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Development of multi-millet therapeutic food product for Type II diabetes

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Abstract
The present study was carried out to develop a multi-millet mix for type II diabetic patients. Foxtail millet, barnyard millet, soyabean, flaxseeds, groundnut, bengal gram dhal, green chillies, mustard seeds and cumin seeds were used to prepare the multi-millet mix. Proximate analysis was done and the glycemic index of this multi-millet mix was estimated. The glycemic index of the multi-millet mix was 64.5% which falls in the medium glycemic index category. Then the therapeutic product was developed from the multi-millet mix.

Keywords: Milltets, Multi-millet mix, glycemic index and therapeutic food product

Introduction
In some parts of India, Africa, China millet is the staple food. Millets are cultivated in some regions of North Africa and Central Asia since prehistoric period. India is the world's leading producer of millet followed by Nigeria for the year 2000 and 2009. Millets like Sorghum (jola), Peral millet (sajje), Finger millet (ragi), Foxtail millet (navane), Kodo millet, Proso millet, Barnyard millet (oodalu) and little millet (saave) are commonly grown in India. Pearl millet which is commonly known as Bajra occupies over 50% of the millet types and it is the largest produced millet in India.

Jammu & Kashmir, Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Karnataka, Haryana, Uttar Pradesh, Gujarat, Maharashtra and Rajasthan are the states where millets are majorly cultivated in India. As of 2016 India is the highest millet producing country with a production of 10.3million tonnes followed by Niger and China. Millet is usually grown in the Kharif or rainy season. But to a lesser extent, states like Karnataka and others have cultivated millets in Rabi or post rainy season too. In the summer season, very little amount of area is put for millet cultivation. The Karnataka state has an annual yield of around 772 kg/ha in Kharif season, while the numbers go up to 2000 kg/ha for the summer season. Karnataka has 3% share of land of all India under millet production.

Millets contains an average of 10 - 12% protein. While its protein is superior to that of wheat or corn in terms of content of essential amino acids, it nonetheless contain less than half the amount of the essential amino acid lysine that is found in high quality protein sources such as meat. Millets are cereal species growing in an equally broad range of environments. The most widely cultivated millets are finger millet (*Eleusine coracona*), foxtail millet (*Setaria itallica*), pearl millet (*Pennisetum typhoideum*), Proso millet (*Panicum miliaceum*), barnyard millet (*Echinochooa colona*) etc.

Diabetes mellitus is a growing health threat for people all over the world. Especially the incidence of type 2 diabetes increases due to aging populations and changing lifestyles. The global prevalence of diabetes was estimated to be 9% in 2014 among adults aged 18 years or more. Diabetes has reached at an epidemic level, with around 366 million people with diabetes globally in 2011 and it is expected to increase to 552 million by 2030. The need for implementation of effective dietary strategies in diabetes prevention and management has been emphasized by the success of diet and lifestyle changes in preventing diabetes in high-risk patients. Glycemic index is an important tool used in dietary management of people with diabetes and in weight loss programs. Low glycemic index foods, by virtue of the slow digestion and absorption of their carbohydrates, produce a more gradual rise in blood sugar and insulin levels and are increasingly associated with health benefits. Low glycemic index foods have thus been shown to improve the glucose tolerance in both healthy and diabetic subjects.

Compared to polished rice, millets release a lesser percentage of glucose and over a longer period. This lowers the risk of diabetes. Millet grains are considered superior among the major cereals with respect to protein, energy, vitamins and minerals. They are nearly 3-5 times nutritionally superior to rice and wheat - be it minerals, vitamins, dietary fibre or other nutrients. Besides, these are a rich source of dietary fibre, phytochemicals and non-starchy polysaccharides and reputed to have a low GI, and hence can be used as a therapeutic diet. Most of the millets are highly nutritious, non-glutinous, non-acid forming and easily digestible foods. Being gluten free, individuals suffering from celiac disease can easily incorporate various millets in their diets. Millet ingestion helps in a slower release of glucose over a longer period of time; thus, due to low glycaemic index (GI), their habitual intake reduces the risk of diabetes mellitus. Due to their high dietary fibre content coupled with low glycaemic index, millets can help in curbing overweight/obesity as well as lowering the risk of hypertension, cardio vascular diseases, type II diabetes mellitus, cancer as well as in preventing constipation. As foods with low glycemic index (GI) are known to result in lower postprandial glucose response in patients with non-insulin dependent diabetes mellitus, GI has been extensively studied as a useful means to determine foods that are appropriate for diabetic subjects. These have often been called the coarse grains; however, due to their nutritional contributions, these are now being referred as 'nutria-millets/nutria-cereals'. Recent studies indicated that minor millets such as foxtail, little and barnyard are nutritionally superior to conventional food grains and exhibit hypoglycemic effect due to presence of higher proportion of complex carbohydrate, resistant starch and slow rising sugars. Hence present study was conducted with the objectives to develop a multi-millet mix and to know the efficacy of multi-millet mix to reduce blood glucose in type II diabetes patients.

