ejpmr, 2016,3(3), 514-518

SJIF Impact Factor 3.628

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH
www.ejpmr.com

Research Article
ISSN 2394-3211
EJPMR

DEVELOPMENT OF VALUE ADDED PRODUCT TO REDUCE THE RISK OF HYPOGLYCEMIA IN DIABETIC POPULATION

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Article Received on 15/01/2016 **Article Revised on 07/02/2016** **Article Accepted on 29/02/2016**

ABSTRACT
Hypoglycemia is a medical emergency that involves an abnormally diminished content of glucose in the blood. It is one of the most important complications in the treatment of diabetes caused due to insulin over dosage. In our study we focused on the hypoglycemic population among children and developed edible products using medium GI foods like Sweet Potato *(Ipomea batatas*) and Finger millet (*Eleusine coracana)* as the key ingredient. These are known to release glucose steadily without causing glucose spikes in the blood. The product developed were Muffins (3 variations with sweet potato and finger millet) - a confectionary product having long shelf-life, major acceptability as a snack and easy to carry. The muffins were first subjected to sensory evaluation using the Nine-Point Hedonic Scale to determine consumer acceptability, followed by Proximate Analysis (Moisture, Ash and Crude fibre content) and Biochemical Analysis (Reducing sugars, Total sugars and Protein content). The Glycemic Index of each product variation was determined *in vitro*. The results of all the above analysis were compared with that of a control product devoid of Sweet Potato and Finger millet. The developed products were found to be nutritionally superior to the control and most importantly had a lower GI value as compared to the control: variation 2 having the lowest relative GI value. Thus the prepared value added product could be useful in the effective management of Hypoglycemia.

KEYWORDS: Hypoglycemia, muffins, *Ipomea batatas, Eleusine coracana,* Glycemic index.

INTRODUCTION

Hypoglycemia is an abnormally low concentration of glucose in the blood. This occurs when a person has eaten too little food, or exercised without food or if they have diabetes and have injected too much insulin.[1] The incidence of hypoglycemia is reported to be between 3 and 27 episodes per 100 patients per year in children with type I diabetes. The recurrent and severe episodes of hypoglycemia cause hypoglycemic fearfulness and emotional morbidity both for patients and their parents, which could act as a limiting factor in achievement of good glycemic control.[1] To prevent hypoglycemia, a low glycemic diet is recommended. [1] The glycemic index (GI) is the incremental area under the blood glucose response curve of a specific 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 subject. Foods can be assigned a glycemic index number based on the comparative increases in blood glucose (sugar) levels they produce when that food is consumed. A low glycemic food (GI = 55 or less) causes a slower and more gradual rise in blood sugar than a high glycemic food (GI = 70 or more), and maintains increased energy levels for a longer duration. A high glycemic food increases blood sugar concentrations quickly, thus providing energy to the body in a short period of time. However, insulin is released in response to this rise in blood sugar, which, in turn, brings the blood sugar down rapidly. This rapid decrease induces a hypoglycemic state.[2] Choosing low-GI foods in place of conventional or high-GI foods has a small but clinically useful effect on medium-term glycemic control in patients with diabetes. The incremental benefit is similar to that offered by pharmacological agents that also target postprandial hyperglycemia[3]. The best evidence of the clinical usefulness of GI is available in diabetic patients in whom low-GI foods have consistently shown beneficial effects on blood glucose control in both the short-term and the long-term. In these patients, low-GI foods are suitable as carbohydrate-rich choices, provided other attributes of the foods are appropriate.[4] In long-term trials, low-GI diets result in modest improvements in overall blood glucose control in patients with insulin-dependent and non-insulin-dependent diabetes. Of perhaps greater therapeutic importance is the ability of low-GI diets to reduce insulin secretion and lower blood lipid concentrations in patients with hypertriglyceridemia.[5]

In our study, we aim to develop value added edible products composed of sweet potato and finger millet which would aid in preventing hypoglycemic state in an individual. Consumption of finger millet diets result in significantly lower plasma glucose levels, mean peak rise, and area under curve in a glucose response curve which is due to the higher fiber content of finger millet. The lower glycemic response of whole finger millet based diets may also be due to the presence of antinutritional factors in whole finger millet flour which are known to reduce starch digestibility and absorption.[6] Rich in vitamin A and beta-carotene, the sweet potato offers complex carbohydrates along with antioxidant nutrients which make the starchy sweet potato rank low on the glycemic index scale.[7] Consistent consumption of sweet potato improves metabolic control in type 2 diabetic patients by decreasing insulin resistance without affecting body weight, glucose effectiveness, or insulin dynamics, without any side effects.[9] Therefore these two items are used as the key ingredients in our products, which are variations of standard muffin; a popular quick bread product similar to cupcakes. The acceptability of the developed variations in comparison to the control (standard muffin) is assessed through sensory evaluation using the 9- point Hedonic Scale.[9]

MATERIALS AND METHODS

Product Ingredients

Table 1: Ingredients used for the preparation of the control muffin and its variations.

