RESEARCH ARTICLE

Organoleptic and nutritional assessment of product developed from foxtail millet and jackfruit seed and its effect on blood glucose response among late adulthood population

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Diabetes is one of the leading causes of mortality and morbidity and it is also among the most chronic diseases of the 21st century. Diabetes is ranked in 7th position by WHO, for the total death caused by non-contagious disease. Nutrition intervention plays a critical role in the prevention and treatment of diabetes. Therefore, the study was conducted to develop products from foxtail millet and jackfruit seeds and assess their effect on blood glucose. Foxtail millet has a low glycaemic index and is rich in dietary fibre. Jackfruit seeds are a good source of resistance starch, vitamins and minerals. The processing of Jackfruit seeds was done by drying seeds at 80°C for 4 hrs and converted into flour. The product was formulated in two different concentrations of foxtail millet and jackfruit seeds i.e., 50 g and 60 g foxtail millet and 10 g and 20 g jackfruit seed flour (T1 and T2 respectively) and one controlled sample (wheat flour-100 g). The acceptability of the products was checked by using 9-point hedonic rating scale and proximate analysis of the most acceptable product was done. The Glycaemic Index and glycaemic load of the product were done by intervening with the product on 10 subjects without diabetes and assessing blood glucose levels at 0, 15, 30, 60, 90, and 120 minutes by using the OGTT method. The data revealed that the product formulated with 50% foxtail millet and 10% jackfruit seed flour was highly acceptable. The proximate analysis result showed that 100 g of thepla contain energy (270.36 kcal), protein (5.21 g), fat (2.24 g), carbohydrate (57.34 g), moisture (31.72 g), ash (3.49 g), fibre (8.3 g) and resistance starch (11.46 mg). The glycemic load of the product was 43.77 which falls in the category of low glycemic index food. The study concluded that this product can be used for diabetic patients, due to its low Glycemic index and load.

Key Words: *Diabetes; Glycemic index; Millets*

INTRODUCTION

Diabetes is one of the leading cause of mortality and morbidity and it is also among the most chronic diseases of 21st century. Diabetes is ranked at 7th position by WHO, for the total death caused by non-contagious disease. Approximately 537 million people lying in between the age range of 20 to 79 was suffering from diabetes in 2021 as estimated by the International Diabetes Federation (IDF) [1] and it is also estimated that the number is projected to rise upto 783 million cases by 2045.

Foxtail millet (*Setaria italic*) is considered one of the major millets, yet it receives less attention compared to other cereals [2]. It belongs to the Poaceae family. Foxtail millet per 100 grams contains 12.3 g of protein, 60.9 g of carbohydrate, 331 kcal energy, 4.3 g fat and 14 g dietary fiber [3]. These nutrients present in foxtail millet gives physiological function prevents the onset of non-communicable diseases. It is very important maintain these nutritional qualities for the development and processing of healthy foxtail millet-based products.

The activity of intestinal α-glucosidase and pancreatic α-amylase is inhibited with high phenolic acid content present in germinated and raw foxtail millet. Intestinal α-glucosidase and pancreatic α-amylase are two important enzymes involved in the digestion and absorption of glucose in the intestine [4]. Polysaccharides are hydrolysed into glucose and then transported into the bloodstream which in turn increases the post prandial glucose in the blood. Phenolic acid blocks the access to the of the enzyme's active site which prevents spike in post prandial glucose in the blood [5].

Jackfruit seeds are less acknowledged and underutilized by people, even though they are considered as highly nutritious and constitute approximately 10-15% of the total Jackfruit weight [6]. Each jackfruit contains approximately 100-150 seeds. Jackfruit seeds contain phytonutrients such as isoflavones, lignans, and saponins. Jackfruit seeds have wide ranging health benefits from antihypertensive to anticancer, antiulcer, antiaging, antioxidant, etc [7]. Jackfruit seeds contain phytonutrients that are good for human health, including saponins, isoflavones, lignans, and other substances [8]. Jackfruit seed contains resistant starch which helps in controlling the blood sugar and also keeps the gut healthy. The consumption of resistance starch of jackfruit seed consequently leads to the slow release of glucose into the bloodstream.

