± 28.32	± 2.73
Diabetic	162.68 [a]	306.09 [a]	101.92 [a]	263.97 [a]	-16.39 [a]	193.18 [a]	-28.90 [a]
Total (20)	± 16.77	± 18.18	± 9.10	± 25.57	± 3.88	± 22.89	± 2.43
Non diabetic male	109.93 [a]	212.89 [a]	94.07 [a]	163.76 [a]	-21.00 [a]	125.93 [a]	-22.35 [a]
(3)	± 4.14	± 17.88	± 16.58	± 23.13	± 16.40	± 14.09	± 3.80
Non diabetic	131.04 [a]	237.02 [a]	82.29 [a]	175.69 [a]	-27.36 [a]	129.42 [a]	-24.71 [a]
female (2)	± 21.61	± 28.21	± 8.53	± 50.08	± 12.48	± 27.70	± 5.69
Non diabetic Total	118.37 [a]	222.54 [a]	89.36 [a]	168.53 [a]	-23.55 [a]	127.33 [a]	-23.30 [a]
(5)	± 8.86	±14.50	± 9.91	± 20.49	± 9.94	± 11.71	± 2.81
'F' Value	1.55 [NS]	1.61 [NS]	0.17 [NS]	1.00 [NS]	0.26 [NS]	0.60 [NS]	0.44 [NS]

NS = Non significant, % ch = Percent change, Values are Mean±SEM
Means bearing the same superscript within the column do not differ significantly ($p \leq 0.05$)
Values in parentheses indicate number of subjects

Table 3: Fasting and postprandial as well as percent change in blood glucose levels after feeding wheat bran bread

Group	Fasting	1 hr	% ch (1 hr)	2 hr	% ch (2 hr)	3 hr	% ch (3 hr)
Diabetic male	166.70 [a]	248.67 [ab]	55.56 [a]	216.19 [a]	-15.60 [a]	197.39 [a]	-7.82 [a]
(15)	± 16.75	± 16.33	± 7.37	± 24.28	± 5.35	± 22.36	± 2.70
Diabetic female	174.61 [a]	306.59 [b]	84.37 [a]	267.45 [a]	-13.01 [a]	203.97 [a]	-27.33 [a]
(5)	± 32.53	± 35.36	± 16.20	± 33.45	± 3.14	± 46.03	± 7.39
Diabetic	168.67 [a]	263.15 [a]	62.76 [a]	229.00 [a]	-14.95 [a]	199.04 [a]	-12.70 [a]
Total (20)	±14.54	± 15.70	± 7.22	± 20.27	± 4.05	± 19.70	± 3.26
Non diabetic male	101.09 [a]	182.42 [a]	80.84 [a]	130.98 [a]	-26.83 [a]	104.51 [a]	-16.77 [a]
(3)	± 1.75	± 8.33	± 11.18	± 22.97	± 16.33	± 5.12	± 9.79
Non diabetic female	133.11 [a]	203.11 [a]	56.90 [a]	161.04 [a]	-21.71 [a]	138.03 [a]	-14.13 [a]
(2)	± 28.85	± 18.78	± 19.89	± 36.62	± 10.79	± 30.31	± 0.71
Non Diabetic	113.90 [a]	190.69 [a]	71.26 [a]	143.00 [a]	-24.78 [a]	117.92 [a]	-15.72 [a]
Total (5)	± 12.07	± 9.04	± 10.56	± 18.62	± 9.66	± 12.93	± 5.40
'F' Value	1.15 [NS]	2.91 [NS]	1.57 [NS]	1.87 [NS]	0.39 [NS]	1.30 [NS]	3.22 [NS]

NS = Non significant, % ch = Percent change, Values are Mean±SEM
Means bearing the same superscript within the column do not differ significantly ($p \leq 0.05$)
Values in parentheses indicate number of subjects

