Glycemic Index and Glycemic Load of Selected Foods Incorporated with Green Leafy Vegetables, Millets and Soy Products

Sathiya V[1], Chithra R[2]

[1]Assistant Professor, Department of Nutrition and Dietetics, PSG College of Arts & Science, Coimbatore, Tamil Nadu, India–641014

[2]Associate Professor, Department of Nutrition and Dietetics, PSG College of Arts & Science, Coimbatore, Tamil Nadu, India–641014

Abstract: _Background: Glycemic index (GI) is a scale that ranks carbohydrates depending on the extent to which they raise the blood glucose levels, compared to a reference food. Methods: Using Green leafy vegetables (G), Millets (M) and Soy products (S), five common foods suitable for diabetics namely GMS Idli, GMS Adai, GMS Noodles, GMS Kitchedi and GMS Rotiwere formulated, organoleptically evaluated, standardized and the nutritive value was estimated by factorial method. The GI and GL (Glycemic Load) of these items were studied using the procedure given by Jennie Brand Miller (2004). Findings: GMS Roti topped the list with respect to overall acceptability. The carbohydrate content of all the formulated foods per serving was 50 g as it was matched so for the study of GI. The protein content of all the specially formulated items varied from 11.4 to 15.7 g per serving and the fat content from 2.6 to 9.2 g per serving. The GMS Noodles registered the lowest GI of 42.13 which was on a par with GMS Adai. GMS Idli, GMS Roti and GMS Kitchedi recorded medium GI and GMS String Hoppers recorded high GI. GL of GMS Noodles was less and GMS String Hoppers had a higher GL when compared to other food items. Conclusion: Inclusion of fibre rich greens and millets and protein rich soy products certainly reduces the GI simultaneously improving the nutritive value._

Keywords: GI, GL, Green Leafy Vegetables, soy, millets, diabetes, carbohydrates and blood glucose

1. Introduction

Diabetes mellitus (DM) is a metabolic disorder and it is characterized by elevated levels of blood glucose.DM is associated with an increased risk of micro- and macrovascular complications (Fowler[1]_et al.,_ 2008).Western dietary patterns that include large amounts of processed meats, French fries, sweets and desserts have been condemned by nutrition experts because they fail to protect us against obesity, heart disease and Type 2 diabetes mellitus (Liu[2], 2002). Boyle[3](2004)pointed out that implementing preventive measures of diabetes at early stage, would act as an effective foundation for healthy adulthood. Preventive measure is the sustainable solution to curb the upswing in the prevalence of diabetes mellitus. The glycemic index (GI) of a food is thought to directly reflect the rate of digestion and entry of glucose into the systemic circulation (Schenk[4], _et al._, 2003). Hence it is essential that diabetics should consume healthy diet containing foods with low GI for good glycemic control.

2. Literature Survey

Yeonen[5]_etal._ (2004)stated that high intake of dietary fibre was associated with enhanced insulin sensitivity and might have a role in the prevention of type 2 diabetes. Anandhi[6](2004)elucidated that soybean, being a true elixir among foods, if consumed regularly could keep oneself healthy and strong. Use of whole grains instead of refined grain may reduce a range of chronic diseases and the risk of death (Update[7], 2000). Malleshi[8](2004) stated that _Jowar_ and millets namely _Ragi_, _Bajra, Navane_(foxtail millet), _Samai_(little millet)etc. possessed unique nutritional characteristics. They were reported to be gluten free with complex carbohydrates, rich in dietary fibre as well as

unique phenolic compounds and phytochemicals having medicinal properties. The starches in millets were also reported to get digested slowly compared to other cereals and so it was considered beneficial to manage maturity onset diabetes.Vegetables have been coined as functional foods, since they not only fulfill our physiological needs but also have health promoting capacity. They have become "star nutrients" as they contain antioxidants which guard our health, protect cells and organs from damage caused by free radicals neutralizing their damaging effects (Indra[9], 2004).

3. Problem Definition

It is challenging for people with diabetes to obtain foods that contain the right balance of ingredients to normalize blood glucose concentrations. Nutritious, fibre rich, low GI, foods would definitely help diabetics to obtain all the required nutrients and also to maintain the blood glucose levels. Standard _Idli, Adai,_ Noodles_, Kitchedi_and_Roti_ are a few commonly consumed breakfast / dinner item in India. Standard _Idli_ is a steamed item consumed with _chutney_ / sambar / gravies as side dishes. Standard _Adai_ is a shallow fried item consumed with _chutneys_. It is known that standard noodles are made with refined flour. Standard _Kitchedi_ is a boiled item made with semolina and mixed vegetables. Standard _Roti_is a shallow fried item made usually with _ragi_ and other flour mixtures and consumed with chutneys as side dish. All these five items are carbohydrate rich and lack in fibre, protein and protective nutrients. Hence the present study was undertaken with the following objectives:
- To incorporate nutrient dense / fibre rich Greenleafy vegetables (G), Millets (M)and Soy (S) in the above food items suitable for diabetics and
- To study the acceptability, nutritive value, glycemic index (GI) and glycemic load (GL).