Glucose absorption is decreased by the dietary fiber present in the foxtail millet and jackfruit seed. There are two mechanisms by which fiber helps in decreasing the glucose absorption. First, it helps in preventing the diffusion of glucose in the intestine and also increases the small intestine viscosity. Second, it also binds the glucose as well as it decreases glucose concentration in small intestine and also slows down the digestive enzyme of starch [9].

MATERIALS AND METHODS

The procurement of jackfruit seeds and foxtail millet was done from the local market situated in Faridabad, Haryana. The processing of jackfruit seed was done after its procurement. Seeds were washed and the outer brown coating and white aril of the seeds were removed manually. Seeds were again washed with water and cleaned properly. After washing, seeds were dried at 80°C for 4 hours. After drying process is done, jackfruit seeds were grinded, sieved properly and packed in an air tight container.

Millet thepla was prepared by using foxtail millet and jackfruit seed in different concentrations (Table 1).

TABLE 1

Different concentration of ingredients used for different samples

Ingredient	Sample	T1	T2
Wheat flour (g)	100%	40%	20%
Foxtail millet flour (g)	0%	50%	60%
Jackfruit seed flour (g)	0%	10%	20%

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Sensory evaluation of the prepared samples of millet thepla was done by using 9-point hedonic scale to evaluate sensory characteristics that included taste, aroma, texture, appearance, mouthfeel, and overall acceptability of millet theplas. Sensory evaluation was done by 50 panelists. The proximate analysis of the most acceptable sample was done. The data gathered by sensory evaluation of millet thepla was statistically analyzed by using SPSS software version 22. Chi Square was used to find out the difference between all the varieties of bread and thepla and also to assess the highly acceptable product. After data analysis the most acceptable product was used for intervention. Glycemic Index and glycemic load of the product was done by intervening the product on 10 subjects without diabetes and assessing the blood glucose level at 0, 15, 30, 60, 90 and 120 minutes by using OGTT method. T-test was used to assess the difference between blood glucose concentrations (mg/dl) in between and within the group. Graph was plotted by using GraphPad prism.

RESULTS AND DISCUSSION

Sensory evaluation

The sensory attributes of breads including the texture, aroma, mouthfeel, appearance, taste, and overall acceptability were evaluated by using 9-point hedonic scale. 50 participants assessed the product.

Table 2 depicts the appearance acceptability (%) of the millet bread by using the 9-point hedonic rating scale. The results demonstrated that when compared to the other two samples, the highest acceptability (8-like very much) of millet thepla in terms of appearance was of normal wheat bread i.e., standard (44.7 %). On the other hand, when compared with T1 and T2, 30.3% of subject liked T1 (Millet thepla incorporated with 50% foxtail millet and 10% jackfruit seed powder) sample moderately and 42.5% of the subjects liked the same product moderately as compared to T2 (25% and 40% respectively). The differences were statistically significant.

Table 3 depicts the texture acceptability (%) of the millet thepla by using the 9-point hedonic rating scale. The results demonstrated that when compared to the other two samples, the highest acceptability (9-like extremely) of millet thepla in terms of texture was of normal wheat thepla i.e. standard product (43.5%). On the other hand, when compared with T1 and T2, 34.8% of the subjects liked T1 (Millet thepla incorporated with 50% foxtail millet and 10% jackfruit seed powder) sample extremely and 42% of the subjects liked the same product moderately as compared to T2 (21.7% and 32% respectively). The differences were not statistically significant.

Table 4 depicts the color acceptability (%) of the millet thepla by using the 9-point hedonic rating scale. The results demonstrated that when compared to the other two samples, the highest acceptability (9-like extremely) of millet thepla in terms of color was of normal wheat thepla i.e. standard product (42.4%). On the other hand, when compared with T1, and T2, 35.9% of subject liked T1 (Millet thepla incorporated with 50% foxtail millet and 10% jackfruit seed powder) sample very much as compared to T2 (26.6%). The differences were not statistically significant.