Ingredient	Control Muffin	Variation 1	Variation 2	Variation 3
Maida	225 g	112 g	112 g	112 g
Sweet potato	-	112 g	56 g	67 g
Finger millet	-	-	56 g	45 g
Granulated sugar	50 g	50 g	50 g	50 g
Baking powder	10 g	10 g	10 g	10 g
Salt	2.5 g	2.5 g	2.5 g	2.5 g
Egg	60 g	60 g	60 g	60 g
Milk	180 ml	180 ml	180 ml	180 ml
Oil	65 ml	65 ml	65 ml	65 ml
Vanilla essence	5 ml	5 ml	5 ml	5 ml
Cardamom	A pinch	A pinch	A pinch	A pinch
Butter	3.5 g	3.5 g	3.5 g	3.5 g

Product preparation

Flour, baking powder and salt were combined in the above mentioned proportions to prepare the control muffin (Table 1). In case of variation, 112 g of smashed sweet potato was added to the flour, baking powder and salt mixture. Similarly for variation 2 and 3 finger millet flour and sweet potato were added to the mixture in the proportions mentioned above. Eggs were beaten in a separate bowl; milk, sugar and vanilla essence was added to the eggs accordingly, followed by butter and beaten further. The dry ingredients and wet ingredients were mixed together until uniform. The mixture was added into greased molds and baked at 220 ^{0}C for 16 min in a preheated oven.

Sensory Evaluation

The sensory evaluation was done using 21-members of panelists who gave their views on acceptability, taste, flavor, texture and overall acceptability.

Table 2: Nine-Point Hedonic Scale.

Nine-point Hedonic Scale	
9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

Proximate Analysis: The total moisture, ash and crude fibre content of the developed products was estimated using AOAC Official Methods.[10]

Estimation of Total Proteins: The total protein content was determined using modified Lowry method.[11] 0.5 g of sample was weighed, homogenized with 5 ml of 0.01M sodium phosphate buffer (pH 7) and centrifuged at 8000 rpm for 15 min. 0.1 ml of supernatant was made up to 1 ml with distilled water and mixed with 5 ml of alkaline copper reagent. It was allowed to stand for 10 min at room temperature followed by addition of 0.6 ml Folin-Ciocalteau reagent (1:1 dilution) and was incubated for 30 min in the dark at room temperature. The absorbance was then measured at 660 nm. Bovine Serum Albumin (BSA) was used as a reference standard for plotting calibration curve. The total protein content was determined from the linear equation of a standard curve prepared with BSA.

Estimation of Reducing Sugars: Estimation was done using dinitro salicylic acid (DNS) reagent according to Miller.[12] 0.5g of sample was weighed, homogenized with 5 ml of 0.01M sodium phosphate buffer (pH 7) and centrifuged at 8000 rpm for 15 minutes. 0.1 ml of supernatant was made up to 2 ml with distilled water and mixed 2.0 ml of DNS reagent. The test tube was then placed in boiling water bath for 15 min followed by addition of 16 ml distilled water. The absorbance was then measured at 540 nm. Alpha-D-glucose was used as a reference standard for plotting calibration curve. The amount of reducing sugars present in the sample was determined from the linear equation of the standard curve.

Estimation of Total Sugars: 0.1g of sample was taken in a boiling tube and hydrolyzed by placing in a boiling water bath for 3h with 6 ml of 2.6 N HCl and cooled to room temperature. It was neutralized it with solid sodium carbonate until the effervescence ceases. The volume was made up to 100 ml and centrifuged. 0.1 ml of supernatant was used for analysis. The reaction mixture was shaken with 4 ml of anthrone reagent and heated for 8 min in boiling water bath. The absorbance of the resulting green to dark green colour was read at 630 nm. D-glucose was used as a reference standard for plotting calibration curve. The amount of reducing sugars present in the sample was determined from the linear equation of the standard curve.[13]