4. Methodology

1) Formulation of foods based on greens, millets and soy products (GMS)

Five common foods suitable for diabetics using green leafy vegetables, millets and soy products (GMS) were formulated. Green Leafy vegetables namely curry leaves, coriander leaves, mint leaves and drumstick leaves were used for the preparation. The millets included in the recipes were Bajra (Pennisetumglaucum), Italian millet (Setariaitalic), Jowar (Sorghum bicolour) and Ragi (Eleusinecoracana). Soybeans / Texturized soy protein was added to the recipes. The items were GMS *Idli*, GMS *Adai*, GMS Noodles, GMS *Kitchedi* and GMS *Roti*.

Ingredients Used in Food Formulation

GMS *IDLI* (Portion Size: 2 ½ *idli's* (118 g)	GMS *ADAI* (Portion Size: 4 *Adai's* (195 g)	GMS NOODLES Portion Size: ½ cup (170 g)	GMS *KITCHEDI* Portion Size: 2 cups	GMS *ROTI* Portion Size: 4 *roti's* (200 g)
Ingredients Bajra Italian Millet Jowar Rice *Ragi* Bengal gram Dhal Black gram Cowpea Green gram Horse gram Red gram dhal Soya bean Fenugreek seeds Salt **Shade dried & Powdered Greens** Curry leaves Drumstick leaves Mint Coriander leaves	**Ingredients** Bajra Italian Millet *Ragi* (Flour) Rice Green Gram Black gram dhal Bengal gram dhal Soyabean Coriander leaves Curry leaves Onion (Big) Cumin Seeds Ginger Green Chillies Gingelly oil Salt	**Ingredients** **For Noodles** Wheat Flour Green gram (powder) *Ragi* flour **Shade dried & Powdered Greens** Curry leaves Drumstick leaves Mint Coriander leaves **For Preparation** Carrot Tomato Peas Onion (Big) Texturised soy chunks Cabbage Gingelly oil Green chillies Salt Ginger	**Ingredients for *Rava* Rava (one serving)** Rice *Ragi* Bajra Bengal Gram Italian Millet Green gram Jowar Texturised soy flakes **For Making Kitchedi** Carrot Curry leaves Cabbage Coriander leaves Beans Onion Plantain stem Green Chillies Tomato Mustard Seeds Drumstick leaves Gingelly oil Salt	**Ingredients** Teturised soy granules Bengal gram flour *Ragi* Flour Curry leaves Drumstick leaves Onion small Salt Green chillies Gingelly oil
The ingredients were ground into fine batter, mixed with green leafy vegetable powder. Salt was added and fermented overnight. Poured the batter into *idli* moulds and steamed.	Soaked cereals, millets and pulses for 2 hours and ground with green chillies, onion, ginger, cumin seeds and sufficient salt. Added chopped green leafy vegetables and mixed well. Poured the batter on *dosa* pan and shallow fried with a little oil.	Wheat Flour, green gram flour, *ragi* flour and powdered green leafy vegetables were made into dough, extruded and dried in a pre – heated oven at a temperature of 80° C for 20 – 30 minutes. The dried noodles were cooled and packed in air – tight containers. **Method of cooking Noodles:** Noodles were added to boiling water and cooked for 2 – 3 minutes on a low flame, drained the excess water and cooled. Chopped the vegetables into long strips. The soy chunks were soaked in hot water for 15 minutes and squeezed. To the heated oil added ginger – garlic paste, chopped vegetables, soy chunks and sauted. To this added the cooked noodles and salt, mixed and served hot.	The ingredients for *rava* were roasted for 5 – 10 minutes and then dry ground coarsely into a *rava*. The vegetables were washed and chopped. To the heated oil, added mustard, green chillies, onion, green leafy vegetables, other vegetables and soy flakes and sauted. To this, added required amount of water, salt and allowed to boil. Then added the *rava* by sprinkling. Stirred and cooked until done.	Soaked the granules in hot water, squeezed and ground. Added the flours, finely chopped onion, green chillies and green leafy vegetables. Added sufficient salt and water and made into a stiff dough. Take lemon size dough and pressed in the palm into a *roti* form. Fried the *roti* on the heated pan by adding a little oil.