Table 5 depicts the taste acceptability (%) of the millet thepla by using the 9-point hedonic rating scale. The results demonstrated that when compared to the other two samples, the highest acceptability (8-like very much) of millet thepla in terms of taste was of normal wheat thepla i.e. standard product (40.4 %). On the other hand, when compared with T1, and T2, 32.7% of the subjects liked T1 (Millet thepla incorporated with 50% foxtail millet and 10% jackfruit seed powder) sample very much and 34% of the subjects liked the same product moderately as compared to T2 (26.9% and 25.5% respectively). The differences were statistically significant.

Table 6 depicts the aroma acceptability (%) of the millet thepla by using the 9-point hedonic rating scale. The results demonstrated that when compared to the other two samples, the highest acceptability (9-like extremely) of millet thepla in terms of aroma was of normal wheat thepla i.e., standard product (38.1%). On the other hand, when compared with T1, and T2, 33.3% of subject liked T1 (Millet thepla incorporated with 50% foxtail millet and 10% jackfruit seed powder) sample very much as compared to T2 (27%). The differences were not statistically significant.

Table 7 depicts the mouthfeel acceptability (%) of the millet thepla by using the 9-point hedonic rating scale. The results demonstrated that when compared to the other two samples, the highest acceptability (9-like extremely) of millet thepla in terms of mouthfeel was of normal wheat thepla i.e. standard product (36%). On the other hand, when compared with T1, and T2, 32% of the subjects liked T1 (Millet thepla incorporated with 50% foxtail millet and 10% jackfruit seed powder) sample extremely and 31.7% of the subjects liked the same product very much as compared to T2 (32% and 23.3% respectively). The differences were not statistically significant.

Table 8 depicts the overall acceptability (%) of the millet thepla by using the 9-point hedonic rating scale. The results demonstrated that when compared to the other two samples, the highest acceptability (9-like extremely) of millet thepla in terms of overall acceptibility was of normal wheat thepla i.e. standard product (34.5 %). On the other hand, when compared with T1, and T2, 31.5% of the subjects liked T1 (Millet thepla incorporated with 50% foxtail millet and 10% jackfruit seed powder) sample very much and 42.5% of the subjects liked the same product moderately as compared to T2 (26% and 35% respectively). The differences were not statistically significant.

TABLE 2

Distribution of subjects based on appearance acceptability of developed thepla samples

Appearance	Standard	Sample T1	Sample T2	Chi-square	p value
	N (%)	N (%)	N (%)		
Like extremely	9(31)	10(34.5)	10(34.5)		
Like very much	34(44.7)	23(30.3)	19(25)		
Like moderately	7(17.5)	17(42.5)	16(40)		
Like slightly	0(0)	0(0)	5(100)		
Neither like nor dislike	0(0)	0(0)	0(0)	19.382	<0.004
Dislike slightly	0(0)	0(0)	0(0)		
Dislike moderately	0(0)	0(0)	0(0)		
Dislike very much	0(0)	0(0)	0(0)		
Dislike extremely	0(0)	0(0)	0(0)		

Note: Standard: Normal wheat thepla; Sample T1: Millet thepla formulated with 50% foxtail millet and 10% jackfruit seed flour; Sample T2: Millet thepla formulated with 60% foxtail millet and 20% jackfruit seed flour.

TABLE 3

Distribution of subjects based on texture acceptability of developed products

Texture	Standard	Sample T1	Sample T2	Chi-square	p value
	N (%)	N (%)	N (%)		
Like extremely	10(43.5)	8(34.8)	5(21.7)		
Like very much	26(39.4)	19(28.8)	21(31.8)		
Like moderately	13(26)	21(42)	16(32)		
Like slightly	1(10)	2(20)	7(70)		
Neither like nor dislike	0(0)	0(0)	1(100)	12.994	<0.112
Dislike slightly	0(0)	0(0)	0(0)		
Dislike moderately	0(0)	0(0)	0(0)		
Dislike very much	0(0)	0(0)	0(0)		
Dislike extremely	0(0)	0(0)	0(0)		

Note: Standard: Normal wheat thepla; Sample T1: Millet thepla formulated with 50% foxtail millet and 10% jackfruit seed flour; Sample T2: Millet thepla formulated with 60% foxtail millet and 20% jackfruit seed flour.

