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Development and Clinical Evaluation of a Low Glycaemic Index Multi-Millet Snack

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Abstract - The prevalence of metabolic disorders, including obesity, diabetes, and high cholesterol, has been closely linked to dietary habits characterized by a high intake of refined carbohydrates and unhealthy fats. Addressing this issue through healthy eating practices is crucial in preventing the onset of these disorders. However, popular snacks in society often contribute to unhealthy diets. In response, this study aimed to develop a nutritious multi millet snack using food technologies like protein extraction, extrusion puff technology, tumble blending and no-fry oil treatment. The nutritional analysis revealed high protein and high fibre content, as well as a low-fat profile. Clinical evaluation of the snack on 16 human volunteers demonstrated a low glycemic index (GI) 45.7, indicating slower sugar release into the bloodstream. The experiment's outcome presents a promising avenue for promoting health-conscious and diabetic-friendly dietary choices. The study underscores the potential of combining food technologies with millet-based formulations to create foods that align with the needs of individuals seeking to maintain or improve their metabolic health. Further investigations and long-term studies are needed to evaluate benefits of this multi millet snack on cholesterol and obesity when used as a replacement to regular dietary practices

***Key Words*:** Food technology, Millet, Snack, healthy, Low Glycemic index, GI

INTRODUCTION

Metabolic disorders, comprising obesity, diabetes, and high cholesterol, have become increasingly prevalent[1], casting a shadow over global public health. The closely entwined relationship between these disorders and dietary habits, particularly characterized by the consumption of refined carbohydrates and unhealthy fats, has prompted a critical need for intervention. Recognizing the pivotal role of nutrition in preventing the onset of these disorders, this study addresses the alarming impact of popular snacks in contemporary society, which often contribute to unhealthy dietary patterns.

In response to this imperative, our research embarked on the development of a novel and nutritious multi millet snack. Leveraging various food technologies such as protein extraction, extrusion puff technology, tumble blending, and no-fry oil treatment, we aimed to create a snack that not only tantalizes the taste buds but also aligns with the principles of a health-conscious diet.

The resultant product underwent meticulous nutritional analysis, unveiling a culinary delight with commendable nutritional characteristics. Boasting high protein and fibre content, as well as a low-fat profile, our multi millet snack represents a promising departure from the nutritional pitfalls associated with conventional snacks. Furthermore, the clinical evaluation involving 16 human volunteers yielded encouraging results, indicating a low glycemic index (GI) [2] and, consequently, a slower release of sugar into the bloodstream.

The significance of these findings lies in the potential for promoting health-conscious and diabetic-friendly dietary choices. Our multi millet snack not only offers a delectable alternative to mainstream snacks but also holds promise as a mitigating factor against adverse metabolic outcomes. This study underscores the fusion of food technologies with millet-based formulations, presenting a compelling avenue to address the nutritional needs of individuals seeking to safeguard or enhance their metabolic health.

While the initial outcomes are promising, the study advocates for prudence and calls for further investigations and long-term studies. Specifically, the focus should extend to evaluating the potential benefits of incorporating this multi millet snack into regular dietary practices, with a keen eye on its impact on cholesterol levels, blood sugar levels and obesity. By doing so, we aim to contribute to the evolving landscape of nutritional research and foster a shift towards healthier dietary choices in the pursuit of sustained metabolic well-being.

MATERIALS AND METHODS

1. Formulation of the Nutrifusion multi-millet snack

a. Materials: Soyabean, Sorghum, Pearl millet, Ragi, soyabean oil, garlic powder, ginger powder, chilli powder, cumin powder, onion powder, mango powder, asafoetida, Himalayan rock salt.

b. Method: Soya protein was obtained from soyabean using protein extraction method and the soya protein was converted into nuggets. Individual puffs of Sorghum, Pearl millet and Ragi were obtained using extrusion technology. All the traditional Indian spices garlic powder, ginger powder, chilli powder, cumin powder, onion powder, mango powder, asafoetida and Himalayan rock salt were mixed in Soyabean oil to prepare the natural flavour blend. Soya protein Nuggets, and three types of millet puffs all taken in an equal proportion were mixed in octagonal tumbler blender, whereas oil-based flavour blend was uniformly sprayed over the millet mix to obtain a homogeneous mixture of all the ingredients. No synthetic flavouring substance, colour, preservatives or excipient were added in the formulation. Very less oil was utilized in the process and any frying was not done. The

product was stored in PET jars in an airtight packing and was tested for nutritional analysis as well as the accelerated stability study using industrial methods.

c. Observations and results: The multi-millet snack had a commendable taste profile. The product was found stable for nine months in shelf-life studies. The nutritional analysis revealed the product to be rich in protein and dietary fibres; whereas low on fats.