2) Organoleptic Evaluation

The prepared foods were organoleptically evaluated by 20 semi trained judges in order to find the acceptability of the products with the criteria *viz.*, colour and appearance, texture, flavour and taste using the five-point Hedonic scale.

3) Assessment of Nutritive Value and Determination of portion sizes

The energy, carbohydrate, protein, fat, fibre, calcium, phosphorus and iron content of the formulated food items were studied by factorial method. The portion size of each food containing 50 g of carbohydrate was determined for the study of Glycemic Index (GI).

4) Estimation of Glycemic Index and Glycemic Load (GL)

Fasting blood glucose levels were studied in selected 10 non diabetic volunteers. Administered 50 g of glucose dissolved in 150 ml of water. The blood glucose values in mg / dl were recorded after 30 minutes, 60 minutes, 90 minutes and 120 minutes. On the following day, in the same volunteers, the fasting blood glucose levels were recorded. Previously fixed portion of selected food item containing 50 g of

carbohydrate was administered and the blood glucose levels were recorded as above.

Making use of the blood glucose values and nominal serve size of each food, the glycemic index and glycemic load of the selected foodswere determined using the standard formula given by Brand Miller[10](2004).

Glycemic load depends on the GI of the food items, the available carbohydrate content and its nominal serve size.

5. Results and Discussion

1) Acceptability of the formulated foods
From table 1, it is clear that the GMS *Roti* had the highest score of 19.4 with respect to overall acceptability. The mean scores of all the other food items ranged from 15.5 to 18.5 out of 20. The judges did not express any negative opinion about the organoleptic qualities of these fibre rich and nutritious food items.

Table 1: Mean Scores of the Formulated Food Items (20 Judges)

Name of the Food Item	Colour and Appearance (5)	Texture (5)	Flavour (5)	Taste (5)	Overall Acceptability (20)
GMS *Idli*	3.6	4.3	4.6	4.0	16.5
GMS *Adai*	4.3	4.6	4.6	5.0	18.5
GMS Noodles	3.6	5.0	4.0	4.6	17.2
GMS *Kitchedi*	4.6	4.3	3.3	3.3	15.5
GMS *Roti*	5.0	4.8	4.6	5.0	19.4

2) Nutritive Value of the Formulated Foods
Table 2 gives the nutritive value of the formulated food items per portion size (containing 50 g of carbohydrate) used for the study of GI.

Table 2: Nutritive Value of the Formulated Food Items (Per Portion Size (Containing 50g of Carbohydrtae) used for the Study of GI) in Comparison with Respective Standards

S.NO	Name of the Food Item	Energy (k.cal)	Carbohydrate (g)	Protein (g)	Fat (g)	Fibre (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)
1.	GMS *Idli*	278	50	13.5	2.6	2.6	127	248	4.0
2.	GMS *Adai*	345	50	15.7	9.2	2.8	159	268	4
3.	GMS Noodles	304	50	13.5	5.6	2.6	157	331	5
4.	GMS *Kitchedi*	309	50	11.4	7	2.5	137	252	4
5.	GMS *Roti*	319	50	14.5	6.8	2.3	191	337	5

a) Carbohydrate, Protein, Fat and Energy Content
The carbohydrate content of one serving of all the formulated foods was 50 g as it was matched so for the study of GI. The protein content of all the specially formulated items making use of greens, millets and soy products varied from 11.4 g (GMS *Kitchedi*) to 15.7 g (GMS *Adai*) per serving. The fat content of the itemsranged from 2.6 g (GMS *Idli*) to 9.2 g (GMS *Adai*) per serving.

b) Fibre, Calcium, Phosphorus and Iron Content
Fibre, calcium, phosphorus and iron content of all the formulated food items registered noticeably higher values when compared to the respective standard items due to the incorporation of varieties of green leafy vegetables, millets and soy products.

3) Glycemic Response to glucose and the formulated food items
Table 3 shows the glycemic responses in the selected volunteers on ingestion of glucose and the formulated foods.

