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DEVELOPMENT OF VALUE ADDED LOW GLYCEMIC INDEX BARNYARD MILLET (*Echinochloa frumentacea* Link) NOODLES

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ABSTRACT

Barnyard millet *(Echinochloa frumentacea* Link) is one of the important nutritious minor millet and good source of macronutrient, micronutrient and nutraceutical components. As the concept of low glycaemic index foods is gaining interest for the effective management of diabetes mellitus, efforts have been accelerated in this direction to bring into light various foods of low glycaemic index. Noodles are most preferred food items among all age groups having longer shelf life and good commercial importance. Hence an attempt was made to develop barnyard millet based value added low glycaemic index noodles. Trials were conducted by incorporating sago flour, pulse flour and bengal gram leaf powder at different levels to barnyard millet flour to develop plain, pulse and vegetable noodles respectively and were evaluated organoleptically. The best accepted variations of plain, pulse and vegetable noodles were evaluated for nutrient composition and glcaemic index. The findings indicated significant increase in nutrient composition in pulse and vegetable noodles. The glycaemic index of pulse noodles (35.65) and vegetable noodles (38.02) were significantly less than plain noodles (42.07). Thus, the developed noodles with low glycaemic index can be recommended for inclusion in diabetic diet.

Key words: Barnyard Millet, glycemic index, noodles.

INTRODUCTION

Minor millets are a group of grassy plants with short slender culm and small grains possessing remarkable ability to survive under severe drought conditions. Millets have been food commodities since ancient times. Because of their important nutritional qualities, there is a need to revive their usage in daily diet. Millets can substitute major cereals for better health benefits. Barnyard millet (Echinochloa frumentacea Link) of which synonyms are Japanese barnyard millet, *Ooda, Oadalu, Sawan* and *Sanwank* is an important minor millet because of its fair amounts of protein (12%) that is highly digestible (81.13%) coupled with low carbohydrate content (58.56%) of slow digestibility (25.88%) (Veena,2003).
The dietary fiber is an important photochemical component of barnyard millet (13% total dietary fiber with 4.66 and 8.18% of solub6 le and insoluble fractions, respectively) that could be considered in the management of disorders like diabetes mellitus, obesity, hyperlipidemia, etc (Veena,2003).

Today there is a significant change in the lifestyle of people owing to the rapid industrialization, improved socio-economic status, enhanced health facilities and increased life expectancy. Economic affluence coupled with sedentary lifestyles and changing food patterns are contributing to several chronic degenerative diseases such as diabetes mellitus, cardiovascular diseases, cancer, etc. Diabetes mellitus is a salient disease and is now recognized as one of the fastest growing threats to public health in almost all countries of the world. Around 171 million people suffer from diabetes in the world, of which 40.9 million are Indians, the highest number in any country (http://indiandiabetics.com/DiabetesScene.aspx).

Dietary modification, weight control and regular exercise are the main approaches in the management of diabetes, diet being the corner stone. New research findings in this area indicate the potential value of diets in prevention of such disorders. Currently, the challenge is to identity hypoglycemic diet supplements to control blood glucose levels. As foods with low glycaemic index (GI) are known to result in lower post-prandial glucose response in patients with non-insulin dependent diabetes mellitus, GI has been extensively studied as an useful means to determine foods that are appropriate for diabetic subjects. Thus, for the health conscious genera of the present world, minor millet especially Barnyard millet is perhaps one more addition to the existing list of healthy foods, owing to its nutritional superiority. Apart from this, the grain has high utilization potential owing to its excellent capacity to blend with other food grains without imparting any off flavor or aftertaste. Thus the millet can be incorporated in traditional foods and valuarized to novel food uses (Veena, 2003). Noodles are one of the convenience and preferred items of both children and women due to ready to cook nature. The present study was undertaken to develop value added low glycaemic index barnyard millet noodles.

MATERIALS AND METHODS

PROCESSING OF RAW INGREDIENTS

Barnyard millet (*Echinochloa frumentacea* Link)and other ingredients such as soybean (*Glycine max* Merr.) green gram *dhal* (*Phaseolus aureus* Roxb) and bengal gram leaves (*Cicer arietinum*) were purchased from local market. Barnyard millet constituted the main ingredient and other ingredients were added either as a source of lysine, antioxidants, minerals, dietary fiber or hypoglycemic constituents. The millet grains were cleaned to separate sand grits and other heavy particles and stored in air tight containers for further use. Millet grains and Green gram *dhal* was made into fine flour (Sieve mesh No 65 mics)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 *dhal* was dehusked. The ground *dhal* was cleaned and separated from husk and then made into fine flour (Sieve mesh No 65 mics).with the help of domestic electric mixer(Model Supreme ***Flora)., which was then used for preparation of value added products. Fresh bengal gram leaves cleaned thoroughly for any foreign materials, rotten leaves and dirt particles. These cleaned leaves were further washed in water then dried in cabinet drier (50-55^0C for 3 hrs). After drying, the leaves were powdered and then stored in air tight container for further use.

