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Comparative study on Glycemic index, glycemic load of millet idli (Fermented millet cake) with rice idli (Fermented rice cake)

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ABSTRACT

Different starchy foods produce different glycemic responses when fed individually. The reason for differences in glycemic response appears to relate to the rate at which the foods are digested and the many factors influencing this. The glycemic index (GI) is a system of classification.The glycaemic index (GI) concept is based on the difference in blood glucose response after ingestion of the same amount of carbohydrates from different foods, and possible implications of these differences for health, performance and well-being. GI is defined as the incremental blood glucose area (0_2 h) following ingestion of 50 g of available carbohydrates in the test product as a percentage of the corresponding area following an equivalent amount of carbohydrate from a reference product. A high GI is generally accompanied by a high insulin response. The glycaemic load (GL) is the GI_/the amount (g) of carbohydrate in the food/100. Many factors affect the GI of foods, and GI values . Some epidemiological studies and intervention studies indicate that low GI diets may favourably influence the risk of chronic diseases such as diabetes and coronary heart disease, although further well-controlled studies are needed for more definite conclusions. Diet plays an important role in management of diabetes and foods having low glycemic index are gaining more importance as they delay the release of glucose in the blood. It is essential to develop low glycemic foods from regionally available ingredients for use in daily dietaries.Hence, the present study was undertaken to assess the glycemic index of the traditional recipes prepared from millet on normal subjects. The traditional recipe idli (fermented millet cake) from south India was developed from from five different millets namely Pearl, Kodo,little,bayrn yard and foxtail and rice . Standardization were done to provide 50g of carbohydrate from one portion (3 Nos). The millet idli prepared from different millet

were subjected to glycemic index and GL on selected normal subjects (n=10). The glycemic index and load was found to be 49.64 ± 1.5,50±2.4,52± 2.4,55± 2.4,58± 2.1,75± 1.8 and 11.3± 1.2,12.5± 1.4,10.2,11.1± 1.6,11.2± 1.4,14.4± 1.3,and13.2± 1.5 for Foxtail, Bayrnyard, Little, Pearl, Koda millet and Rice idli respectively .

Keywords: Glycemic index, glycemic load, Fermented millet cake, Fermented rice idli

INTRODUCTION

The appearance of glucose in the bloodstream following eating—the glycemic response (GR)—is a normal physiological occurrence that depends on the rate of glucose entry into the circulation, the amount of glucose absorbed, the rate of disappearance from the circulation due to tissue uptake, and hepatic regulation of glucose release (Triplitt 2012). Foods containing carbohydrates have a wide range of effects on the GR, with some resulting in a rapid rise followed by rapid fall in blood glucose concentrations, while others show an extended rise and slow extended fall in blood glucose. The Glycemic Index (GI) was created in 1981 as a tool for people with diabetes to select foods (Jenkins et al 1881). GI provides information on the GR that might be expected when a person consumes the quantity of a food containing a fixed amount of carbohydrate (usually 50 g). In this system, GR is defined as the increase in the blood glucose concentration following eating, expressed as the incremental area-under-the-blood-glucose-curve (iAUC) over a period of two hours. The GI value is actually given as a relative GR; the GR of the food is expressed as a percentage of the GR of a reference food (usually a glucose solution or white bread):

$$GI = (iAUC_{test\ food}/iAUC_{reference\ food}) \times 100$$

To a large extent, control of the GR is governed by the amount of food eaten; that is, if a large amount of a low or a high GI food is consumed, the GR will be large and vice versa, a small amount of either a low or a high GI food will limit the GR. The concept of the glycemic load (GL) was introduced as a means of predicting the GR; it takes into account the GI and the amount of available carbohydrate in a portion of the food eaten (GL = GI × available carbohydrate in a given amount of food) (Salmerón et al 2007).Much work has been undertaken since the introduction of the concepts of GI and

GL to ascertain how they relate to health and disease. In applying the concepts, foods have been classified by GI into low (GI ≤ 55), medium (GI 56–69), and high (GI ≥ 70) categories, and classified by GL as being low (GL ≤ 10), medium (GL 11–19), and high (GL ≥ 20).

MATERIALS AND METHODS

Sample selection:

10 Normal female volunteers with the age (mean age 21 ± 4 years were selected for estimating the GI of the test meal (millet and rice idli).The characteristic of 10 selected normal female volunteers for glycemic index study is given in Table 1.