Table 4: Glycemic index and glycemic load of wheat bran bread

Group	AUC of Control bread (cm^2)	AUC of Experimental bread (cm^2)	Glycemic$ Index (%)	Glycemic@ Load (g)
Diabetic male	74.03 [ab]	56.36 [a]	77.70 [a]	38.85 [a]
(15)	± 5.67	± 4.43	± 4.24	± 2.12
Diabetic female	84.15 [b]	60.67 [a]	75.05 [a]	37.53 [a]
(5)	± 8.77	± 6.69	± 9.50	± 4.75
Diabetic	76.56 [a]	57.44 [a]	77.04 [a]	38.2 [a]
Total **(20)**	± 4.78	± 3.66	± 3.84	±1.92
Non diabetic male	61.66 [ab]	50.93 [a]	82.39 [a]	41.20 [a]
(3)	± 5.69	± 5.41	± 1.46	±0.73
Non diabetic female	46.03 [a]	37.42 [a]	81.25 [a]	40.62 [a]
(2)	± 0.66	± 2.04	± 3.24	±1.62
Non Diabetic	55.41 [a]	45.52 [a]	81.93 [a]	40.97 [a]
Total (5)	± 4.94	± 4.49	± 1.33	± 0.07
'F' Value	2.03 [NS]	1.15 [NS]	0.15 [NS]	0.15 [NS]

AUC = Area Under Curve, NS = Non significant
Means bearing the same superscript within the column do not differ significantly ($p \leq 0.05$)
Values in parentheses indicate number of subjects
$ = AUC of experimental bread / AUC of control bread X 100
@ = GI X Carbohydrate content of food / 100

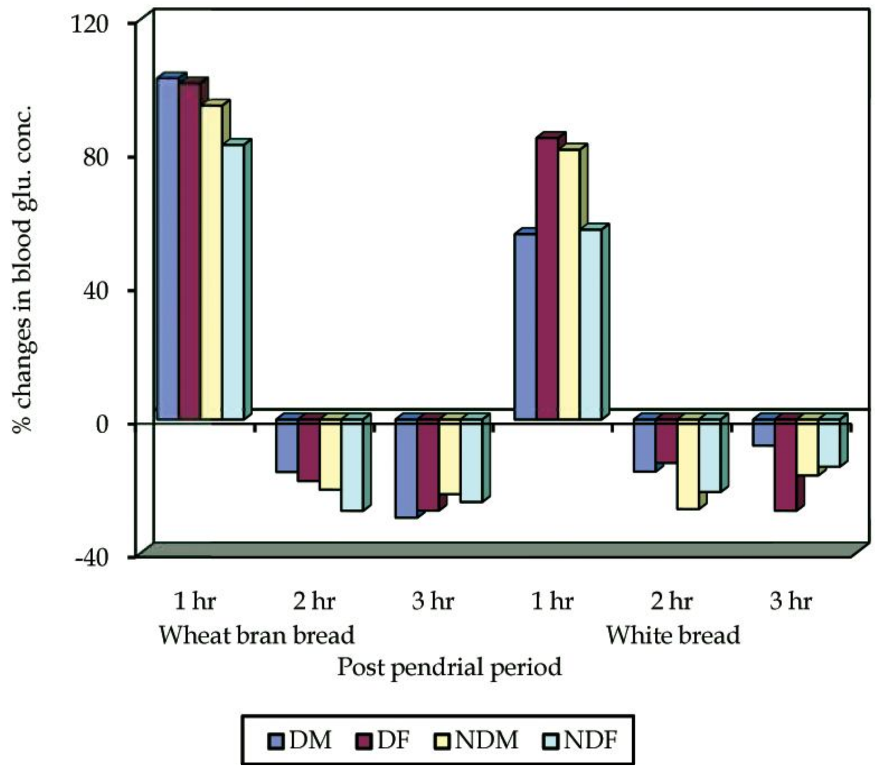

Fig. 2: Percent changes in postprandial blood glucose levels as compared to fasting after feeding white and wheat bran bread

WBB = Wheat bran bread, WB = White bread, DM = Diabetic male group, DF = Diabetic female group, NDM = Non diabetic male group, NDF = Non diabetic female group