PRODUCT DEVELOPMENT

Three types of noodles namely plain, pulse and vegetable noodles were prepared with barnyard millet. Four variations of plain noodles were developed with incorporation of sago flour. Sago flour at the levels of 10, 15 and 20 per cent was taken and basic noodles with 100 per cent barnyard millet were prepared. Three variations of pulse noodles were prepared. 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). Three variations of vegetable noodles were prepared. Each variation comprised of barnyard millet flour and dried bengal gram leaf powder in different ratios as 90:10 (variation I), 85:15 (variation II) and 80:20 (variation III). All the three types of noodles were evaluated organoleptically.

ORGANOLEPTIC EVALUATION

The value added barnyard millet noodles were evaluated for organoleptic quality attributes by ranking the responses using a 5 point ranking test method (Amerine *et al.*, 1965) by a panel of ten semi-trained judges from Department of Foods and Nutrition, College of Home Science, Parbhani.

NUTRITIONAL QUALITY

The proximate principles namely protein, fat, carbohydrate, total ash, crude fiber, vitamins such as vitamin C, total and β-carotene and minerals such as iron, calcium, magnesium and phosphorus content of all the three types of noodles has been assessed following the standard AOAC methods (Anon, 1990).

Each selected developed value added noodles were analyzed in triplicate for moisture, protein, fat, total mineral, iron, calcium, magnesium, phosphorus, vitamin C, total and β-carotene and total and reducing sugars. Moisture, fat and total minerals were estimated by AOAC (2005) method. The crude fibre content of developed value added noodles 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 noodles 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. The products were analysed for total sugars using Anthrone method (Thayumanavan and Sadasivam, 1984). Reducing sugars were determined by Nelson-Somogyi method (Somogyi, 1952). Vitamin C by titration method (A.O.A.C. 1984) and 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).

GLUCOSE TOLERANCE TEST (GTT):

GTT was conducted following the methods of Wolever and Jenkins (1986) in six normal healthy female volunteers. The volunteers were administered glucose and test food (25g carbohydrate equivalent) separately on alternate days after 12 hour over night fasting. The capillary blood samples were drawn by finger prick method at 0, 30, 60, 90 and 120 min intervals for estimation of glucose using active glucose strips in a Glucometer (One touch model). The blood glucose response curves were plotted for both glucose and test food (noodles). With the help of the graph, the postprandial incremental areas were calculated and the glycaemic index of value added noodles was determined following the formula given by Wolever 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

For glycaemic 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

The results of the present study indicated that plain noodles with 100 per cent incorporation of barnyard millet, pulse noodles with 20 per cent incorporation of soybean flour and green gram dhal flour and vegetable noodles with 15 per cent incorporation of dried bengal gram leaf powder were highly acceptable after organoleptic evaluation. The detail of variations taken for development of three types of noodles is given in materials and methodology.

Table 1: Acceptability scores of plain noodles

Sr. No.	Variations	Mean value of sensory score				
		Color	Taste	Texture	Flavor	Overall Acceptability
1.	I (100:0)	4.40	4.40	4.30	4.40	4.40
2.	II (90:10)	4.30	3.80	4.10	3.80	3.90
3.	III (85:15)	4.20	4.00	4.30	4.10	4.30
4.	IV	3.90	3.70	4.00	3.80	3.80
	Mean	**4.20**	**3.97**	**4.17**	**4.02**	**4.10**
	SE±	0.25	0.23	0.25	0.26	0.21
	CD	NS	NS	NS	NS	NS

