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Development and standardization of low glycemic index foods for type 2 diabetic patients

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Abstract

The aim of this study was keeping in view about the importance of low glycemic index foods for type 2 diabetic patients. A ready-to-eat nutritious snacks was developed by blending the flour from sprouted millets, pulses and oilseeds added with other ingredients to develop a low glycemic index food product. Two food products were developed namely Nutri wrap and Nutri ball with different ingredients from different food groups and their physical characteristics, nutritional composition, glycemic analysis and the sensory qualities of the product were analyzed. These products are very low cost, because of the easily available ingredients which is having low Glycemic Index taken for preparation. Hence it is concluded that this Nutri wrap and Nutri ball is inexpensive, nutritious, acceptable, promotes satiety and helpful in management of blood glucose level in type 2 diabetic patients.

Key words: *Diabetes mellitus, Glycemic index, Dietary fibre, Dietary carbohydrates.*

1. Introduction

Type 2 diabetes is the leading cause of cardiovascular disease, with a global prevalence of 10%. An individual's diet is considered to contribute to the development of type 2 diabetes, in particular, the capacity that foods containing carbohydrates have to increase blood glucose [1]. Along with obesity, prevalence of diabetes is increasing in all parts of the world which poses an urgent need to identify the most cost-effective strategies of management [2]. Dietary carbohydrate increases blood glucose concentration, particularly in the postprandial period. Therefore, in diabetic patients, particularly those treated with insulin or who have more severe form of type 2 diabetes, a carbohydrate-rich diet can have detrimental effects on glycemic control, which plays a major role in the development of coronary artery disease and other macro vascular and micro vascular complications [3].

India is the leading producer of small millets namely, finger millet (ragi), kodo millet (kodo), foxtail millet (kangni), barnyard millet (sawan), proso millet (cheema) and little millet (kutki) [4]. Finger millet (Ragi) has both nutritional and medicinal values .Hence, there is an increased interest in finger millet due to its excellent nutritional value and health benefits [5]. The finger millet contains important amino acids viz., isoleucine (4.4 g), leucine (9.5 g), methionine (3.1 g) and phenyl alanine (5.2 g) which are deficient in other starchy meals. Millets also contains B vitamins, especially niacin, B6 and folic acid and minerals like calcium, iron, potassium, magnesium and zinc [6]. Among cereals such as rice, wheat, barley and maize, finger millet grain has higher contents of polyphenols. High dietary fibre and phenolic content makes finger millet very beneficial for diabetic patients. Apart from this, it also has low glycemic index (GI) that makes it an ideal snack to prevent late night food thirst and helps to maintains blood sugar at a constant ratio [7]. Finger millet has manifold nutritional benefits, it contains thirty times more calcium than rice (Millet Network of India-Deccan Development Society-FIAN, 2009) [8]. Mung Beans are a small, oval type of green bean that is high in fiber and when the bean is split in half it is referred to as moong dal. Moong dal, also known as Moong, Green gram or Golden Gram or Pesalu (in Telugu) is the seed of Vigna Radiate and is native to the Indian subcontinent[9]. Nutritionally, mung bean seems to have a good potential with a higher protein content than chickpea, lower fat content than soya bean and