TABLE 4

Distribution of subjects based on colour acceptability of developed thepla samples

Color	Standard	Sample T1	Sample T2	Chi-square	p value
	N (%)	N (%)	N (%)		
Like extremely	14(42.4)	9(27.3)	10(30.3)		
Like very much	24(37.5)	23(35.9)	17(26.6)		
Like moderately	12(24)	17(34)	21(42)		
Like slightly	0(0)	1(50)	1(50)		
Neither like nor dislike	0(0)	0(0)	1(100)	8.056	<0.428
Dislike slightly	0(0)	0(0)	0(0)		
Dislike moderately	0(0)	0(0)	0(0)		
Dislike very much	0(0)	0(0)	0(0)		
Dislike extremely	0(0)	0(0)	0(0)		

Note: Standard: Normal wheat thepla; Sample T1: Millet thepla formulated with 50% foxtail millet and 10% jackfruit seed flour; Sample T2: Millet thepla formulated with 60% foxtail millet and 20% jackfruit seed flour.

TABLE 5
Distribution of subjects based on taste acceptability of developed thepla samples

Taste	Standard	Sample T1	Sample T2	Chi-square	p value
	N (%)	N (%)	N (%)		
Like extremely	10(34.5)	8(27.6)	11(37.9)		
Like very much	21(40.4)	17(32.7)	14(26.9)		
Like moderately	19(40.4)	16(34)	12(25.5)		
Like slightly	0(0)	9(42.9)	12(57.1)		
Neither like nor dislike	0(0)	0(0)	1(100)	16.623	<0.034
Dislike slightly	0(0)	0(0)	3(100)		
Dislike moderately	0(0)	0(0)	2(100)		
Dislike very much	0(0)	0(0)	0(0)		
Dislike extremely	0(0)	0(0)	0(0)		

Note: Standard: Normal wheat thepla; Sample T1: Millet thepla formulated with 50% foxtail millet and 10% jackfruit seed flour; Sample T2: Millet thepla formulated with 60% foxtail millet and 20% jackfruit seed flour.

TABLE 6
Distribution of subjects based on aroma acceptability of developed thepla samples

Aroma	Standard	Sample T1	Sample T2	Chi-square	p value
	N (%)	N (%)	N (%)		
Like extremely	8(38.1)	6(28.6)	7(33.3)		
Like very much	25(39.7)	22(33.3)	17(27)		
Like moderately	10(20.4)	19(38.8)	20(40.8)		
Like slightly	7(43.8)	4(25)	5(31.2)		
Neither like nor dislike	0(0)	0(0)	0(0)	8.399	<0.396
Dislike slightly	0(0)	0(0)	1(100)		
Dislike moderately	0(0)	0(0)	0(0)		
Dislike very much	0(0)	0(0)	0(0)		
Dislike extremely	0(0)	0(0)	0(0)		

Note: Standard: Normal wheat thepla; Sample T1: Millet thepla formulated with 50% foxtail millet and 10% jackfruit seed flour; Sample T2: Millet thepla formulated with 60% foxtail millet and 20% jackfruit seed flour

TABLE 7

Distribution of subjects based on of mouthfeel acceptability of developed thepla samples

Mouthfeel	Standard	Sample T1	Sample T2	Chi-square	p value
	N (%)	N (%)	N (%)		
Like extremely	9(36)	8(32)	8(32)		
Like very much	27(45)	19(31.7)	14(23.3)		
Like moderately	11(22)	19(38)	20(40)		
Like slightly	3(23.1)	4(30.8)	6(46.2)		
Neither like nor dislike	0(0)	0(0)	2(100)	12.37	<0.135
Dislike slightly	0(0)	0(0)	0(0)		
Dislike moderately	0(0)	0(0)	0(0)		
Dislike very much	0(0)	0(0)	0(0)		
Dislike extremely	0(0)	0(0)	0(0)		

Note: Standard: Normal wheat thepla; Sample T1: Millet thepla formulated with 50% foxtail millet and 10% jackfruit seed flour; Sample T2: Millet thepla formulated with 60% foxtail millet and 20% jackfruit seed flour.