Methodology

Sample: A sample of 10 adults of the age group 40-65 years were selected for the study. Among 10 adults 5 diabetic subjects (2 male and 3 female) and 5 non-diabetic subjects (2 male and 3 female) residing in Vijayapura were randomly selected.

Procedure: Height and weight of the adults was measured. Subjects consent was taken to participate in the study. BMI was also recorded. The multi-millet mix consisting of foxtail millet, barnyard millet, soyabean, flaxseeds, groundnut, bengal gram dhal, green chillies, mustard seeds and cumin seeds was prepared and the glycemic index of this multi-millet mix was estimated. The multi-millet mix of 100 grams was fed for study sample (5 diabetic and 5 non diabetic patients) for a period of seven days. After feeding, their fasting and postprandial blood glucose level were recorded for seven days using Accucheck-active blood glucose monitoring system which gives results in 5 seconds. Mean and standard deviations were computed.

Results

Table 1: Demographic characteristics of the diabetic and non-diabetic subjects.

Variables		Diabetic(n=5)	Non-diabetic(n=5)
Age	Male	55.5 ±7.78	50.5 ±2.12
	Female	55.3 ±2.51	49.67± 4.72
Height	Male	165.5 ±3.54	162 ±4.24
	Female	156 ±7.0	155± 5.0
Weight	Male	67 ±7.07	74 ±1.41
	Female	57.67± 4.50	53.33 ±4.93
Incidence of disease	>5 years	4	-
	< 5years	1	-
BMI	Male	24.40 ± 1.56	28.25 ± 2.05
	Female	24.00 ± 0.94	22.6 ± 0.85

Demographic characteristics of the diabetic and non-diabetic subjects is presented in table 1. The mean age of the diabetic male and female, non-diabetic male and female was 55.5 years, 55.3, 50.5 and 49.67 years respectively. The average height of diabetic male was 165.5cms and the diabetic female 156cms and average height of non-diabetic male and female was 162cms and 155cms respectively. The average weight of diabetic male and female was 67kgs and 57.67kgs and the average weight of non-diabetic male and female was 74kgs and 53.33kgs. It was also found that among diabetic 80% had incidence of diabetes from 5years and about 20% had the incidence of diabetes from 1 year. The non-diabetic males had the higher BMI (28.25) than diabetic males (24.40) while diabetic females had higher BMI (24.00) than non-diabetic females (22.6).

Table 2 shows the levels of fasting blood glucose of diabetic and non-diabetic subjects. The average initial fasting blood glucose levels (before feeding therapeutic diet) of diabetic subjects was higher (160.2) than the non-diabetic subjects (92.21). Similarly, diabetics also had a higher levels of final fasting blood glucose levels i.e., 150.20 (after feeding therapeutic diet) than the non-diabetics (89.60). The diabetic subjects showed a greater difference (10) between initial and final fasting blood glucose levels than the non-diabetic subjects (2.6)

Table 2: Fasting blood glucose levels of diabetic and non-diabetic subjects

	Fasting blood glucose level (mg/dl)	Postprandial blood glucose level (mg/dl)	Difference
Diabetic	160.48±6.60	152.37±6.22	8.19
Non-diabetic	98.11± 6.90	93.71±2.62	4.4

Table 3. shows the levels of postprandial blood glucose of diabetic and non-diabetic subjects. It was found that the initial (before feeding therapeutic diet) and final (after feeding therapeutic diet) postprandial blood glucose levels of diabetic subjects were 162 and 148.60 respectively and the difference was 13.4. Postprandial blood glucose level before and after feeding of therapeutic food for non-diabetics was 94 and 92 respectively and the difference between before and after feeding was 2.

Table 3: Postprandial blood glucose levels of diabetic and non-diabetic subjects.

	Initial (mg/dl)	Final (mg/dl)	Difference
Diabetic	162 ± 71.29	148.6± 40.92	13.4
Non-diabetic	94±6.28	92± 1.58	2

The difference between before and after feeding therapeutic diet was higher in diabetics compared to non-diabetics.

Table 4: Mean blood glucose levels of diabetic subjects for 7 days.

