Egyptian Journal of Nutrition
Official journal of the Egyptian Nutrition Society
Print ISSN: 1687-1235
Online ISSN: 2090-2514
Vol. 39 (3): 14 – 28 (2024)
https://ejn.journals.ekb.eg/

Effect of Different Processing Methods on Glycemic Index(GI) of Value Based Products Added Barnyard Millet (Echinochloa frumentacea Link.)

[1]Rokhade, Chandramati Jinnappa [2]Mysore, Surekha Nagaraj

[1]Shri Dharmasthala manjunatheshwar medical College and Hospital, SDM University, sattur, Dharwad, Karnataka

[2] Government Home Science College Hassan, Karnataka. Dept. of Collegiate Education, Govt. of Karnataka, Bangalore, India

ABSTRACT

Millets are small seeded annual grasses with good nutritional profile.Among millets, Barnyard millet is one of the important minor millet having nutritional and therapeutic importance. The present investigation was undertaken to study the effect of different processing methods on Glycaemic Index (GI) of value based products added Barnyard millet *(Echinochloa frumentacea* Link.) based products. GI is a measurement carried out on carbohydrate containing foods and their impact on blood sugar. Barnyard millet based products such as Noodles, Cookies and *Khakara* were developed by extrusion, baking and roasting methods respectively. Value addition with pulses to these products was carried out at different level (10%, 15% and 20%). By sensory evaluation the highly accepted products were subjected to nutritional and GI studies. The nutritional analysis and GI study was carried out by following standard procedures. The GI study was conducted on eighty healthy female adult volunteers. The volunteers were given glucose and test carbohydrate separately on alternate days after 12 hour overnight fasting. The rise in blood glucose level after consumption of glucose e and test carbohydrate was measured to assess the GI. The result of the present investigation indicated that there was increase in macro and micronutrient composition after value addition with pulses. Pulse cookies recorded low Glycemic Index value (24.42) which was statistically significant from Pulse Noodles (35.68) and Pulse *khakara* (37.95**)**.Thus, it was concluded that among the three different processing methods, products prepared from baking elicited low Glycemic Index value followed by extrusion and roasting methods.

Keywords: Barnyard Millet, Glycemic Index, Extrusion, Baking and Roasting

Received:3-8-2024 ***Accepted:26-8-2024*** ***Published: 1-9-2024***

INTRODUCTION

Millet is a collective term referring to a number of small-seeded annual grasses. In Africa and India, millet has been used as a staple food for thousands of years. Today millet ranks as the sixth most important grain in the world, sustains 1/3 of the world's population. (http://www.agriculturalproducts india.com/cereals-pulses/cereals-millets.html). It is a tall erect annual grass with its short growing season and can be harvested within 65 days. Millets grow in harsh environments, on poorly fertilized dry soils and in areas which receive low rainfall. The minor millets are familiar staple foods among weaker sections of the society in developing countries and of great economic importance in starch-making and malt industry. However, exploitation of these minor millets as a ready to eat food products is limited.

The nutritive value of millets is comparable to other cereals with regard to protein, fat and mineral contents **(ICAR 1987 and Gopalan *et al*. 2004)**. Millets contain higher proportion of unavailable carbohydrate and hence release of sugar from millet is slow. Millets contain water soluble gum, β-glucan that is useful in improving glucose metabolism **(Anderson *et al*., 2003).**Therefore millets are suitable for diabetes but the characteristic flavor and difficulty in processing are the limitations for its incorporation in diets.

Millets like foxtail, little, proso, and barnyard millet are good sources of dietary fiber and are beneficial in diabetic diet and other metabolic disorders **(Geetha and Easwaran, 1990 and Vijaylakshmi and Radha, 2006).** But the utilization of these millets is limited due to presence of anti nutrient, poor digestibility of protein and carbohydrates and low palatability **(Thompson and Yoon 1984, Pawar and Parlikar 1990, Chitra *et al* 1996).**However various processing treatments are known to affect the chemical composition and improve nutritive value of foods (Kadlag *et at*., 1995).Processing also enhances the palatability of millet. Moreover, these mighty minor millets have excellent capacity to blend with other food grains. They do not impart any off flavor after taste and thus can be incorporated in traditional foods for value addition and for novel end uses (Veena,2001).

Among millets, Barnyard millet (*Echinochloa frumentacea* Link.) is one of the important nutritious minor millet. Several experiments have proved the beneficial role of barnyard millet as an effective faecal bulking, hypoglycemic and hypolipidemic agent due to the presence of higher proportion of unavailable complex carbohydrate, resistant starch and slow release of sugars **(Krishna Kumari and Thayumanavan, 1997).**Further, barnyard millet having low glycaemic index value can be utilized in designing therapeutic, nutritious and acceptable food products as an effective supportive therapy in the treatment of diabetes mellitus **(Arora and Srivastava, 2002).**

Glycemic Index (GI) is ranking of carbohydrates based on their immediate effect on blood glucose level. Carbohydrates that break down quickly, releasing glucose rapidly into the blood stream have the highest GI.On the other hand carbohydrates that break down slowly releasing glucose gradually into the blood stream have the low GI.Diets with low glycemic index are recommended for all pre-diabetics, diabetics and for health conscious people as they provide numerous health benefits.Selection of foods with lower glycemic index would contribute in prolonging the absorption of glucose thereby improving the glycemic profile and reducing insulin requirements and fasting lipids. GI is affected by many factors such as protein and fat, nature of carbohydrate, anti-nutrients, enzyme inhibitors and the presence of starch-nutrient interactions, food processing and cooking, ripeness and food storage.