Table 1. Characteristics of Normal Volunteers selected for GI study(n-10)

Parameter	Participants	Normal Range
Characteristics	Mean	
Age (Yrs)	21 ± 4	
Wt (Kg)	50± 5	
Ht (cm)	1.58± 5	
BMI (Kg/mt2)	20±.2	<24.9
Systolic Blood Pressure(mm Hg)	110±6	<130
Diastolic Blood Pressure(mm Hg)	70± 7	<85
Fasting Blood Sugar (mg/dl)/	87±9	70-126/dl
Sex	Female	

Selection of products: The traditional recipe idli (fermented millet cake) was developed from from five different millets namely Pearl, Kodo, little, bayrnyard and foxtail and rice . Standardization were done to provide 50g of carbohydrate from one portion (3 Nos) .These idles were prepared by using millet/rice with black gram (Vigna mungo.)Millet and rice idles was prepared by using the ingredients, Little millet(Panicum milliare) Barnyard millet(Echinochloa fumentacea) ,Foxtail millet (Setaria Italica), Kodo millet idli(Paspalum scrobiculatum,Pearl millet(Penniselum typhoideum) and Rice idli(Oryza sativa) in the propotion of 90:20

Table 2 Nutrient composition of prepared millet idlies with its Batter quantity

S.N	Name of the millet	Batter Quantity (g)	Millet Qt g	Black gram g	Energy K.Cal	Pro g	Fat g	Carb g	Tt.Fb g	InSo. fb g	So. fb g	Available carbo g
1	Pearl	290	90	20	352.16	9.57	4.12	75.9	6.7	3.77	2.93	69.2
2	Small	290	90	20	332.13	11.55	4.57	70.5	9.22	6.38	2.84	61.28
3	Koda	290	90	20	312.56	12.09	1.6	69.51	7.06	4.31	2.75	62.45
4	Foxtail	290	90	20	324.56	15.69	4.21	64.38	8.41	5.88	2.52	55.97
5	Bayrnyard	290	90	20	300.86	10.2	4.66	69.15	14.6	9.98	4.64	54.53
6	Rice	290	90	20	349.64	10.74	0.80	80.58	5.71	4.13	1.49	74.87

Standardization for 50 g of carbohydrate:

Table 3 : Carbohydrate content of standardized millet idlies with its adjusted Batter volume (for 50 g carbohydrate/portion)

*** 1 Portion =3 no.of idlies**

Name of the millets	Common name	Scientific name	Wt.of millet/ rice (g)	Wt.of black gm dhal (g)	Vol.of batter (g)	Amt.of CHO (g) (290 g of batter)	Vol.of batter adjusted for 50 gm CHO	Amt.of CHO (g) (standardized idli per portion)	Wt / idli	No.of idli
Bajra	**Pearl millet**	**Pennisetum typhoideum**	**90**	**20**	**290**	**69.2**	**210**	**50**	**70**	**3**
Samai	**Small millet**	**Panicum**	**90**	**20**	**290**	**61.28**	**237**	**50**	**79**	**3**

		milliare								
Varagu	**koda millet**	**Paspalum scrobiculatum**	**90**	**20**	**290**	**62.45**	**232**	**50**	**77**	**3**
Thinai	**Foxtail millet**	**Setaria Italica**	**90**	**20**	**290**	**55.97**	**259**	**50**	**86**	**3**
Kuthiraivalli	**Bayrnyard millet**	**Echinochloa fumentacea**	**90**	**20**	**290**	**54.53**	**266**	**50**	**89**	**3**
Rice	**Rice**	**Oryza sativa**	**90**	**20**	**290**	**74.87**	**194**	**50**	**65**	**3**

50g carbohydrate was used for standardization of recipe(one portion containing 3 units of idli) . The total carbohydrate content of recipe prepared with various millets were calculated to know the available carbohydrate content,and to adjust 50 g carbohydrate /portion (3 numbers).Portion size is very important for to assess its glycemic index and load.Carbohydrate content of the standardized idli items was calculated by making use of the food composition table 2 given by ICMR-Indian food Composition.(Gopalan etal 2000). For the preparation of millet idli 90 g of millets and 20 g of black gram dhal were used.The final quantity of the batter was weighed accurately.The final weight was 290 g . This weight (290g) of (pearl, small, koda,

foxtail and bayrnyard) millet batter was provided 69.2,61.28, 62.45,55.97, and 54.53 g of carbohydrate respectively, while rice batter provided 74.87 g of carbohydrate.In table 3 the available carbohydrate content was calculated by subtracting total fiber content from its total carbohydrate of millet and rice idli. The quantity of different millet batter were adjusted such a way to provide 50 g of carbohydrate for one portion (3 Numbers) .The batter quantity of 210g for pearl millet idli (70g /idli), 237g for small millet idli (79g/idli),232g for koda millet idli (77g / idli) , 259g for foxtail

millet idli (86g/idli) and 266g for barnyard millet idli (89g/idli) and 194gms of rice idli (65 g/ idli) were taken to prepare standardized idli.