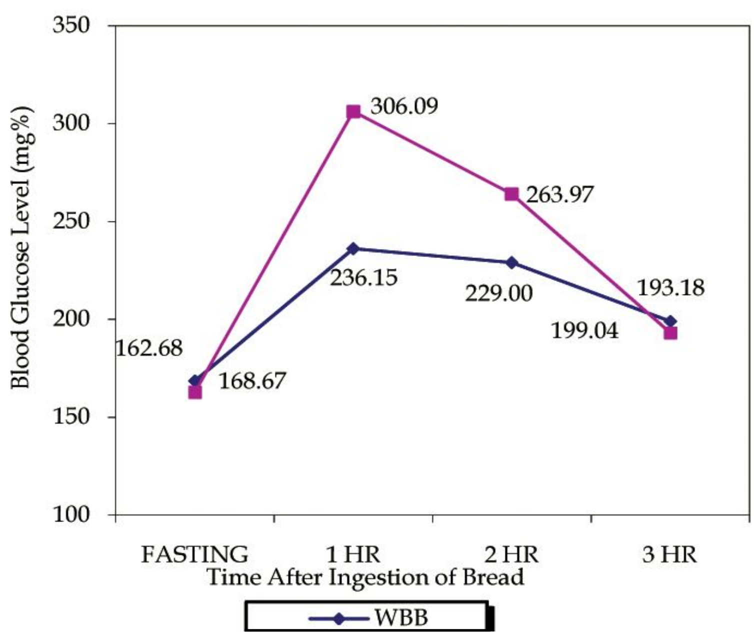

Fig. 3: Average glycemic response of diabetics for white and wheat bran bread

WBB = Wheat bran bread, WB = White bread

Discussion

Results for blood glucose levels are in concurrence with the high fiber bakery produts developed by other workers. Dubois et al. (1995) reported that adding oat bran to the test meals markedly reduced the post meal insulin rise (p £ 0.05). Ellis et al. (1988) reported that a significant insulin sparing effect in non diabetic subjects was achieved using a palatable guar biscuit containing less than 3 g of guar flour. Smith et al. (1982) reported that guar containing biscuit has been found to be effective in reducing the postprandial rise in blood glucose level.

Values for GI of WBBfound at par with Bell and Sears (2003) reported 81% GI for whole grain dark rye bread. Bell and Sears (2003) reported 13 and 15 g GL for whole grain brown rice and whole grain dark rye bread. Powel (2002) also reported the GL for different types of wheat breads to vary between 10 to 12 g. In the present study although the GI was similar to the other reported studies the GL was surprisingly high.

Conclusion

Considering the low GI obtained for WBB in comparison to WB in both diabetics as well as non diabetics, 7.5% wheat bran fortified bread may be recommended as a replacement for the commercially available white flour bread in the daily diet of diabetic as well as normal human subjects.

Future Scope

Like bread other bakery products such as biscuits, cookies, cakes and pastries could be modified to make it useful for diabetics.

References

1. AndersonJW and Akanji AO. Treatment of diabetes with high fiber diets in : Dietary fibre in human nutrition, 2nd edn spiller GA, CRC Press, Boea Raton FL. 1993; pp 443.
2. Bailey R. Diabetes prevention in Japan : an update. Nutraceuticals World. 2004; 7(9): 22-23.
3. Bamji MS, Pralhad RN and Reddy V. Text Book of Human Nutrition, 2nd edn. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 2004; pp 341.
4. Bell SJ and Sears B. Low GLdiets : Impact on obesity and chronic diseases. Critical Reviews in Food Science and Nutrition. 2003; 43(4): 357-377.
5. Dubois C, Armand M, Senft M, Portugal H, Pauli AM, Bernard PM, Lafont H and Lairon D. Chronic oat bran intake alters postprandial lipemia and lipoproteins in healthy adults. Am J ClinNutr 1995; 61(2): 325-333.
6. EllisPR, Kamalanathan T, Dawoud FM, Strange RN and CoultateTP. Evaluation of guar biscuits for use in the management of diabetes : tests of physiological effects and patability. Eur J ClinNutr. 1988; 42(5): 425-435.
7. Kamaliya MK and Kamaliya KB (2001) Baking Science and Industries. 1st edn. MK Kamaliya, Anand, India. 2001; pp 474 - 586.
8. Kamaliya KB. Nutritional modification of commercially available bakery products and their evaluation. Ph.D. thesis submitted to Sardar PatelUniversity, VallabhVidhyanagar. 2005; pp 6-7.
9. Matz SA (1996) Ingredients for Bakers. 2nd edn. Pan-Tech International, Inc, Texas Powell KF, Holt S HA and Miller J CB (2002) International table of glycemic index and glycemic load values. Am J ClinNutr. 1996; 76(5): 56.
10. Smith CJ, Rosman MS, LevittNS and Jackson WP. Guar biscuits in the diabetic diet. S Afr Med J 1982; 61(6): 196-198.
11. Steel, RGD and TorrieJH. Principles and procedures of statistics, Mcgraw Hill Publication, New York.1980; 25-27.
12. Wolever, TMS, Jenskins, DJA, Jenkins AL and Josses RG. The glycemic index methodology and clinical importance Am J ClinNutr.1991; 54: 846-854.