Supplementation of cereal based products with millets has become increasingly popular due to nutritional, therapeutic and economic advantages. With proper preparation, 30 per cent of minor millets can be gainfully substituted for value added foods such as bakery products, extruded foods and allied mixes for the convenient preparation by rural and town folk at low cost. Further, in the present existing situation of the society it is the need of the day to exploit the positive nutritional benefits of millets and popularize them among all the sectors of the society for achieving nutritional and therapeutic food security.

Therefore considering the therapeutic benefits of barnyard millet with suitable processing protocol, the present investigation was undertaken to study the effect of different processing methods on Glycemic Index(GI) of value added Barnyard Millet *(Echinochloa frumentacea* Link.) based products to cater to the needs of the population or urging society.

MATERIALS AND METHODS

The basic raw material barnyard millet and other ingredients such as pulses/legumes namely soybean and green gram *dhal* were purchased from local market. All the materials were collected in one lot, Barnyard millet constituted the main ingredient and other ingredients were pulses as source of lysine and dietary fiber wewr utilized for value addition to basic barnyard millet based food products were added either as a source of lysine, antioxidants, minerals, dietary fiber or hypoglycaemic constituents. Barnyard millet was procured from local market and the grains were cleaned by sedimentation process to separate sand grits and other heavy particles. These grains were shade dried (24 hour) and then sun dried and stored in air tight containers for further use.

Pulses as a source of lysine and dietary fiber were utilized for value addition to basic barnyard millet based food products. Common pulses such as soybean and green gram *dhal* were incorporated at varied levels and evaluated for acceptability. Prior to the preparation, all the procured food materials were cleaned and made free of soil and unwanted material, made into flour and stored in air tight containers at room temperature. Green gram *dhal* was made into fine flour with the help of an electric mixer. Millet grains and whole wheat were made into flour with the help of an electric mixer (Model Supreme ***Flora).

The soy flour was made by roasting the whole soybean for 5-10 minutes at 80^0 C on low flame. Later, it was made into *dhal* by passing through household grinder. During this process the *dhal* was dehusked. The ground *dhal* was cleaned and separated from husk and then made into fine flour with the help of domestic electric mixture, which was then used for preparation of value added products.

Spices were added to pulse khakara as a source of dietary fiber or as anti-carcinogenic, hypoglycaemic, hypocholesterimic and diuretic constituents. These spices were cleaned for any foreign material and then roasted for 5 to 8 min at 80^0C on low flame. Spices were then powdered using an electric mixture. The spice powder was again sieved (Sieve mesh No 65 mics).

Three products namely noodles, cookies and *khakara* were developed utilizing barnyard millet and pulses. Each variation comprised of barnyard millet flour, soybean flour and green gram *dhal* flour in different ratios as 70:15:15 (variation I), 60:20:20 (variation II) and 50:25:25 (variation III). Pulse cookies comprising of barnyard millet flour, soybean flour and green gram *dhal* in different ratio as 40:5:5 (variation I), 30:10:10 (variation II) and 20:15:15 (variation III).were developed. Three variations of pulse *Khakara* were developed. Each variation comprised of barnyard millet flour: wheat flour: soybean flour: and green gram *dhal* flour in the ratio of 40:40:10:10 (variation I), 30:40:15:15 (variation II) and 20:40:20:20 (variation III) and evaluated for acceptability.

Organoleptic Quality

Consumer acceptability of any food product depends on organoleptic appeal, storage quality and also nutritional qualities. Hence, the value added barnyard millet based products were evaluated for organoleptic quality attributes by ranking the responses using a 5 point Hedonic Scale **(Amerine *et al.*, 1965)** by a panel of ten semi-trained judges.