Days	Fasting blood glucose level (mg/dl)	Postprandial blood glucose level (mg/dl)
1	160.2±44.99	162± 71.29
2	160± 43.23	151± 39.87
3	160.8± 46.91	150± 44.79
4	172.2± 50.39	160± 53.53
5	157± 34.59	145± 24.24
6	163± 41.90	150± 33.73
7	150.2±44.42	148.6±40.92

Table 4 shows Mean Blood glucose levels of diabetic subjects for 7 days. The fasting and postprandial blood glucose level for diabetic subjects range from 150 to 172.2 and 145 to 162 respectively. The highest fasting blood glucose level was at day 4 (172.2 mg/dl), followed by day 6 (163 mg/dl), day 3 (160.8 mg/dl), day 1(160.2 mg/dl), day 2 (160 mg/dl) and day 5 (157 mg/dl). The lowest fasting blood glucose level was on the day 7 (150.2 mg/dl). The highest postprandial blood glucose was on day 1(162 mg/dl), followed by day 4 (160 mg/dl), then the third highest blood glucose level was on day 2 (151 mg/dl) followed by day 3 (150 mg/dl) and day 6 (150 mg/dl) and day 7 (148.6 mg/dl).

Table 5. Shows Blood glucose levels of non-diabetic subjects for 7 days. The fasting and postprandial blood glucose level for non-diabetic subjects range from 89.6 to 106.6 and 90 to 98 respectively. Highest levels of fasting and postprandial blood glucose was on day 4 (106.6 mg/dl). Second highest levels of fasting blood glucose level was on day followed by day 3 (102.66 mg/dl), day 5 (101 mg/dl), day 1 (92.2 mg/dl) and day 2 (91.2 mg/dl). The lowest level of fasting blood level was day 7 (89.6 mg/dl). The second highest level of postprandial blood glucose was day 3 (95 mg/dl) and day 6 (95 mg/dl). The third highest level of postprandial blood glucose was day1 (94 mg/dl), followed by day 5 (92 mg/dl) and day 7 (92 mg/dl).

Table 5: Mean blood glucose levels of non-diabetic subjects for 7 days.

Days	Fasting blood glucose level (mg/dl)	Postprandial blood glucose level (mg/dl)
1	92.2 ± 7.66	94 ± 6.28
2	91.2 ± 6.45	90 ± 4.24
3	102.6 ± 15.22	95 ± 4.89
4	106.6 ± 5.85	98 ± 6.04
5	101 ± 3.93	92 ± 1.22
6	103.6 ± 9.44	95 ± 7.38
7	89.6 ±8.32	92 ± 1.58

Table 6: Mean blood glucose levels of diabetic and non-diabetic subjects.

	Fasting blood glucose level (mg/dl)	Postprandial blood glucose level (mg/dl)	Difference
Diabetic	160.48±6.60	152.37±6.22	8.19
Non-diabetic	98.11± 6.90	93.71±2.62	4.4

Table 6 shows mean blood glucose levels of diabetic and non-diabetic subjects. Mean fasting blood glucose level of diabetic subjects for seven days was 160.48 mg/dl and for non-diabetic subjects it was 98.11 mg/dl. Mean postprandial blood glucose level of diabetic and non-diabetic subjects for 7 days was 152.37 mg/dl and 93.71 mg/dl respectively. The difference between fasting blood glucose level and postprandial blood glucose level of diabetic and non-diabetic was 8.19 and 4.4 respectively.

Discussion

There was significant decrease in the fasting blood glucose level and postprandial blood glucose level of both diabetic (160.2 mg/dl was initial and 150.2 mg/dl was final) and non-diabetic (92.21 mg/dl was initial and 89.6 mg/dl was final) subjects. Itagi *et al*. (2012) [1] reported that there was a significant reduction in the in the plasma glucose of experimental diabetic (117.33 was initial and 95.11 was final) and non-diabetics (94.17 was initial and 78.67 was final) and the reduction in fasting glucose level of diabetic (18.94) was more compared to nondiabetic (16.46) subjects. Significant decrease in fasting blood glucose of diabetic subjects (initial was 139.2 and final was 131.1) and non-diabetic (initial was 103.2 and final was 96.1) was reported by Ugare *et al*. (2014) [2], replacing rice-based dosa with millet-based dosa showed a significant reduction in the postprandial blood glucose levels (Narayanan *et al*., 2016) [3]. The barnyard millet khichdi had very slow release of blood sugar, a quality suited and desirable for diabetic patients. (Joshi and Srivastava, 2013) [4]. Since the therapeutic product is mixture of multi millets which have varied nutrient composition, this may be the cause for difference in the nutrient composition of the therapeutic product. Millets are the rich source of dietary fibre and they have low glycemic index this might be the reason for the glycemic index of the therapeutic product which is intermediate group. The diabetic patients are advised to eat the food with low and intermediate glycemic index. One of the potential effects of low- GI diets is to reduce insulin secretion in patients with type 2 diabetes and to reduce daily insulin requirements in patients with type 1 diabetes. So as the therapeutic product is the mixture of millets and have low glycemic index this may be the cause for reduction in the blood glucose levels of diabetic and non-diabetic subjects.

Conclusion

The present study has indicated the benefits of millets and their role in reducing the blood glucose level in diabetics. However, there is a need to conduct further study to know the potential benefits of the millets in management of diabetes through long term feeding intervention.

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