a considerable amount of iron [10]. Green gram is low glycemic index food, low glycemic foods promote healthy blood sugar levels [11]. Flaxseed is one of the richest vegetarian source of α- linolenic acid (omega 3 fatty acid) and soluble mucilage [12]. Among the functional foods, flaxseed has emerged as a potential functional food being good source of alpha-linolenic acid, lignans, high quality protein, soluble fiber and phenolic compounds [13]. Flaxseed has recently gained recognition as a functional food ingredient for human nutrition as its consumption has been demonstrated to provide health benefits including decreasing rate of tumor growth, reducing serum cholesterol level, decreasing risk of cardiovascular disease and cancer, particularly of the mammary, prostate gland and colon cancers, anti-inflammatory activity, laxative effects and alleviation of menopausal symptoms and osteoporosis [14]. Cucumber folk medicine includes treatment of diarrhea, gonorrhea, diabetes, hypertension and it has been used to detoxify, as an anti-inflammatory, serum lipids regulator, antioxidant, and analgesic [15]. The genus Amaranthus has received considerable attention in many countries, because of the high nutritional value of some species that are important sources of food, either as vegetable or grain. The leaves contain 17.5 to 38.3% dry matter as protein of which 5% is lysine. Vitamin A and C are also present in significant levels. Compared to spinach, Amaranthus contains three times more vitamin C, calcium and niacin [16]. The antioxidant activity of flavonoids, such as flavonols (present in Brassica species), has been reported to be greater than that of vitamins C and E [17]. Low calorific value is it's another advantage. Cauliflower is considered as one of the highest antioxidative activity among plants [18]. Many studies have suggested that increasing consumption of plant-based foods like cabbage decreases the risk of diabetes, obesity, heart disease, and overall mortality. It can also helps to promote a healthy complexion, increased energy, and overall lower weight [19]. Pearl millet is one of the four most important cereals (rice, maize, sorghum and millets) grown in the tropics and is rich in iron and zinc, contains high amount of antioxidants and these nutrients along with the antioxidants may be beneficial for the overall health and wellbeing [20]. Lignans are a group of natural compounds defined as oxidative coupling products of beta-hydroxyphenylpropane. Sesame seed contains some specific lignans such as sesamin, sesaminol, and sesamolin [21]. The monounsaturated and polyunsaturated fatty acids found in cashews can help decrease LDL cholesterol and triglyceride levels. This reduces the risk of cardiovascular disease, stroke, and heart attack. Cashews also contain vitamins C and B, including 7 micrograms (mcg) of DFE folate [22]. Both honey and cane sugar have GIs of around 50, while the GI of coconut palm sugar, as reported by the Food and Nutrition Research Institute of the Philippines, is 35 [23]. Green cardamom (Elettaria cardamomum) is a dietary spice (in the ginger family) with nutraceutical effects that has antioxidant, anti-inflammatory and anti-carcinogenic properties. In a recent study, indicated that cardamom supplementation by suppression of αamylase and α-glycosidase enzymes has anti-diabetic effects and may regulate glucose metabolism [24]. All major and minor food groups included food products developed in this study.

2. Objectives

1) To select low Glycemic Index foods for preparing Nutri wrap and Nutri ball for Type-2 diabetics.

2) To prepare low Glycemic Index Nutri wrap and Nutri ball by using sprouted flours (whole grains, pulses, seeds) along with other ingredients by applying standard procedures.

3) To analyze the nutrient compositions and antioxidants present in the prepared Nutri wrap and Nutri ball.

2. MATERIALS AND METHODS

2.1. Procurement of raw materials

The raw materials were procured from the Salem local market, Tamilnadu namely ragi, green gram dal, flax seed, cauliflower, cabbage, cucumber, A.blitum for Nutriwrap and kambu, sesame seed, cashews, palm sugar and cardamom for Nutri ball.

2.2. Preparation method of Nutri wrap

Mix all the sprouted flours of finger millet (35 g), green gram dal (30 g) and flax seed (15 g) in a bowl and add a little amount of hot water to make a dough. Once the dough is formed, knead it properly for several times to make a wrap neatly. If needed, oil can be touched to avoid stickiness while wrapping the flours. All the stuffing veggies such as cauliflower, cabbage, A.blitum each (5 g) is boiled before stuffed into a wrap. Cucumber is need not to be boiled as it is easy to eat raw. After boiling the vegetables, put all the vegetables in an appropriate amounts and make it as a stuff in a

wrap and steamed the whole wrap till it gets cooked.