Nutrient Analysis

Each selected developed value added products were analyzed in triplicate for moisture, protein, fat, total mineral, iron, calcium, magnesium, phosphorus, vitamin C, total and β-carotene. Moisture, fat and total minerals were estimated by AOAC (2005) method. The crude fiber in developed products was analysed by the procedure given by AOAC (1990).While protein and carbohydrate content was found out by (NIN, 1983). The energy content of value added products were computed by summing up the values obtained by multiplying the values with Atwater constants for carbohydrates, crude fat and protein with the 4, 9 and 4, respectively. Vitamin C by titration method **(A.O.A.C. 1984)** total and β-carotene was estimated by procedures given by **Zakaria (1979).** Iron, calcium and magnesium were analyzed by Atomic Absorption Spectrophotometer (AAS) (Model: AAS Analyst 700). Phosphorus was calculated by using food composition tables **(Gopalan et al., 2004).**

Glycemic index

Glycemic response in terms of glycemic Index (GI) was evaluated following the methods of Jenkins *et al*. (1981) in normal volunteers. The value added barnyard millet based food products were tested for glycemic response among eight healthy female adult volunteers. The volunteers were administered glucose and test carbohydrate (50 g, food products) separately on alternate days, after 12 hour overnight fasting. The rise in blood glucose level after consumption of glucose and test carbohydrate was measured to assess the GI. The subjects were asked to consume the foods within 15 minutes and the capillary blood samples were drawn by finger prick method using lancet at 0, ½, 1, 1 ½ and 2 hours intervals for estimation of glucose level using Glucometer (One touch). The blood glucose response curves were plotted for both glucose and test carbohydrate meal. With the help of the graph, the postprandial incremental areas were calculated and the glycemic index of value added products was determined following the formula given by **Wolver and Jenkins (1986).**

$$GI = \frac{\text{Incremental area under blood glucose curve for test food}}{\text{Incremental area under blood glucose curve for reference food}} \times 100$$

Statistical Analysis

The analysis of variance (ANOVA) was used to find out significant differences between the variations for different sensory characters and for glycemic index. For glycemic index, the ANOVA was carried out to know the significant differences in glucose levels between the intervals of the experiments **(Panse and Sukhatme, 1985). .**

RESULTS AND DISCUSSION

RESULTS

. Table 1 explains the mean acceptability scores of noodles with variations in pulses. There was non- significant difference among the variations with respect to the sensory parameters except for overall acceptability. The scores of overall acceptability of variation II were significantly ($p<0.05$) high over variation I and III. Variation II containing barnyard millet flour: soybean flour: green gram *dhal* flour in the ratio of 60:20:20 was highly acceptable and it was statistically significant from the other two variations.

Three variations of pulse cookies were developed each variation comprised of barnyard millet flour, soybean flour and green gram *dhal* flour respectively in different ratio. (table 2). There was significant difference among all variations with respect to all sensory parameters. The Mean scores for acceptability ranged from 3.60 (color) to 4.06 (texture). Overall sensory scores of pulse cookies revealed that cookies prepared with 10 per cent of incorporation of pulses was highly acceptable and scored highest (4.50) over the other two cookies. The sensory scores of variation II was significantly higher ($p<0.05$) than variation I for all the parameters. The scores of variation III were at par with variation II for all the sensory parameters. Variation III scored statistically higher ($p<0.05$) score for all the parameters as compared to variation I.

The Mean acceptability scores for *khakara* prepared with incorporation of pulses to barnyard millet are presented in table 3.There was a significant difference among all the variations for different sensory characters. The Mean scores for acceptability ranged from 3.30 to 3.83 with lowest score for taste and highest score for color respectively. Variation I scored significantly higher ($p<0.05$) values for all the sensory parameters when compared to variation II and variation III. The scores of variation II and variation III were at par for all the sensory characters. The overall acceptability scores decreased as the level of incorporation of pulses increased. The overall acceptability score ranged from 2.80 (III variation) to 4.80 (I variation) with highest score for *khakara* prepared with 10 per cent incorporation of pulses.

Glycemic index of value added products

The glycemic index of value added products from barnyard millet was tested by feeding individuals the highly accepted value added products and recording the rise in blood glucose level at fasting and at an interval of 30 to 120 minutes.

Glucose response of developed value added barnyard millet products

The three types of value added products viz., pulse noodles, cookies and *khakara* were fed to the selected sample and their glucose response at different intervals was recorded and presented in comparison to control sample who were given glucose. Later the results are presented by comparing the glucose response of all the three value added products at different intervals (Table 5) and their glycaemic index values (Table 6).

In case of pulse noodles when control sample were fed the glucose the mean fasting levels were 93.00 mg/dl which rose to 110.16 mg/dl by 60 minutes. After 90 and 120minutes, the glucose level gradually decreased recording 100.00 mg/dl and 87.83mg/dl, respectively. There was a significant difference in blood glucose level at fasting and at 60 minutes of interval while non-significant difference at fasting and at 120 minutes after feeding interval was noted. When value added pulse noodles was fed, non-significant differences were noted with pulse noodles at different intervals of feeding where the values ranged between 92.66 mg/dl at 0 minutes to 91.33 mg/dl at 120 minutes. The value reached its peak at 60 minutes interval (98.33 mg/dl) and then gradually declined (table 4).