Assessment of Glycemic Index

The in vitro method [14] for evaluating starch digestibility involves mechanical disruption and multi-enzyme digestion based on proteolysis, followed by incubation with pancreatic α-amylase. This method allows the calculation of a hydrolysis index (HI), which is indicative of the food's GI. A sample of each product as eaten, containing 2 g of carbohydrate was sliced and homogenized with 20 ml of a 0.1 M potassium phosphate buffer solution buffer solution (pH 6.9) kept at 37 °C was added. After grinding, the samples were homogenized with a homogenizer at a constant speed, and rinsed with an additional 20 ml buffer solution. The pH of the samples was decreased to pH 2.5 with o-phosphoric acid, after which 1 ml of Trypsin enzyme solution containing 10 µg of Trypsin (Sigma-Aldrich) was added. The samples were placed in a 37 °C stirring water bath for 60 minutes to simulate the time that food would be churned in the human stomach. Each sample was then buffered back to pH 6.8 with KOH, and 2 ml α-Amylase enzyme solution containing 20 micrograms of α-Amylase (Sigma-Aldrich) was added. The entire contents of the flask were then transferred into a dialysis tube. The tube was closed and placed in flasks containing 500 ml buffer solution. The flasks were placed in the stirring water bath and 40 ml of the buffer solution was extracted every 30 min in order to determine the rate of hydrolysis of carbohydrate from the dialysis tube into the buffer solution.

The values were plotted on a graph and the area under the concentration-over-time curve (AUC) was determined. The Hydrolysis Index (HI) values were calculated as the relation between the AUC of the specific food compared to the AUC of maltose as the reference food. The following equation was followed:

AUC food tested ÷ AUC reference food = Hydrolysis Index of food tested.

RESULTS AND DISCUSSION

Developed Product:

A standard muffin devoid of sweet potato and finger millet flour was prepared which served as the control. Three variations comprising of 50% maida, 50% sweet potato; 50% maida, 25% sweet potato and 25% finger millet flour; 50% maida, 30% sweet potato and 20% finger millet flour respectively were developed.

Fig 3: Variation 2 and Variation 3 of the developed products

Results of sensory evaluation on the nine-point hedonic scale.

Table 3: Results of sensory evaluation of the product on the Nine-Point Hedonic Scale by a 21-member panelist

Attributes	Control		Variation 1		Variation2		Variation 3	
	No.	%	No.	%	No.	%	No.	%
Appearance	6	28	8	38	6	23.8	4	19
Colour	3	14.2	6	28	6	23.8	3	14.2
Odour	2	9.6	3	14.2	6	28	4	19
Texture	4	19	6	28	10	47.6	6	28
Flavour	-	-	7	33.33	8	38.06	6	23.8
Overall palatability	2	9.6	8	38.06	12	67.1	10	47.6
Overall acceptability	7	33.33	14	66.66	17	80.9	19	90.4

The food product developed was a Muffin because it is a confectionary product with long shelf life and is socially acceptable to all the age groups. Its consumer acceptability was analysed by the 9-point hedonic scale since sensory evaluation is the most important aspect to for consumer acceptability. The results show higher probability of acceptance of the developed variations in comparison to the control.

Proximate Analysis: Results of proximate analysis show that moisture, ash and fibre content is highest in variation 2 followed by variation 3 (Fig 4). The glycemic index values of foods are weakly negatively related to their dietary fibre. Thus the higher fibre content in developed product contributes to slower post prandial glucose rise, thereby ensuring a non-hypoglycemic state.

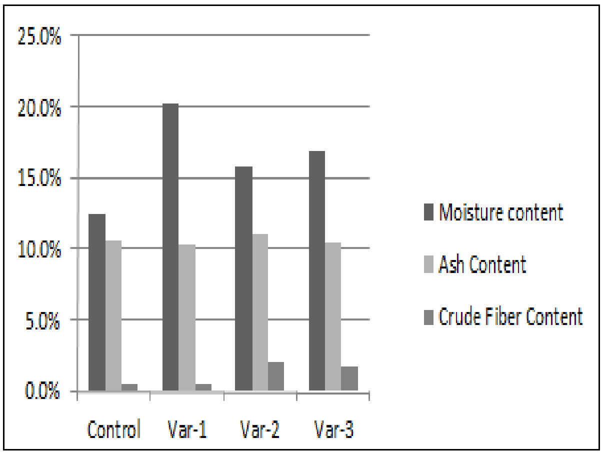

Fig 4: Amounts of Moisture, Ash and Crude Fibre Content in the control and muffin variations.