2.3. Preparation method of Nutri ball

Mix all the ingredients such as sprouted pearl millet flour (70 g), sesame seed (15 g), cashews (10 g), palm sugar (5 g) and cardamom (needed) to add flavor in a bowl in an appropriate amount and add hot water slowly to get a dough like form. After getting like a dough, make like a small round sized ball in which 100g proportioned ingredients can make 8 medium sized Nutri ball. Then steam the Nutri ball till it get cooked.

2.4. Sensory evaluation of the developed food product

The sensory evaluation of developed Nutri wrap and Nutri ball is done by twenty subjects selected by using 9 point hedonic scale which gives scores like 9 to 1. The attributes which is assessed for prepared Nutri wrap and Nutri ball is appearance, color, flavor, taste, texture and overall acceptability. The statistical analysis to determine the level of significance. The statistical analysis was done by using SPSS.

2.5. Nutrient analysis and antioxidant activity of Nutri wrap and Nutri ball

The nutrients such as carbohydrate counting, protein, fat, dietary fibre, vitamin C, iron and calcium and glycemic index, glycemic load and antioxidants were analyzed using standard procedures for both Nutriwrap and Nutriball.

Glycemic Index: The total blood glucose response was expressed as the incremental area under the blood glucose response curve (IAUC), ignoring the area beneath the baseline, and was calculated geometrically using the trapezoidal rule. The mean, and the IAUC of each subject's repeated reference food (50 g of carbohydrate from white bread) were calculated. The IAUC of oat beverage by each subject was expressed as a percentage of the mean IAUC of the reference food eaten by the same subject. The glycemic index value (GI) of the oat beverage was taken as the mean for the whole group (Brouns et al., 2005).

Glycemic Load: The incremental area under the post-prandial blood glucose curve (IAUC), ignoring the area beneath the baseline, was calculated geometrically for each tested food (Wolever et al., 2008), and the GI was evaluated as a percentage of the mean IAUC of the reference glucose solution consumed by the same subject (GI = IAUC test food/IAUC reference food × 100). When the individual GI values for any subject fell outside the range of values calculated as mean ± 2 SD (standard deviation), this result was considered as an outlier and was thus excluded from the mean GI calculation. The glycemic load (GL) of a specific serving of each food was calculated using the formula: GL = GI food/100 × g of available Foods 2017, 6, 83 5 of 10 carbohydrates in the portion. Based on the consumption habits observed in Côte d'Ivoire (Kouame et al., 2015), the GL of the different tested foods was calculated.

Determination of carbohydrates: The carbohydrate content was determined according to the method of Dubois et al., 1956. The absorbance was read at 490 nm against a reagent blank. The analysis was performed in triplicates and the results were expressed as mg/g sample.

Determination of proteins: Protein content was determined according to the method of Lowry et al., 1957. Absorbance was read at 660 nm against a reagent blank. The analysis was performed in triplicates and the results were expressed mg/g sample.

***Determination of crude fat*:** Crude fat was determined by ether extract method using Soxhlet apparatus.

% Crude fat = Weight of ether extract X 100/ Weight of Sample.

Determination of Dietary fibre: This was done on moisture-free, ether-extracted powdered sample. % crude Fibre = W1- W2 X 100/ Weight of Sample.

***Vitamin C Estimation*:** Vitamin C in the seed sample was estimated using the method of Omaye et al. (1971). Absorbance was determined at 520 nm.

Determination of metals: All the atomic measurements are carried out with PerkinElmer model 400/HGA 900/AS 800 coupled with Mercury Hydride System-15 (MHS-15) and Flame Photometer.

DPPH radical scavenging activity: DPPH radical scavenging activity was carried out by the method

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of Molyneux (2004). All the nutrients and antioxidants were analyzed by using these standard procedures.

3. Results and discussion

3.1. Physical characteristics of Nutri wrap and Nutri ball

The physical characteristics of the Nutri wrap and Nutri ball. Height in cm and weight in g were measured for both samples. Nutri wrap was measured with the height of 12 cm and 40 g in weight as initial value. After steaming, the weight of sample is increased to 44.3 g. For 100 g of ingredients, one piece of Nutri wrap can made.For Nutri ball, around 7 pieces of balls can be made by 100 g of taken ingredients. One Nutri ball weighs about 10g and 3.5 cm in height and its diameter was about 3.5 and also its circumference was measured as 11.