In case of pulse cookies, when control sample were fed the glucose the mean fasting levels were 93.50 mg/dl which rose to 109.66 mg/dl by 60 minutes. After 90 and 120minutes, the glucose level gradually decreased recording 100.16 mg/dl and 88.50mg/dl, respectively. There was a significant difference ($p<0.05$) in blood glucose level at fasting and at 60 minutes of interval while non-significant difference was recorded at fasting and at 120 minutes after feeding interval was noted. However, when pulse cookies were fed, no significant differences were noted at different intervals of feeding. The values recorded 88.00 mg/dl at 0 and 85.50mg/dl at 120 minutes. The values reached its peak at 60 minutes interval (92.00 mg/dl) and then gradually declined (table 4).

In case of pulse *khakara,* when control sample were fed the glucose the mean fasting levels were 92.50 mg/dl which rose to 109.33 mg/dl by 60 minutes. After 90 and 120 minutes, the glucose level gradually decreased recording 97.50 mg/dl and 85.00 mg/dl, respectively. There was a non-significant difference in blood glucose level at fasting and at different time intervals 30 minutes to 120 minutes). When value added pulse *Khakara* was fed non-significant differences were noted at different intervals of feeding. The values recorded 89.83 mg/dl at 0 and 88.83 mg/dl at 120minutes. The values reached its peak at 60 minutes interval (96.00 mg/dl) and then gradually declined (table 4).

Table 5. shows the mean glycaemic index values of all the three value added products. Based on the rise in blood glucose level the Glycaemic Index (GI) of all the three value added products was calculated and the results of the study are presented in Table 6. The mean glycaemic index values were found to be 32.67 per cent where the values ranged from 24.42 to 37.95 per cent. The least glycaemic index value was recorded by pulse cookies (24.42) and highest value was recorded by pulse *Khakara* (37.95).Pulse cookies exhibited significant ($P<0.05$) low glycaemic index value over the other two products. However, there was a non-significant difference among pulse noodles and *Khakara*.

DISCUSSION

Among pulse noodles and cookies the incorporation of pulse i.e., soybean flour and green gram *dhal* flour in equal proportions at 20 per cent for noodles and 10 per cent level for cookies resulted in significantly high overall acceptability (table 1 & 2). Though the other sensory characters exhibited non-significant difference, in general their sensory scores were high as compared to variation I and III, which supported the opinion that variation II is better accepted as compared to other two variations. The overall acceptability of variation II in both pulse noodles and pulse cookies was significantly high. These findings reveal that pulse incorporation in barnyard millet at 20 per cent level for noodles and 10 per cent level for cookies is desirable and the better acceptability noted could be attributed to the sensory and chemical properties of both the pulses. When critically considered the acceptability scores of pulse noodles revealed that for variation II, scored highest for overall acceptability (4.10) followed by taste (4.0). The addition of soybean enhanced hidden fat content of the product which might have resulted in better acceptability of the product. On the other hand, pulse incorporation at 10 per cent level for each pulse resulted in better acceptability scores for pulse cookies. Pulse cookies, variation II scored highest for texture (4.60) followed by overall acceptability (4.50) than variation I which contained only 5 per cent incorporation of each pulses. Oluwamukomi *et al*. (2011) also reported better acceptability of biscuits when soy flour incorporation increased**.** Lakshmi **Devi and Khader (1997)** developed vermicelli with pulse blends for geriatrics' where they have used three *dhal* flour i.e., black gram *dhal*, green gram and bengal gram flour at 25 per cent incorporation and reported better acceptability of green gram *dhal* flour over bengal gram flour. Even in the present study the noodles containing 20 per cent of green gram *dhal* flour i.e. variation II exhibited better acceptability.

The variation I scored least marks for several sensory characters. This variation contained lowest incorporation of pulses as compared to variation II. The least scores could be attributed to low incorporation of pulses because the bland taste of barnyard millet flour is dominating the product. Further, the variation I contained 10 per cent incorporation of soy flour as compared to variation II which contained 20 per cent incorporation of soybean. Several other studies reported less acceptability of developed products when 10 per cent of soybean was incorporated in the product as against 20 per cent incorporation **(Deshpande *et al*., 2004 and Singh *et al*., 2004).**

Variation III scored least acceptability over variation II probably due to more per cent of incorporation of soybean. According to Surarez *et al*. (1999) soy flour is high in oligosaccharide, raffinose, stachyose and is characterized by beany flavor that may be objectionable to some consumers. Sheth *et al*. (2009) developed a high protein pulse analogue by extrusion process using more soy flour and less wheat flour and reported that the characteristic, chewy, grainy nature of soy flour could not be significantly altered even by extrusion cooking method which affected the mouth feel and other sensory characteristics resulting in low acceptability. The pulse noodles developed in the present study with more incorporation of pulses were less acceptable due to above reasons.

Khakara is a famous Gujrati snack item usually prepared from wheat flour. The whole process of preparation of *khakara* almost resembles chapatti except for roasting process. During roasting, pressure is applied with cloth bundle or wooden bundle to avoid puffing so that crispy texture will be obtained. For preparation of *khakara* gluten content in wheat flour plays an important role for flexible and smooth rolling and to obtain required shape and texture.