NS-Non Significant

Table 2: Acceptability scores of pulse noodles

Sr. No	Variations	Mean value of sensory score				
		Color	Taste	Texture	Flavor	Overall acceptability
1.	I (70:15:15)	3.30	3.30	2.90	3.00	3.00
2.	II (60:20:20)	3.90	4.00	3.60	3.70	4.10*
3.	II (50:25:25)	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

a) NS-non significant b)* significant at $p<0.05$

Table 3: Acceptability scores of vegetable noodles

Sr. No	Variations	Mean value of sensory score				
		Color	Taste	Texture	Flavor	Overall acceptability
1.	I (90:10)	3.91*	3.91	3.91	4.08	4.04
2.	II (85:15)	3.83	4.33	4.08	4.33*	4.16
3.	III (80:20)	3.25	3.66	3.66	3.50	3.54
	Mean	3.66	3.97	3.88	3.97	3.91
	SE±	0.18	0.20	0.17	0.22	0.23
	CD	0.49	NS	NS	0.63	NS

a) NS-non significant b) * significant at $p<0.05$

Table 4 exhibits the macronutrient composition of all the three highly acceptable noodles. Plain noodles had significantly high total carbohydrates (78.98%) and total ash (3.46 %) content than pulse and vegetable noodles. The plain noodles contained 100 per cent barnyard millet flour and barnyard millet comparatively had higher amounts of minerals and carbohydrates than pulses (Gopalan et al., 2010). Pulse and vegetable noodles had significantly high content of protein, fat and crude fiber than plain noodles. The increase in macronutrient composition of pulse and vegetable noodles is possibly due to the addition of protein and dietary fiber rich food ingredients such as pulse flour and dried bengal gram leaf powder (Sankeshwar, 2000). Similar increase in protein content were also observed by Mridula et al. (2006) when incorporated defatted mustard flour (DMF) for development of noodles. Significant increase in crude fiber was noted in vegetable noodles possibly because of vegetables being rich in crude fiber (Ganiyu, 2005).

The micronutrient composition of noodles has been displayed in table 5, which depicts an increased amount of β-carotene, total carotene, calcium, phosphorus and magnesium in pulse noodles. The increase is possibly due to addition of pulses specially soybean flour which is excellent source of micronutrients (Singh et al., 2006). Vegetable noodles exhibited significant high amount of vitamin c (2.906%) and iron (5.55%). Similar results are also reported by shah (2006), where the iron content of the recipes increase from 1.94 mg to 7.83 mg after incorporation of bengal gram leaves.

Table 4: Macronutrient composition of value added noodles

Macronutrient Composition	Moisture (g/100g)	Protein (g/100g)	Fat (g/100g)	Total ash (g/100g)	Crude fibre (g/100g)	Carbohydrate (g/100g)	Energy (Kcal/100g)	Total sugars (g/100g)	Reducing sugars (g/100g)
Plain noodles	8.86	4.64	3.2	3.46*	0.88	78.98*	363.00	2.24	0.197
Pulse noodles	9.23	15.54*	7.00*	2.26	0.84	65.17	386.00*	7.11	0.807
Vegetable noodles	9.86*	8.34	1.6	2.46	1.77*	75.97	352.00	8.14*	1.33*
Mean	9.31	9.50	3.93	2.72	1.16	73.15	367.00	5.83	0.77
SE+	0.11	0.30	0.12	0.09	0.02	0.86	2.24	0.21	0.02
CD	0.34	0.90	0.36	0.29	0.07	2.61	6.74	0.65	0.06

a) NS-Non Significant, b) *significant at ($p<0.05$)

Table 5: Micronutrient composition of value added noodles

Micronutrient composition	Vitamin C (mg/100g)	β-carotene (μg/100g)	Total carotene (μg/100g)	Iron (mg/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)	Magnesium (mg/100g)
Plain noodles	2.325	119.55	1160.00	4.35	12.73	280	23.72
Pulse noodles	1.744	138.50*	1740.00*	2.95	51.11*	387*	61.60*
Vegetable noodles	2.906*	90.00	1058.20	5.55*	44.70	256	49.50
Mean	2.32	116.02	1319.4	4.28	36.18	307	44.94
SE+	0.04	1.29	44.27	0.12	0.65	3.32	0.57
CD	0.14	3.91	133.21	0.37	1.97	10.01	1.74

a) NS-Non Significant, b) *significant at ($p<0.05$)

Table 6: Mean Glyceamic Index of Value Added Noodles

Noodles	Glyceamic Index
Plain noodles	42.07[a]
Pulse noodles	35.68[b]
Vegetable noodles	38.02[b]
Mean	**38.59**
SE+	1.32
CD	3.73

Means carrying different superscripts differ significantly ($p<0.05$)

Figure 1, 2 and 3 shows the blood glucose response of developed noodles in healthy volunteers (n=6). Results revealed that maximum peak rise after one hour was remarkably higher with glucose when compared to all the three developed noodles. The decrease in the peaks after two hour of food ingestion is a desirable feature and the peaks of blood glucose among the three noodles has followed the same trend as was observed in one hour peaks.