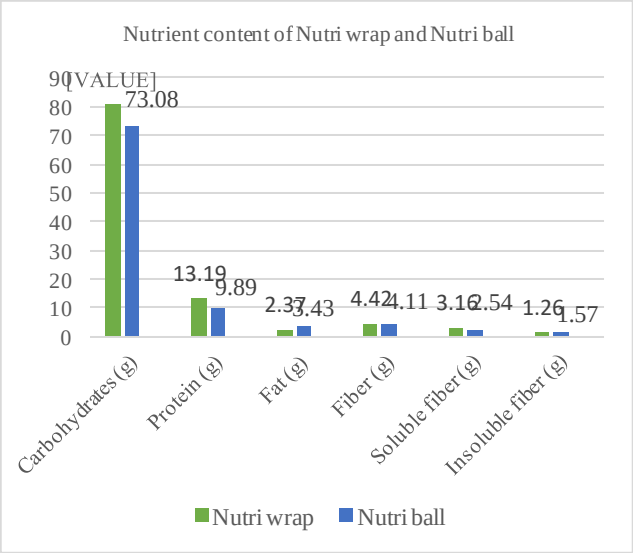
3.2 Analysis of the nutrient content of the nutria warp and nutria ball

Table-1-Nutrient content and graphical represents of Nutri wrap and Nutri ball

N:	Parameters (Gm)	Nutri wrap	Nutri ball
		Mean ± S.D	Mean ± S.D
1	Carbohydrates	80.77 ± 0.56	73.08 ± 0.42
2	Protein	13.19 ± 0.10	9.89 ± 0.56
3	Fat	2.37 ± 0.44	3.43 ± 0.36
4	Fiber	4.42 ± 0.17	4.11 ± 0.03
5	Soluble fiber	3.16 ± 0.02	2.54 ± 0.06
6	Insoluble fiber	1.26 ± 0.16	1.57 ± 0.63

The above table indicated that Nutri wrap contains 80.77 g of carbohydrates, 13.19 g of protein, 2.37 g of fat, 4.42 g of fibre, 3.16 g of soluble fibre and 1.26 g of insoluble fibre and the other table showing that carbohydrate is having 73.08g, protein of 9.89g, fat of 3.43g, 4.11g of fibre, 2.54g of soluble fibre and 1.57g of insoluble fibre.

The P value is lesser than the t value i.e. 0.920 < 2.221. So we reject the null hypothesis (H_0). Since Nutri ball is slightly better than Nutri wrap.



3.2.1. Vitamins and Mineral Content of Nutri wrap and Nutri ball

Micro may mean small, but micronutrients are far from insignificant. Without a regular supply of micronutrients, our bodies would literally starve. Micronutrients include all vitamins and minerals we take it in, often without realizing, and are an essential part of a diabetic diet.

The below table showed that Nutri wrap contains 2.69 mg of vitamin C, 3.57 mg of iron and 34.33 g of calcium and the other table represented that Nutri ball contains 0.13 mg of vitamin, 2.13mg of iron and 32.09mg of calcium.

Table-2 Vitamin and mineral content of Nutri wrap and Nutri ball

S. no	Parameters (Mg)	Nutri wrap	Nutri ball
		Mean ±S.D	Mean ± S.D
1	Vitamin C	2.69 ± 0.23	0.13 ± 0.07
2	Iron	3.57 ± 0.36	2.13 ± 0.02
3	Calcium	34.33 ±3.70	32.09 ± 0.07