However, barnyard millet flour doesn't contain any gluten (http://www.gramene.org/species/setaria/foxtailmillet_intro.html) which is causing poor acceptability of 100 per cent barnyard millet flour *Khakara* due to its poor texture. It is for the same reason the acceptability score increased as wheat flour increased in *khakara*. In pulse *khakara,* as the pulse content increased the acceptability decreased. Though the pulses are rich in protein they do not contribute to increased gluten. Instead the carbohydrates present in pulses increased starch content in the mixture which interferes with the different sensory characters and functional properties of other flour. Hence the variation with least incorporation of pulse resulted in high acceptability.

Perusal of the table 4 revealed that in most of the cases the mean blood glucose level significantly increased ($p<0.05$) when glucose feeding was carried out. Glucose is the basic sugar present in blood. Therefore consumption of glucose in any form is directly absorbed into the blood and increases the blood glucose level. Therefore glucose is used as the standard for any glycaemic index studies **(Wolever *et al*., 1991).** In the present study glucose is used as standard and the blood glucose levels significantly ($p<0.05$) raised after consumption of glucose in the selected control subjects because of easy digestion and readily absorbable quality of glucose. On the other hand when developed products were fed to the experimental subjects such drastic increase in glucose level was not noticed. This is because the products contained mixture of several foods**. Choudhary (2011)** also reported less increase in blood glucose levels in experimental subjects. In the present study the developed products contained different products such as millet, pulses namely soybean and green gram *dhal* flour and spices such as seeds of fenugreek, cumin, coriander and omum. All these foods not just provide glucose but also other nutrients such as protein, fiber and few anti-nutrients which contribute to slow rise in blood glucose levels. Therefore in the present study the experimental group exhibited non-significant ($p<0.05$) differences with respect to glucose levels at different intervals when feeding was carried out with developed products namely noodles, cookies and *khakara*. Blair *et al.* (2006) reported that soy-based foods generally have a low to medium GI value and would be suitable for individuals concerned with regulating blood glucose and insulin levels.

Reported the blood glucose levels at different levels for different products. From the observations it is evident that the peak level reached at 60 minutes after feeding and is gradually declined after 60 minutes. This is in line with the physiological principal that blood values increase after 1 hour and gradually decline. Similar findings are also reported by **Choudhary (2011).** Further, in the present study all the products were tested on normal individuals. Therefore the values increased upto 60 minutes of feeding and gradually declined. In case of diabetic subjects the pattern of decline is not usually recorded unless the person is under medication (Swaminathan, 2008). Since all the subjects experimented in present study were normal subjects without any complications of diabetics and all the products were prepared combining different foods. The increase and decline of glucose levels at different intervals was noted to be non-significant ($p<0.05$).

The glycemic index values of developed products is presented in fig 2. It was evident from the result that all the products exhibited low glycaemic index value, where the values recorded for GI value were below 50. According to Raghuram *et al* (1993) foods with GI less than 40 are classified as low and above 65 as high GI foods. In the present study the highest GI value recorded for pulse khakara(37.95). Thus, the recorded highest GI value of product is less than 40 indicating that all the three products having low GI can be included in diabetic diets.

Millets contain higher proportion of unavailable carbohydrate and hence release of sugar from millet is slow. Millets contain water soluble gum β-glucan that is useful in improving glucose metabolism **(Anderson *et al*., 2003).** In addition to it millets supply phytochemicals that enhance the health benefits and the dietary fiber of millets protects against hypoglycaemia. Further antinutrient constituents such as phenols and tannins have potential benefits to mitigate or delay the onset of complications associated with diabetes. Similarly the barnyard millet like any other millet is also well known for its neutraceutical function. As reported by Ugare (2008) the barnyard millet is a good source of nutraceutical components such as total dietary fiber (12.60%) with higher soluble (4.24%) and insoluble (8.36%) fractions. The antioxidants of barnyard millet *viz.*, tannins (62.50%), total free phenols (51%) and phytic acid (96.00%) were fairly high. Therefore due to high per cent of barnyard millet flour present in plain noodles, cookies and *khakara* the GI values were noted to be low**.** **Shukla *et al*.(1991**) revealed that millets evoke lower glycemic response than other cereals.

Among the three processing techniques, the product prepared by employing baking elicited low GI values i.e., pulse cookies recorded a significantly low GI value (24.42) when compared to products prepared by extrusion and by roasting method. Several authors have reported that during baking, a fraction of starch rendered itself inaccessible to amylases (**Rizkalla et al.,2007)** and total dietary fibre content increases (Kavitha, Parvathi Easwaran and Maheshwari, 2001) due to retrogradation (Fredrikson et al.,2001). Also during baking of cookies, 1, 6 anhydro D-glucose units may have been liberated from the starch and other polysaccharides to form enzyme resistant complexes that are different from resistant starch **(Gurcia-Alonso and Goni, 2000, Leeman, Ostman and Bjorck,2005). Further Kavitha *et al*. (2001) and Priya and Kapoor (2001**) reported low glycaemic index values in baked products. The present study on pulse cookies is also in line with the above findings. **Kavitha *et al*., (2001**) reported that dry heat cooking methods like baking, roasting and pan roasting; a usage of minimum possible amounts of water for cooking; ensures better glycemic control in diabetic subjects. Probably this also added to low GI value of pulse cookies**. Priya and Kapoor (2001)** also reported that preparations involving baking and germination produced lower glycemic response.