Total Protein content: The variations 2 and 3 which had finger millets as a key ingredient were found to have relatively higher protein content (Fig 5). High-protein diet foods are recommended to patients of hypoglycemia because these foods take long to be digested, thereby preventing sudden drops and spikes in blood sugar levels.[15][16]

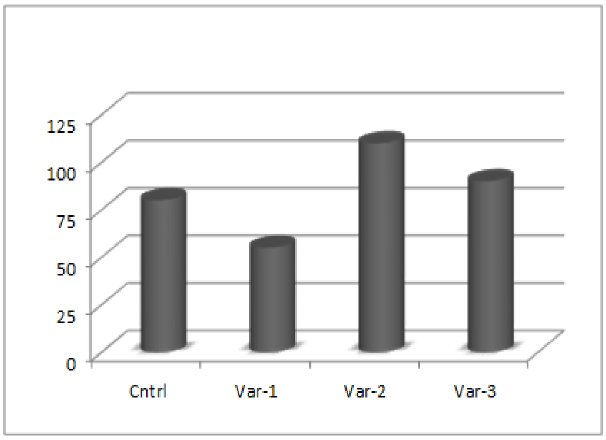

Fig 5: Levels of Total protein present in 25 g of the control and muffins variations.

Reducing and Total Sugars content: All the variations of the developed product were found to contain relatively higher amounts of carbohydrates than the control (Fig 6). However, the carbohydrate present in sweet potato and finger millet are complex carbohydrates, which take a longer time to be digested. Glucose from digested complex carbohydrates is also released into the bloodstream gradually, which helps to regulate blood glucose levels.[17] Consumption of simple carbohydrates is discouraged in patients with hypoglycemia because simple carbs such as table sugar only increase blood sugar for a few minutes.

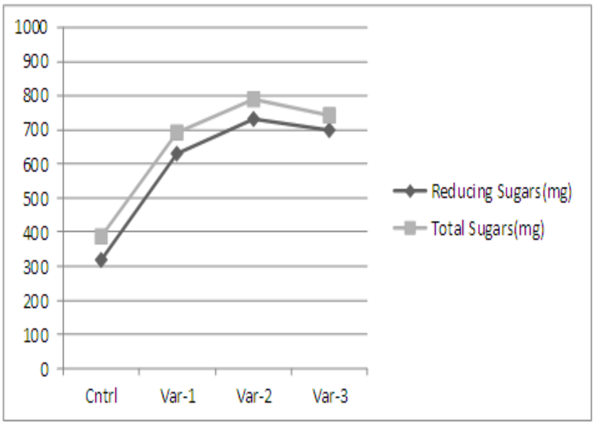

Fig 6: Levels of reducing sugar and total sugars present in 25 g of control and muffin variations.

Glycemic Index: The GI value is significantly lower in all the three variations of product developed in comparison to the control (Fig 7). However, of the three variations, variation 2 has lowest GI value, thereby making it most suitable product for hypoglycemic individuals. Lower GI values indicate slower glucose release into the blood stream, thereby making low GI foods ideal for diabetic individuals so that the blood glucose level does not spike after consumption of the food. At the same time low GI foods are extremely helpful in hypoglycemic individuals as they gradually release glucose, maintaining optimum blood glucose levels over prolonged period of time. [19]

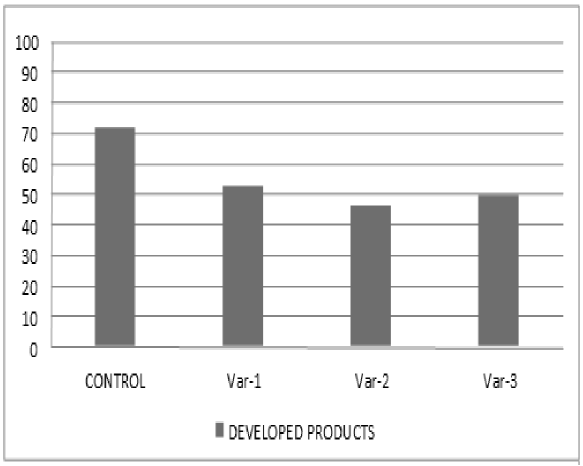

Fig 7: Glycemic Index of control and muffin variations

ACKNOWLEDGEMENT

The Authors acknowledge the financial support provided by Mount Carmel College, Bengaluru in the form of Interdisciplinary Project Funding.

CONCLUSION

The value added products developed using sweet potato and finger millet as the key ingredients, being a confectionary product with a reasonably long shelf- life were found to have high acceptability among children and adults alike, as assessed by the 9 – point Hedonic Scale. These products were found to have a low Glycemic Index (55 and below) and thus can be considered useful in the effective management of hypoglycemia. Also each variation of the developed product was found to have relatively higher amounts of crude fibre, protein and complex carbohydrates, which enhance its anti- hypoglycemic effects.

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