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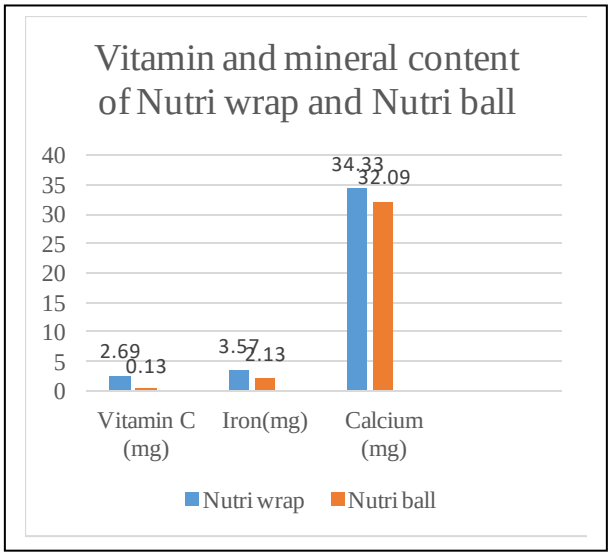
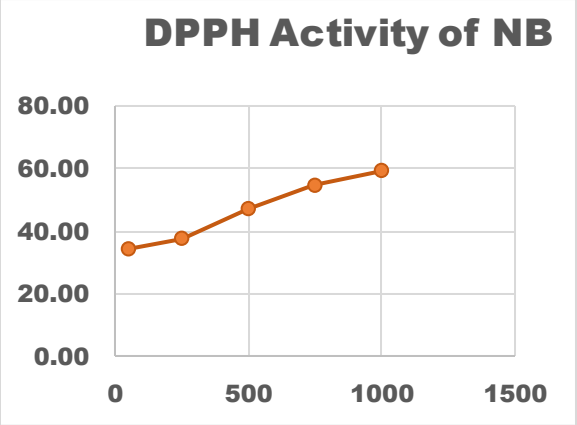


3.2.3. DPPH analysis of Nutri ball

Nutri ball antioxidant activity concentrations was analyzed 50-1000 level .antioxidants indicated the nutria ball are 626.55 percent. The graphical results indicated the DPPH activity pathway of nutria ball.

Table-3 DPPH analysis of Nutri ball

Concentration	IC_{50}	IC_{50}
50	34.46	626.55
250	37.84	
500	47.3	
750	54.73	
1000	59.46	



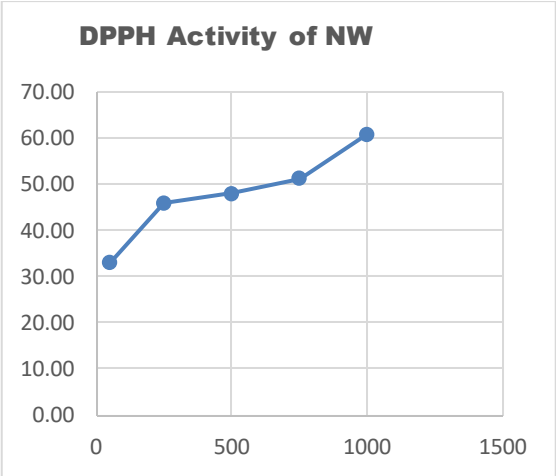
3.2.3. DPPH analysis of Nutri wrap

Table-4 DPPH analysis of Nutri wrap

Nutri warp antioxidant activity concentrations was analyzed 50-1000 level .antioxidants indicated the nutri warp are 595.57 percent. The graphical results indicated the DPPH activity of nutria warp.

Table-4 DPPH analysis of Nutri wrap

Concentration	IC_{50}	IC_{50}
50	33.11	595.57
250	45.95	
500	47.97	
750	51.35	
1000	60.81	



3.2.4 Glycemic analysis of Nutri wrap and Nutri ball

The glycemic index and glycemic load of Nutriwrap and Nutriball were calculated. It was calculated for Nutriwrap and the results presented in the below table results presented in the below table.