Table -1: Nutritional profile of the Multi Millet Snack

Sr. No.	Nutrients	(Per 100 g)
1	Energy (Kcal)	334
2	Protein (g)	15.00
3	Carbohydrate (g)	44.8
4	Total sugar (g)	3.11
5	Added sugar (g)	<0.4
6	Dietary fibre (g)	6.53
7	Total fat (g)	12.00
8	Saturated fat (g)	2.52
9	Polyunsaturated fat (g)	6.36
10	Monounsaturated f at (g)	2.04
11	Trans fat (g)	0.24
12	Cholesterol (mg)	0
13	Sodium (mg)	0.32

2. Clinical evaluation of Glycemic index of the Nutrifusion multi-millet snack

a. Aim of the study: To assess the glycaemic index of the Multi Millet Snack in healthy individuals.

b. Objective:

i. To compare the incremental area under the curve (IAUC) for blood glucose for both the Nutrifusion Multi Millet Snack and glucose using the trapezoid method.

ii. To determine the GI of Nutrifusion Multi Millet Snack.

c. Inclusion Criteria:
Healthy adult volunteers (09 males and 07 females, body mass index between 19-29 kg/m^2) participated in the study. Subjects were healthy males as well as non-pregnant and non-lactating females of age between 21 to 40 years. Subjects with fasting blood sugar levels <110 mg/dl were included in the study.

d. Exclusion criteria:
Subjects with any chronic disease, any known allergy, or intolerance to any ingredients of test food, consumption of any medications which interfere with the physiology of glucose tolerance, and a history of liver, kidney, or gastrointestinal disease were excluded from the study.

e. Study Methodology[3]:
This study was cross-over study with approach to determine the glycaemic index of the Multi Millet Snack. After receiving the Institutional Ethics Committee's approval for the study protocol, 16 healthy adult volunteers between 21 to 40 years of age were recruited in the study. Information on the previous day's diet (24 hours recall) and physical activity was obtained to ensure that they followed the same pre-test diets and refrained from smoking and alcohol during the study period. All the volunteers underwent one day of testing with the 50 g glucose portion (Glucose) and one day with the equivalent Multi Millet Snack after more than or equal to 25 hours post consumption of glucose portion. Gap was maintained between dosing to eliminate carry-over effects. Glucose (50 g) was made up to 200 ml with drinking water and the same volume of water was provided with the test foods. Blood glucose levels were monitored with capillary blood using a medical grade device standard glucometer during fasting and at 30-minute intervals for up to 120 minutes after consumption of glucose as well as the Multi Millet Snack.

The GI was calculated as the incremental area under the blood glucose response curve of a 50 g available carbohydrate portion of a Nutrifusion Multi Millet Snack expressed as a percent of the response to the same amount of carbohydrate from a reference food (glucose) taken by the same volunteer.
The incremental area under the curve (IAUC) for blood glucose was calculated for both the Nutrifusion Multi Millet Snack and glucose using the trapezoid method, and the mean IAUC for the both was calculated for individual subjects. Then GI (Glycaemic Index) was calculated by using the formula:

GI (%) = IAUC of test food/ Mean IAUC of reference food x 100

Subjects were closely monitored for any adverse event throughout the study.

RESULTS

a. Demographic characteristics:
There were 16 subjects enrolled and completed the study and data was analyzed. '*' denotes the data analyzed by student t-test whereas '#' denotes the data analyzed by chi-square test. any data with P value P>0.05 was considered as Not significant. There were no subjects with comorbidity in the study.

Table 2: Demographic details of study subjects

Parameter	Observation	
Group/ Gender#	Male (n=9)	Female(n=7)
Age (years)*	30.7±4.94	30±6.1
Total Age (years)	30.4±5.3	

b. Assessment of blood glucose levels:

Table 3: Assessment of blood glucose levels (mg/dl) after dextrose (50 g)

Blood Glucose Test with 50g Glucose				
Sr. no	Fasting	30 Min	60 min	120 Min
1	117	160	173	155
2	91	172	136	135
3	86	140	133	130

4	78	132	153	109
5	75	155	126	128
6	96	167	165	99
7	89	143	162	158
8	102	188	221	161
9	88	148	135	115
10	92	160	120	134
11	85	156	151	86
12	103	169	147	126
13	116	168	195	162
14	108	157	172	149
15	97	183	153	119
16	97	132	126	141

Table 4: Assessment of blood glucose levels (mg/dl) after Multi Millet Snack

Blood Glucose Test with the Multi-Millet Snack				
Sr. no	**Fasting**	**30 min**	**60 min**	**120 Min**
1	100	121	128	121
2	95	138	107	86
3	83	123	78	79
4	95	137	114	88
5	83	117	109	93
6	95	124	93	95
7	110	146	100	100
8	92	159	139	104
9	88	107	94	84
10	118	136	123	108
11	99	137	99	87
12	102	134	88	99
13	120	137	112	86
14	105	156	123	93
15	94	146	112	108
16	82	120	135	112