The glycemic index value of pulse products i.e., pulse noodles, cookies and pulse *Khakara* revealed that among the three products pulse cookies recorded lower value (24.42) as compared to other two. The pulse noodles comprised of barnyard millet and pulses. Whereas pulse cookies comprised of pulses, barnyard millet flour, sugar and fat. While, pulse *khakara* comprised of wheat flour, barnyard millet flour, pulses and spices. Thus when compared between ingredient compositions of pulse products in the present study, the pulse cookies are containing more per cent of low glycemic index foods i.e. barnyard millet flour, pulses and fat which is reflected in low GI value of pulse cookies. Further, pulse cookies contained fat which contributed to less starch content than other two products. On the other hand the wheat flour in pulse *khakara* caused slightly higher values in case of pulse *khakara* due to its starch content.

Overall when considered (table 6)the least values for GI were recorded by pulse cookies followed by pulse noodles. Mixed diet will have low GI than individual foods. **Mani *et al* (1993)** reported hypoglycemic effect of millet-pulse mix when used in combination in type II diabetic patients. Further as reported by Jenkins *et al*. (1982b,1983) pulses contribute for slow release of glucose due to presence of viscous type of fiber. **Meyer *et al*. (2000**) reported an inverse relation between dietary magnesium and type 2 diabetes. Therefore the pulse products exhibited low GI values. Thus, it was concluded that among the three different processing methods, products prepared from baking elicited low Glycaemic Index value followed by extrusion and roasting methods.

Figures and Tables

Table 1: Acceptability scores of pulse noodles

Sr. No	Variations	Mean value of sensory score				
		Color	**Taste**	**Texture**	**Flavor**	**Overall acceptability**
1	I	3.30	3.30	2.90	3.00	3.00
2	II	3.90	4.00	3.60	3.70	4.10*
3	III	3.60	3.60	3.20	3.40	3.40
	Mean	**3.6**	**3.63**	**3.23**	**3.36**	**3.50**
	SE±	0.23	0.24	0.33	0.24	0.20
	CD	NS	NS	NS	NS	0.59

NS-non significant *** significant at p<0.05**

Table 2: Acceptability scores of pulse cookies

Sr. No	Variations	Mean value of sensory score				
		Color	**Taste**	**Texture**	**Flavor**	**Overall acceptability**
1	I	2.70	2.40	3.10	2.70	2.70
2	II	4.10*	4.40*	4.60*	4.40*	4.50*
3	III	4.00	4.10	4.50	4.40	4.40
	Mean	**3.60**	**3.63**	**4.06**	**3.83**	**3.86**
	SE±	0.16	0.20	0.14	0.15	0.16
	CD	0.46	0.60	0.42	0.46	0.46

NS - Non Significant *** Significant at p<0.05**

Table 3: Acceptability scores of pulse *khakara*

Sr. No.	Variation	Mean value of sensory score				
		Color	**Taste**	**Texture**	**Flavor**	**Overall acceptability**
1	I	4.50*	4.60*	4.70*	4.70*	4.80*
2	II	3.60	2.80	2.80	2.80	3.00
3	III	3.40	2.50	2.50	2.50	2.80
	Mean	**3.83**	**3.30**	**3.33**	**3.33**	**3.53**
	SE±	0.16	0.17	0.15	0.21	0.23
	CD	0.47	0.51	0.43	0.61	0.68

*** significant at ($p<0.05$)**

Table 4: Mean blood glucose levels at fasting and after feeding glucose and value added Products at 30 to 120 min. (mg/dl)

Time (min)	Pulse noodles		Pulse cookies		Pulse khakhara	
	Control	**Experimental**	**Control**	**Experimental**	**Control**	**Experimental**
0	93.00^{b}	92.66	93.50^{bc}	88.00	92.50	89.83
30 min	101.83^{ab}	95.83	102.00^{ab}	90.33	101.16	92.83
60 min	110.16^{a}	98.33	109.66^{a}	92.00	109.33	96.00
90 min	100.00^{ab}	95.66	100.16^{abc}	90.83	97.50	92.66
120	87.83^{b}	91.33	88.50^{c}	85.50	85.00	88.83
Mean	**99.96**	**94.76**	**98.76**	**89.33**	**97.10**	**92.03**
SE±	4.92	1.94	4.38	1.92	5.72	2.54
CD	14.50	NS	12.77	NS	NS	NS