Table-5 Glycemic index and glycemic load of Nutri wrap and Nutri ball

S.no	Parameters	Mean ± S.D
1	Glycemic index of Nutri wrap	22.02 ± 0.19
2	Glycemic load of Nutri wrap	17.78 ± 0.17
3	Glycemic index of Nutri ball	12.22 ± 1.67
4	Glycemic load of Nutri ball	8.23 ± 0.03

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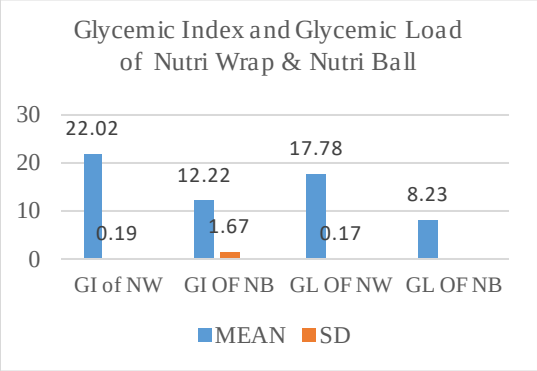

The results that 100 g of Nutri wrap contains glycemic index of 22.02 and glycemic load of 17.78 and the table revealed that 100 g of Nutri ball contains glycemic index of 12.22 and glycemic load of 8.23.From the above tables, Nutri ball is having low glycemic index when compared to Nutri wrap. It shows that glycemic load of Nutri ball is very low when compared with glycemic load of Nutri wrap. The amount of carbohydrate in Nutri ball is very low that has little effect on blood glucose which has low glycemic load. A glycemic load of 10 or less is considerably low, 11 to 19 is medium and 20 or more is high. Carbohydrates with a low GI value (55 or less) are more slowly digested, absorbed and metabolized and cause a lower and slower rise in blood glucose and, therefore usually, insulin levels. Hence comparatively Nutri ball is having very low glycemic index and glycemic load.

3.3. Cost Calculation of the developed products

The cost calculation of Nutri wrap indicated 48 rupees for 100 g wrap and can make one whole wrap. The cost calculation for Nutri ball indicated that 28 rupees for 100 g taken ingredients of Nutri ball and can get 7 medium sized balls.

4. CONCLUSION

Diabetes prevalence has been rising more rapidly in middle- and low-income countries. The key point in controlling in diabetes is to eat a variety of healthy foods from all food groups. From each food groups, millet, pulses, vegetables, greens, nuts and oil seeds were prepared, the product named Nutri wrap and Nutri ball were developed. These two were developed as the low glycemic index and low glycemic load food products for an adult diabetics. The product Nutri wrap developed with sprouted finger millet flour, sprouted green gram dal flour, sprouted flax seed flour along with vegetables which are low in glycemic index and shows beneficial effects for blood glucose maintenance. The other product Nutri ball was developed with sprouted pearl millet flour, sesame seeds with few more ingredients which was very powerful in controlling diabetes. These two products were analyzed for glycemic index, glycemic load, carbohydrates, protein, fat, dietary fibre, vitamin C, iron and calcium. The glycemic index and glycemic load of Nutri wrap was observed with 22.02 and 17.78 respectively and for the Nutri ball was 12.22 and 8.23.respectively.Comparatively Nutri ball is more acceptable due to its low glycemic index and glycemic load and also the carbohydrate content is less. A sensory panel of members evaluated the acceptability of the Nutri wrap and Nutri ball, in terms of colour and appearance, texture, flavor, mouth feel, taste and overall acceptability. By this evaluation the products are acceptable to diabetics and have potential of increasing health benefits. The products are inexpensive because the ingredients taken for preparation are easily available. Hence it is concluded that this Nutri wrap and Nutri ball is inexpensive, nutritious, acceptable, promotes satiety and helpful in management of blood glucose. Nutri wrap and Nutri ball can be suitable for diabetic patients as it is very low in glycemic index and glycemic load. It helps in maintaining the blood glucose levels and low fat diet reduce the incidence of atherosclerosis which is more common in diabetes.

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