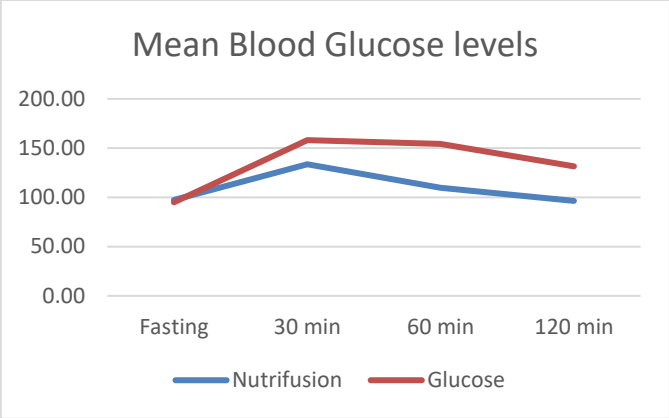
Assessment of mean blood sugar level (mg/dl) at different time points

Table 5 shows the average blood glucose response given by the glucose solution at fasting 95mg/dl. Then, the 30th minute blood glucose level increases 158.13 mg/dl, means an increase of 66.45%, the 60th minute, it was 154.25 a 62.36% increase, at 2 hours after eating blood glucose became normal (131.6 mg/dl). Response of average blood glucose levels of fasting Multi Millet Snack was 97.56 mg/dl. At 30 minutes it was increased 133.63 means 36.97% increase, 60 minutes increased to 109.63 mg/dl i.e. 12.37% increase, 120 minute decreased to 96.44 mg/dl.

Table 5: Mean blood glucose level at different time points

Investigational product	Fasting BSL	30 min BSL	60 min BSL	120 min BSL
Glucose	95.00	158.13	154.25	131.69
Multi millet snack	97.56	133.63	109.63	96.44

Graph 1: Mean blood glucose level at different time points



c. Assessment of Glycaemic Index (GI) of Nutrifusion Multi-Millet Snack

Table 6 shows the incremental area under the curve (IAUC) for glucose and Nutrifusion Multi-Millet Snack considering the increase in the blood glucose levels compared to fasting on 30, 60 and 20 min after consumption of either glucose or the Multi Millet Snack.

Table 6: IAUC for glucose and Multi Millet Snack

Investigational product	**AUC**
Glucose	6680
Multi Millet Snack	3054

GI (%) = IAUC of test food/ Mean IAUC of reference food x 100
GI (%) = 45.71%

DISCUSSION

Glucose has a glycaemic index (GI) of 100. Other High Glycaemic Index foods include dates, rice, wheat, potato, watermelon, pumpkin, pineapple, mango etc. Foods having glycaemic index lower than 55 are considered as low glycaemic index foods. Low GI foods release sugar slowly in the blood stream helping body to cope up with sufficient secretion of insulin and keep the blood glucose levels to normal. Millets particularly have been reported to have glycaemic index between 50 to 55, whereas the glycaemic index of the test food is found to be around 45. Combining high fibre ingredients like spices, high protein ingredients like soya protein nuggets and oils have worked together to further lower the glycaemic index of millet-based snack to 45. Blending high GI ingredients with low GI ingredients helps reduce the GI of overall meal. Adding spices and herbs further improves digestion and metabolism and adds to overall health benefit. Using no-fry method and less oil further makes the snack lower on the calories and healthier as compared to the conventional snacks. There is increasing attention and interest among consumers to prefer the low GI snacking options for themselves, the elderly and even children to avoid unnecessary blood sugar surges and eventually propensity to metabolic disorders.

India has an unenviable reputation as being the epicentre of type 2 diabetes. More significantly, the transition from prediabetes to diabetes is more dramatic and severe in Asians.

There is substantial evidence suggesting that the consumption of low glycaemic index (GI) foods minimizes blood glucose fluctuations, and helps in the prevention and management of diabetes and prediabetes[4]. Given the rising incidence of prediabetes and diabetes, dietary interventions to complement the pharmacological management of diabetes are increasingly being encouraged where the low GI option can fit better.

In the case of health-conscious individuals snacking options with low GI value are most preferred. For children, a snacking option like the Multi Millet Snack could be low on GI as well as easy for digestion.

Using food technology to improve taste, shelf life and nutritional profile. Improvised packaging technology like nitrogen filling, vacuum packing may further enhance the shelf life and commercial application of the product.

CONCLUSION

It is observed from the study results that the GI of Multi Millet Snack is 45.71% and falls under the 'Low Glycaemic Index range'. Blending high fibre and high protein ingredients to millets, minimum utilization of oils and non-fry method of manufacturing helps the millet blend to further achieve lower Glycaemic index, good test as well as a lower fat profile. Prevalence of diabetes and other metabolic disorders are significantly rising in India. On that background, Nutrifusion Multi-Millet Snack offering a low GI and healthy snacking option as compared to other conventional snack is indeed a technological success.

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