TABLE 8

Distribution of subjects based on overall acceptability of developed thepla samples

Overall acceptability	Standard	Sample T1	Sample T2	Chi-square	p value
	N (%)	N (%)	N (%)		
Like extremely	10(34.5)	9(31)	10(34.5)		
Like very much	31(42.5)	23(31.5)	19(26)		
Like moderately	9(22.5)	17(42.5)	14(35)		
Like slightly	0(0)	1(12.5)	7(87.5)		
Neither like nor dislike	0(0)	0(0)	0(0)	16.337	<0.012
Dislike slightly	0(0)	0(0)	0(0)		
Dislike moderately	0(0)	0(0)	0(0)		
Dislike very much	0(0)	0(0)	0(0)		
Dislike extremely	0(0)	0(0)	0(0)		

Note: Standard: Normal wheat thepla; Sample T1: Millet thepla formulated with 50% foxtail millet and 10% jackfruit seed flour; Sample T2: Millet thepla formulated with 60% foxtail millet and 20% jackfruit seed flour.

Proximate analysis

The proximate analysis result depicted that sample T1 incorporated with 50% foxtail millet and 10% Jackfruit seed has protein (5.21 g), fat (2.24 g), carbohydrate (57.34 g), moisture (31.72 g), ash (3.49 g), fibre (8.3 g), and resistance starch (11.46 mg) (Table 9).

TABLE 9

Nutritional composition of most acceptable millet thepla sample (Foxtail millet-50% and Jackfruit seed-10%)

S. No	Nutrient	Unit	T1
1	Energy	Kcal/100 gm	270.36
2	Protein	g/100 gm	5.21
3	Total fat	g/100 gm	2.24
4	Carbohydrate	g/100 gm	57.34
5	Moisture	g/100 gm	31.72
6	Ash	g/100 gm	3.49
7	Dietary Fibre	g/100 gm	8.3
8	Resistance Starch	mg/100 gm	11.46

Intervention phase

Table 10 depicts blood glucose concentration in between the group. At 0 minute, no difference was seen between the control blood glucose concentration and the case blood glucose concentration. At 15 minute, the mean blood glucose concentration of control product was 138 mg/dl which is much higher than that of case product (119 mg/dl) and the differences were statistically significant. The difference was also found to be statistically significant at 30, 90 and 120 minutes. At 60 minute, the mean blood glucose concentration of control product was higher (122.7 mg/dl) than that of case product (107.3 mg/dl) but the difference was not statistically significant.

TABLE 10

Blood glucose concentrations (mg/dl) in between the group

OGTT	Control M ± SD	Case M ± SD	p-Value
0 min	93.4 ± 7.16	92.9 ± 6.29	0.87
15 min	138 ± 17.70	119.4 ± 6.75	0.006
30 min	154 ± 22.91	120 ± 10.45	0
60 min	122.7 ± 25.31	107.3 ± 13.74	0.1
90 min	122.7 ± 12.21	105.9 ± 10.37	0.004
120 min	114.7 ± 15.24	94.9 ± 1.91	0.001

Table 11 depicts that the blood glucose concentrations within the group (case and control). The data revealed that the glucose concentration was statistically significant from 0 minutes to 120 minutes of various intervals in both case and control group. The differences are superscripted as a, b, c, d, e and f.

TABLE 11

Blood glucose concentrations (mg/dl) within the group

Time	Control M ± SD	Case M ± SD
0 min	93.4 ± 7.16^{bcde}	92.9 ± 6.29^{bcde}
15 min	138 ± 17.70^{a}	119.4 ± 6.75^{adef}
30 min	154 ± 22.91^{adef}	120 ± 10.45^{adef}
60 min	122.7 ± 25.31^{ac}	107.3 ± 13.74^{abcf}
90 min	122.7 ± 12.21^{ac}	105.9 ± 10.37^{abc}
120 min	114.7 ± 15.24^{c}	94.9 ± 1.91^{bcd}
p value	0	0

Note: The post hoc test represented as superscript.