Table 3: Glycemic Responses to Glucose and the Formulated Food Items
(Mean Values of 10 Selected Volunteers)

Name of the Item Administered	Mean Blood Glucose Levels (mg/dl) at				
	Fasting	½ hour	1 hour	1 ½ hours	2 hours
Glucose	**91.6**	**139.7**	**128.2**	**109.7**	**93.6**
GMS *Idli*	92.3	119.6	99.5	91.6	83.9
GMS *Adai*	89.6	118.6	100.4	94.5	87.1
GMS Noodles	90.7	111.3	101.9	95.6	90.4
GMS *Kitchedi*	90.7	124.4	112	100.6	92.9
GMS *Roti*	89.9	124.0	110.6	97.6	90.9

The fasting blood sugar levels of the selected subjects varied from 89.6 – 92.3 mg/dl. The peak values were observed at 30 minutes after ingestion of the reference or test foods. Thereafter the levels showed a reducing trend. Glucose recorded the highest response as it was the reference food. All the other foods recorded lower responses. According to Simon Schenk[11](2000), foods high in fibre, such as whole grain,rye bread and all the bran cereals produce low glycemic responses.

4) Glycemic Indices of the Food Items
A low-glycemic index (GI) diet may lower postprandial hyperglycemia and decrease the risk for postabsorptive hypoglycemia in people with type 1 diabetes. (Rovner[12]*et.al*, 2009).

Table 3: Glycemic Indices of the Food Items

Name of the Item	Glycemic Index (GI)	Category
GMS *Idli*	55.9	Medium
GMS *Adai*	50.93	Low
GMS Noodles	42.13	Low
GMS *Kitchedi*	64.25	Medium
GMS *Roti*	57.59	Medium

The GMS Noodles registered the lowest GI of 42.13 which was on a par with GMS *Adai*. GMS *Idli*, GMS *Roti* and GMS *Kitchedi* recorded medium GI. The GI of ordinary *Idli* was reported to be 69 (Medium GI) by Jennie Brand Miller[13], *et al.* (2000). Shital[14]*et al.* (2017) modified the *Idli* with high GI into a medium GI food by incorporation of barley, oats, gluten, and guar gum at suitable levels of substitution.Hence it is evident in the present study that incorporation of GLV (Curry leaves, Drumstick leaves, Coriander leaves and Mint), millets (Bajra, Italian Millet, Jowar and *Ragi*) and whole soybean in *Idli* has considerably

increased the fibre and protein content, which are the two important factors responsible for reduction in GI. The glycemic index (GI) of finger millet incorporated (30%) noodles (best selected by sensory evaluation) was significantly lower (45.13) than control noodles (62.59). (Kamini Shukla and Sarita Srivastava[15], 2014). Mani[16]*et al.* (1997) reported that the GI of *Adai* with chutney registered a medium GI of 69.6. According to Shweta Joshi and Sarita Srivastava[17](2016) the glycemic index of barnyard millet *khichdi* was 34.96 and rice *khichdi* was 62.5. Also Radhika[18]*et al.* (2010) reported lower GI (27.3) for *Atta* mix *Roti* than the whole wheat flour *roti* (45.1).Many factors contribute to glycemic index, including carbohydrate structure, fiber content, cooking method, food processing, ripeness, storage, and presence of enzyme inhibitors and co ingestion of other macronutrients. Foods with a higher amylase, amylo pectin ratio is digested more slowly and has a lower glycemic index (Wolever[19], 1990).

5) Glycemic Load of the Food Items

Diets with low glycemic load can be effective in glycemic control (Ziaee[20],*et.al,* 2011). The tight glycemic control can prevent or delay the development of complications of diabetes mellitus (Silva[21]*etal.,* 2009).
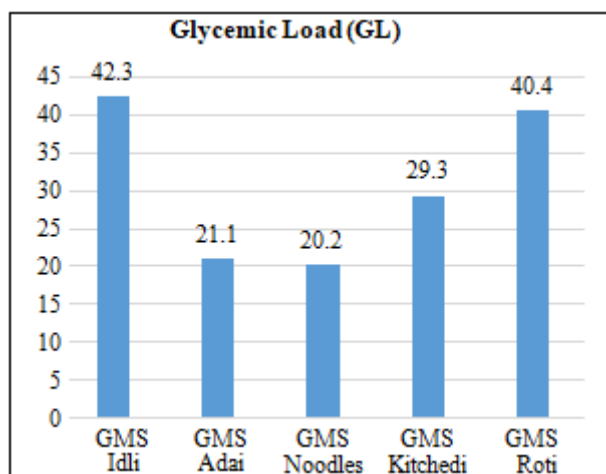
Glycemic load of a food item is calculated based on the nominal serve size of the food item and the available carbohydrate content. Glycemic load of the same item may vary depending upon the quantity consumed because the quantity of food in one serving varies from individual to individual and hence the available carbohydrate content too.Hence GL is an arbitrary value.In the present study, GL of GMS Noodles was less when compared to other food items.