***Means carrying different superscripts differ significantly** ***NS- Non-significant**

Table 5: Mean blood glucose levels at fasting and after feeding value added products at 30 to 120 min. (mg/dl)

products	Time (min)				
	0	30	60	90	120
Noodles	92.66	95.83	98.33	95.66	91.33
Cookies	88.00	90.33	92.00	90.83	85.50
Khakhara	89.83	92.83	96.00	92.66	88.83

Table 6: Glycaemic index of developed products

Developed Products	Glycaemic Index (%)
Pulse cookies	24.42
Pulse noodles	35.65
Pulse *khakara*	37.95
Mean	**32.67**

REFERENCES

A.O.A.C. (1984) Official methods of analysis. Association of Official Analytical Chemists, 14 th Edu. Washington, DC.

A.O.A.C. (1990) Official Methods of Analysis, 14th ed. Association of official analyticalchemists, Washington, DC.

A.O.A.C. (2005) Official Methods of Analysis. Association of Official Analytical Chemists18 th edition. Arlington, U.S.A .

Amerine, M.A. et al. (1965) Principles of sensory evaluation of food. Academic Press., New York.

Anderson, J.W.et al. (2003) Importance of weight management in type 2 diabetes. Journal of American Clinical Nutrition, pp: 331-339.

Anju., T. and Sarita, S. (2010) Suitability of Foxtail millet (Setaria italica) and Barnyard millet (Echinochloa frumentacea)for development of low glycaemic index biscuits. Mal. J. Nutr., 16(3):361-368.

Anon., (1983) Approved methods of American Association of cereal Chemists, 8 th Ed. AACC,The Association: St. Paul, MN.

Arora, S. and Srivastava, S. (2002) Suitability of millet-based food products for diabetics. Journal of Food Science and Technology, 39 (4):423-428.

Ballolli, U., Chimmad, B.V. and Itagi, S. (2011a) Storage quality evaluation of iron enriched Garden Cress seeds (Lipidium sativum L) Barnyard millet (Echinochloa frumantacea Link) cookies. NAIP: National Symposium Recapturing Nutritious Millets for Health and Management of Diseases, UAS, Dharwad, December, 16-17: 41.

Ballolli, U.et al. (2011b) Development of NuttyBarnyard millet (Echinochloa frumantacea Link) cookies. NAIP: NationalSymposium Recapturing Nutritious Millets for Health and Management of Diseases, UAS, Dharwad, December: 16-17, pp-42.

Blair, R.M., Henley, E.C. and Tabor, A. (2006) Soy foods have low glycemic and insulin response indices in normal weight subjects. Nutrition Journal, 5:35.

Chitra, U., Singh, U. and Venkateshwara Rao, P. (1996) Phytic acid, in vitro proteindigestibility, dietary fiber and minerals of pulse as influenced by processing methods. Plant Foods and Human Nutrition, 49:307-316.

Choudhary, M.M. (2011) Development of nutritious bars for diabetes. M.H.Sc. Thesis. Marathwada Krishi Vidhypeeth, Parbhani.

Deshpande, S.et al. (2004) Enhancing the nutritive values of barley based sattu by soy-fortification. The Indian Journal of Nutrition and Dietetics, 41:146-159.

Fredrikson H, et al. (2000) Studies on a-amylase degradation of starch ofretrograded starch gels from waxy maize and high amylopectin potato. Carbohydrate Polymers 43:81-87.

Ganiyu, O. (2005) Nutritional and safety evaluation of some tropical green leafy vegetables. Journal of Food Technology. 3(3):389-392.

Geetha, C. and Easwaran, P. (1990) Hypoglycemic effect of millet incorporated breakfast items on selected non-insulin dependent diabetic patients. The Indian Journal of Nutrition and Dietetics, 27: 316-320.

Gopalan, C., Ramasastry, B.V. and Balasubramanian, S.C. (2004) Nutritive value of Indian foods. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India.

Gurcia - Alonso A and Goni I (2000) Effect of processing on potato starch: in vitro availability and glycaemic index. Nahrung/Food 44: 19-22.

I.C.A.R. (1987) Finger millets and other minor millets. ICAR Krishi Anusandhan Bhawan, New Delhi, pp:7-12.

Jenkins, D.J.A., Thorne, M.J. and Camellon, K. (1982b) Effect of processing on digestibility and the blood glucose response: a study of lentils. American Journal of Clinical Nutrition. 36:1093-1101.

Jenkins, D.J.A. et al.(1983) Glycemic index of foods tested in diabetics: a new basis for carbohydrate exchange favoring the use of legumes: Diabetologia, 24:257-264.

Jenkins, D.M.et al. (1981) Glycemic index of foods: A physiological basis for carbohydrate exchange. The American Journal of Clinical Nutrition, 34:362-366.

Kadlag, R.V., Dhavan, J.K. and Kachare, D.P. (1995) Effects of seed treatments and storage on the changes in lipids of pearl millets meal. Plant Food and Human Nutrition, 47:279-285.