Figure 1 and Table 12 depicted Incremental area under the blood glucose response curve (IAUC) for control and case product. The mean of IUAC of control product was higher than the IUAC of case product. The difference was statistically significant. The results were similar to a previous study [10] which found that the IAUC of glucose was 4197 and the IAUC of foxtail millet bread containing 30% foxtail millet and 70% refined wheat flour was 2076.

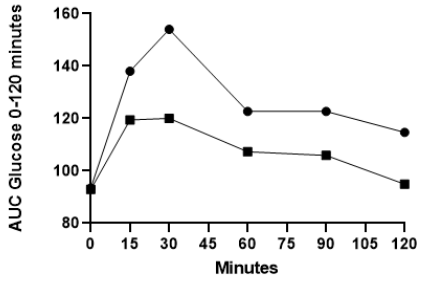

Figure 1) *Depicts the IAUC of control product was much higher than the IAUC of case product;* **Note:** *(●) Control, (■) Case*

TABLE 12

Incremental area under the blood glucose response curve (IAUC) for control and case product

Product	IAUC ± SEM	p value
Control	4110 ± 770.5	0.001
Case	1799 ± 412.4	

Table 13 depicts the glycemic index of the case product that was calculated using the formula,

$$Glycemic\ Index = \frac{Incremental\ blood\ glucose\ area\ of\ test\ food}{Incremental\ blood\ glucose\ area\ of\ referencefood} \times 100$$

The glycemic index was 43.77 that falls in the range of low glycemic index. The glycemic load was calculated by using the formula,

$$Glycemic\ Load = \frac{GI}{100} \times Carbohydrate\ content$$

The glycemic load was 32.82 which make it suitable for diabetes.

The glycemic index of the thepla prepared by the incorporation of foxtail millet and jackfruit seed was low. This may be due to the high levels of dietary fibre in them. In the present study, it was observed there was a significant difference in the post prandial blood glucose levels of control and case product. These results were similar to a pervious study [11] which assessed the glycemic index of foxtail millet rice and glyemic index of foxtail millet rice was 45.3. Another study conducted by Palanisamy, et al., [12] also showed similar results, which assessed glycemic index of different millet idlis. In this study, the glycemic index of foxtail millet idli was found to be the lowest as compared to rice, bayrnyard, pearl, little, and kodo millet idli. The glycemic index was foxtail millet idli was 49.64. The results were also similar to the results obtained by Thara and Nazmi [13] who conducted a study to formulate a ready-to-cook upma mix incorporated with foxtail millet and semolina and assessing the glycemic index of the developed mixes. In this study, product was made by incorporating foxtail millet in different concentrations i.e. 60%, 70% and 80% and their glycemic index value was 50.5, 49.8 and 49.2 respectively. Similar results were found by Chavi and Sarita, [10] in which glucose response of bread incorporated with 30% foxtail millet and 70% refined wheat flour was assessed. The value of glycemic index in this study was 49.53.

TABLE 13

GI, GL of case product

Product	CHO	Portion	GI	GL
Case	75 g	130.8 g	43.77	32.82

CONCLUSION

The study concluded that millet thepla made by the incorporation of 50%

foxtail millet and 10% jackfruit seed was highly acceptable through sensory evaluation. The result of proximate analysis demonstrated that thepla made by incorporating 50% foxtail millet and 10% jackfruit seed was rich in dietary fiber as well as resistance starch. It was also observed that there was a significant difference in the post-prandial blood glucose levels of the control and case products. Millet thepla (incorporation of 50% foxtail millet and 10% jackfruit seed) has a better glucose response as compared to the control group. The glycemic load of the product was 43.77 which falls in the category of low glycemic index food. The study concluded that this product can be used for diabetic patients, due to its low Glycemic index and load. An intervention study can be planned for 12 weeks to see the impact of the product on the blood glucose response of pre-diabetic and diabetic populations.

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