From the figure 1, 2 and 3 it is evident that the peak of glucose decline sharply in case of glucose, whereas, a slow decline was observed in case of developed noodles that may be due to the slow but steady release of the glucose, which is beneficial, as satiety value for such products would be high. The mean glycaemic index values have been displayed in table 3(Fig 4). The mean GI values of the pulse (35.68) and vegetable noodles (38.02) were significantly lower as compared to plain noodles (42.07). The lowering of glycaemic index of pulse noodles can be attributed to the addition of pulses which contain 5-10 per cent more amylose compared to cereal grains, which is more resistant to digestion also. Dietary fiber also inhibits starch digestibility by increasing the viscosity of intestinal content and thereby slowing the absorption of carbohydrates from the food (Dilwari et al., 1981 and Wolever 1990). Vegetable noodles also elicited significantly lower glycaemic index values than plain noodles. Mani et al (1994) reported that recipes with cereal and green leafy vegetable elicited a lower glycaemic index values than those with cereal alone. According to Raghuram et al (1993), the pulse and vegetable noodles were falling under low glycaemic food, whereas plain noodles were falling under medium glycaemic food.

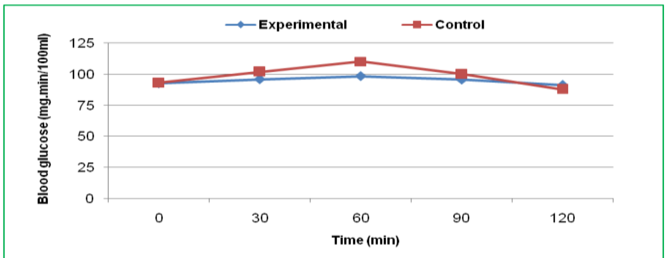

Fig 2: Mean blood glucose levels at fasting and after feeding developed Pulse noodles at 30 to 120 min. (mg/dl)

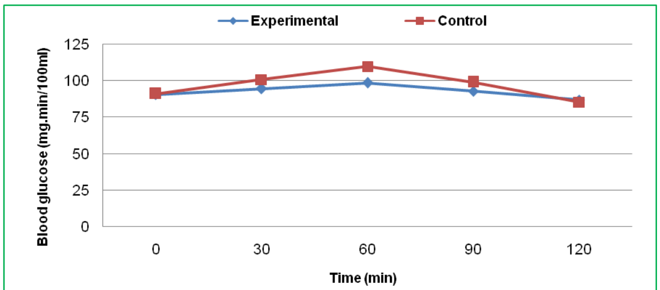

Fig 1: Mean blood glucose levels at fasting and after feeding developed Plain noodles at 30 to 120 min. (mg/dl)

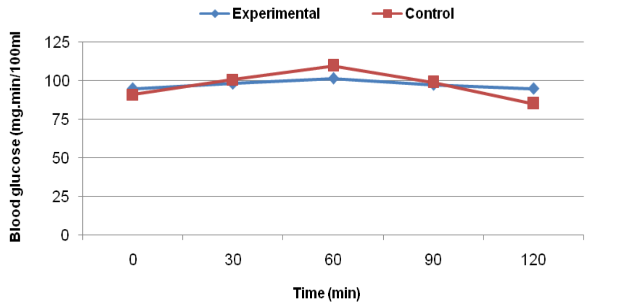

Fig 3: Mean blood glucose level at fasting and after feeding developed Vegetable noodles at 30 to 120 min.(mg/dl)

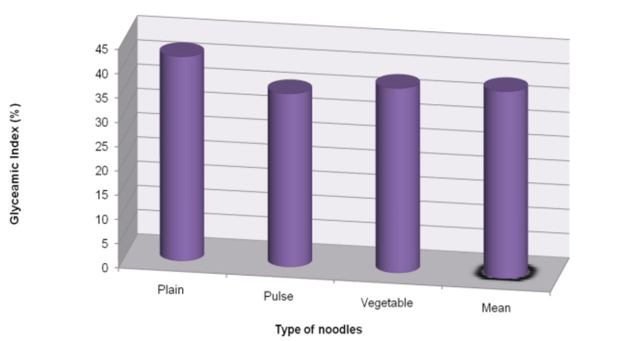

Fig 4: Mean glycaemic index of developed Noodles

CONCLUSION

Thus, from the present investigation it is clear that barnyard millet could be successfully value added. Barnyard millet based noodles have been found beneficial for the management of diabetes. Value addition of functional food ingredients like pulse flour and dried bengal leaf powder has brought the value added noodles under low GI category of foods successfully.

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