Kavita, M.S. and Prema, L. (1995) Post prandial blood glucose response to meals containing different carbohydrates in diabetics. Indian Journal of Nutrition and Dietetics, 32:123-127.

Kavitha, P., Easwaran, P.P. and Uma Mageshwari, S. (2001) Effect of different methods of cooking on the dietary fibre content of wheat and wheat products and their hypoglycemic effect on NIDDM patients. Indian Journal of Nutrition and Dietetics, 38:173-181.

Krishnakumari, S. and Thayumanavan, B (1997) Comparative study of resistant starch from minor millets on intestinal responses, blood glucose, serum cholesterol and triglycerides in rats. Journal of Science of Food and Agriculture, 75: 296-302.

Lakshmidevi, K. and Khader, V. (1997) Preparation of vermicelli from wheat flour-pulse blends
for geriatrics. Journal of Food Science and Technology, 34(6): 513-515.

Leeman M, Ostman E and Bjorck I (2005) Vinegar dressing and cold storage of potatoes lowers post prandial glycaemic and insulinaemic responses in healthy subjects. European Journal of Clinical Nutrition 59: 1266-1271.

Mani, U.V.et al. (1993) Glycemic index of some commonly consumed foods in Western India. Asia Pacific Journal of Clinical Nutrition, 2: 111-114.

Meyer.et al. (2000) Carbohydrates, dietary fiber and incident type 2 diabetes in older women. American Journal of Clinical Nutrition, 71:921-930.

N.I.N. (1983) Manual of laboratory techniques. 2 nd edition,. Indian Council of Medical Research, Hyderabad.

Oluwamukomi, M.O., Oluwalana, I.B. and Akinbowale, O.F. (2011) Physicochemical and sensory properties of wheat-cassava composite biscuit enriched with soy flour. African Journal of Food Science, 5(2):50-56.

Panse, V.G. and Sukhatme, P.V. (1985) Statistical methods for agricultural workers. ICAR Publications. New Delhi.pp:58-60 and 97-110.

Pawar, V.D. and Parlikar, G.S. (1990) Reducing the polyphenols and phytate and improving protein quality of pearl millet by dehulling and soaking. Journal of Food Science and Technology, 27:140-143.

Priya, L.S. and Kapoor, R. (2001) In vitro starch hydrolysis and glycemic effects of processed kodo millet (Paspalum scrobicuatum) products. 34 th Annual Meeting/Conference Scientific Programme and Abstracts, December 5-6, Nutrition society of India,pp.79.

Raghuram, T.C. Pasricha, S. and Sharma, R.D. (1993) Diet and Diabetes, National Institute of Nutrition, Hyderabad.

Rizkalla, S.W., Bellisle, F. and Slama, G. (2002) Health benefits of low glycaemic index foods, such as pulses, in diabetic patients and healthy individuals. British Journal of Nutrition, 88(3):255-262.

Shukla, K.et al.(1991) Glycemic response to maize, bajra and barley, Ind. J. Physiol. Pharmacol., 34: 249-254.

Singh, G., Kawatra, A. and Sehgal, S. (2004) Nutritional evaluation of products developed from dried spinach leaves (Spinacea Oleracea). Indian Food Packer, January- February, pp:68-72.

Surarez, F.I.et al.(1999) Gay production in humans ingesting soybean flour derived from beans naturally low in oligosaccharides. American Journal of Clinical Nutrition, 69:135-139.

Swaminathan, M. (2008). An advanced textbook on Essentials of Food and Nutrition volume 1 pp:135-138

Thompson, L.U., and Yoon, J.H. (1984) Starch digestibility as affected by polyphenol and phytic acid. Journal of Food Science, 49:1228-1229.

Ugare, R. (2008) Health benefits, storage quality and value addition of barnyard millet (Echinochloa frumentacaea Link). M.H.Sc thesis, University of Agricultural Sciences, Dharwad.

Veena, B. (2003) Nutritional, functional and utilization studies on barnyard millet. M.H.Sc. Thesis, University of Agricultural Sciences, Dharwad.

Vijayalakshmi, P. and Radha, R. (2006) Effect of little millet supplementation on hyperlipidaemia. Indian Journal of Nutrition and Dietetics, 43: 469-474.

Wolever, T.M.S. and Jenkins, D.J.A. (1986) The use of glycemic index in predicting the blood glucose response to mixed meals. American Journal of Clinical Nutrition, 43: 167-172.

Wolever.et al. (1991) The glycemic index: methodology and clinical implications. American Journal of Clinical Nutrition, 54: 846-854.

Zakaria, M.et al.(1979) Use of reversed phase HPLC analysis for the determination of provitamin – A carotenes in tomatoes. Journal of Chromatography, 176:179.

http://www.agriculturalproductsindia.com/cereals-pulses/cereals-millets.html

http://www.gramene.org/ species/setaria/foxtailmillet_intro.html..