6. Conclusion

Glycemic index and glycemic load of foods generallyreduce on the incorporation of greens, millets and soy products simultaneously increasing the nutritive value remarkably. Hence diabetics should be encouraged to utilize green leafy vegetables, millets and soy productsin all their foods to have a good glycemic control.

References

[1] Fowler MJ. Microvascular and Macrovascular Complications of Diabetes. Clin. Diabetes. 2008; 26: 77–82.

[2] Liu S. Intake of refined carbohydrates and whole grain foods in relation to risk of type – 2 diabetes and coronary heart disease. Jour.Am.Clin.Nutr. 2008; 21: 298 – 306.

[3] Boyle KJ. Prediction impaired glucose tolerance. Nutr. Abs and Reviews. 2004; 74 (2): 625.

[4] Schenk S, Davidson CJ, ZdericTW, Byerley LO and Coyle EF. Different glycemic indexes of breakfast cereals are not due to glucose entry into blood but to glucose removal by tissue. Am. JourClinNutr. 2003; 78 (4): 742 – 747.

[5] Yeonen K, Saloranta C, Kronberg and Kippila C. Association of dietary fibre with glucose metabolism. Nutr. Abs. Rev. 2004; 74 (4): 265.

[6] Anandhi K. Soyabean – a cardiac protector. Kisan World. 2004; 31 (10): 58.

[7] Update. Nutrition research summaries.2000; 37(9): 317 - 318.

[8] MalleshiNG. Nutritional features of sorghum and millets" "Bridging nutrition gap through vitamins. Minerals and soy. NSI – Special Souvenier – XXXVI Annual Meet, 5 – 6th November, organized by Department of studies in Food Science and Nutrition, CFTRI, DFRL, Mysore. 2004: 98 – 99.

[9] Indra V. Fruits and vegetables – Health foods. KisanWorld. 2004; 1: 49 – 50.

[10] Jennie Brand Miller, Kaye Poster Powell, Stephen Colagiuri. The New Glucose Revolution - The Glycemic Index – Solution for Optimum health. Lisa Lintner. 2004: 41 – 43.

[11] Simon Schenk. Different glycemic indexes of breakfast cereals are not due to glucose entry into blood but glucose removed by tissue. American Jour. Clin.Nutr. 2000; 78: 742 – 748.

[12] Rovner AJ, Nansel TR, Gellar L. The effect of a low-glycemic diet vs a standard diet on blood glucose levels and macronutrient intake in children with type 1 diabetes.J Am Diet Assoc.2009; 109(2):303-7.

[13] Jennie Brand Miller, Kaye Foster Powell and Stephen, C. The GI solution for optimum health. In: The New Glucose Revolution, Hodder Headline, Australia, Pvt Ltd. 2000. 3[rd]Edn: 278.

[14] ShitalGiri, Anamika Banerji, S. S. Lele & Laxmi Ananthanarayan. Starch digestibility and glycaemic index of selected Indian traditional foods: Effects of added ingredients. International Journal of Food Properties. 2017; 20(1): S290-S305.

[15] Kamini Shukla and Sarita Srivastava. Evaluation of finger millet incorporated noodles for nutritive value and glycemic index. Journal of Food Science and Technology.2014;51(3): 527–534

[16] Mani UV, Mani IU, Iyer UM, Prakash B, Manivannan T, Campbell S, Chandalia S. Glycemic and Lipemic Response to Various Regional Meals and South Indian Snacks. Int. J. Diab. Dev. Countries 1997;17: 75 -81.

[17] Shweta Joshi and Sarita Srivastava. Barnyard Millet as a Substitute of Rice in Preparation of khichdi for

Diabetics. International Journal of Science and Research. 2016; 5(6): 1798 – 1802.

[18] Radhika G, Sumathi C , Ganesan A , Sudha V , Jeya Kumar Henry C and Mohan V . Glycaemic index of Indian flatbreads (rotis) prepared using whole wheat flour and 'atta mix'-added whole wheat flour.The British Journal of Nutrition . 2010; 103(11):1642-1647.

[19] Wolever, T.M.S. The glycemic index. In: Aspects of some vitamins, minerals and enzymes in health and disease. World. Rev. Nutr. Diet. 1990;62: 120 – 185.

[20] Ziaee A, Afaghi A, Sarreshtehdari M. Effect of low glycemic load diet on glycatedhemoglobin (HbA1c) in poorly-controlled diabetes patients. Glob J Health Sci. 2011; 4(1):211-6.

[21] Silva FM, Steemburgo T, Azevedo MJ, Mello VD. Glycemic index and glycemic load in the prevention and treatment of type 2 diabetes mellitus. Arq Bras Endocrinol Metabol.2009; 53 (5):560-71.