In table 4, the available carbohydrate for idlies was calculated by subtracting the total dietary fibre (TDF) (which includes the soluble and insoluble fibre) from the total carbohydrate present (Ren et al 2015). The available carbohydrate (39.1 g) from black gram was constant in all millet idlies

Table 4. Nutrient composition of standardized millet idlies / portion* 1 portion = 3 No.of idlies

S.No	English Name	Batter quantity g	Energy K.Cal	Protein g	Fat g	Carbohydrate g	Portion wt (g) (per idli)
1	Pearl millet	210	255.01	6.93	2.9	50	70
2	Small millet	237	270.9	9.4	3.7	50	79
3	koda millet	232	250.02	9.67	1.28	50	77
4	Foxtail millet-	259	290.15	14.01	3.75	50	86
5	Bayrnyard millet	266	275.6	9.3	4.27	50	89
6	Rice	194	273.4	7.1	0.5	50	65

Procedure

Estimation of Glycemic Index of standardized millet idli (In-vivo Human Study)

A step by step procedure is followed to estimate the GI of standardized millet idli as per WHO (2010) and FAO protocol (Dereje et al 2016)

Step 1: Ten healthy female volunteers with normal BMI aged between 20-25 years were selected as subjects for the estimation of Glycemic Index. The volunteers had no family

history of diabetes or any food allergies, not on any medication and also not on weight loss diet. Since, estimating Glycemic Index can only be done in a controlled environment with a control subjects for test food ,normal subjects were selected.

Step 2: The purpose of the study was explained to each participant and got written consent from the participate. 4 slices of white bread containing 50 g of carbohydrates was given to the samples (10 volunteers) as reference food.

Step 3: After an overnight fast, finger prick blood samples were investigated at 0 minutes before taking reference food. 4 slices of white bread containing 50 g of carbohydrates was given to the samples (10 volunteers) as reference food. Blood samples were collected at the intervals of 0min, 30 min, 1 hr, 1 hr 30 min and 2 hours after consuming reference food. Sample was analyzed using glucometer strips with LOT no: 49867 to produce a graph of glucose levels over time. The area under the resulting curve is measured, and it is called as incremental area under the blood glucose response curve or IAUC.

Step 4: After washout periods of 2 days, test food **(**three number of standardized millet idlies containing same 50 g of carbohydrate **)** was given to the volunteers after they have been in fasting mode for at least 10-12 hours. The test was performed in the morning

Step 5: The blood glucose level for the next two hours was produced in a graph the same way as charted for reference food. The IAUC was also calculated similarly as for reference food (white bread).

Step 6: Likewise the interval of two days washout period all five varieties of millet idlies were given. Finally the rice idli was given to the same group.The blood glucose level for the next two hours was produced in a graph the same way as charted for reference food.

Step 6: By dividing the IAUC of the test food by the IAUC of the reference food and multiplying it by 100. The GI of the test food for each test subject was calculated.

(Annexure 3)

Step 7: The Mean was calculated by adding the sum and divided by 10

Calculations of Glycemic Index & Glycemic load of each millet idlies

The incremental area under the curve (IAUC) was calculated for each idli for every volunteer separately (as the sum of the surface of triangles and trapezoids between the B-glucose curve and horizontal baseline going parallel to x-axis from the beginning of B-glucose curve at time 0 to the point at time 120 min) to reflect the total rise in B-glucose concentration after eating the test food.

The IAUCS for the standard reference food (i.e. bread) was obtained in the IAUC/IAUCS calculations, all B-glucose values in the course of the test lower than the first value (at time 0) were equalized to the respective first value. In each volunteer the GI (percent) was calculated by dividing the IAUC for the tested food by the IAUCS for the standard food and multiplying by 100

IAUC Incremental Area Under the blood glucose response Curve for the tested meal/

IAUCS Incremental Area Under the blood glucose response Curve for the standard meal

The AUC was calculated using the general formula, GI (percent) was calculated as follows:

$$GI = \frac{\text{Area under curve for 50 g CHO from test food}}{\text{Area under curve for 50 g CHO from reference food}} X100$$

Estimation of Glycaemic Load (GL)

Glycaemic load is defined as the weighted mean of the dietary glycaemic index multiplied by the available carbohydrate content per serve size divided by 100 (Turati, et al 2019 **)**. The GL was calculated using the following formula

GL= GI × Available carbohydrate content per serve size/100

Glycemic load depends on the GI of the food items, the available carbohydrate content and its nominal serving size.

RESULTS & DISCUSSION

Mean Glycemic index and Glycemic load of Test and Reference Food

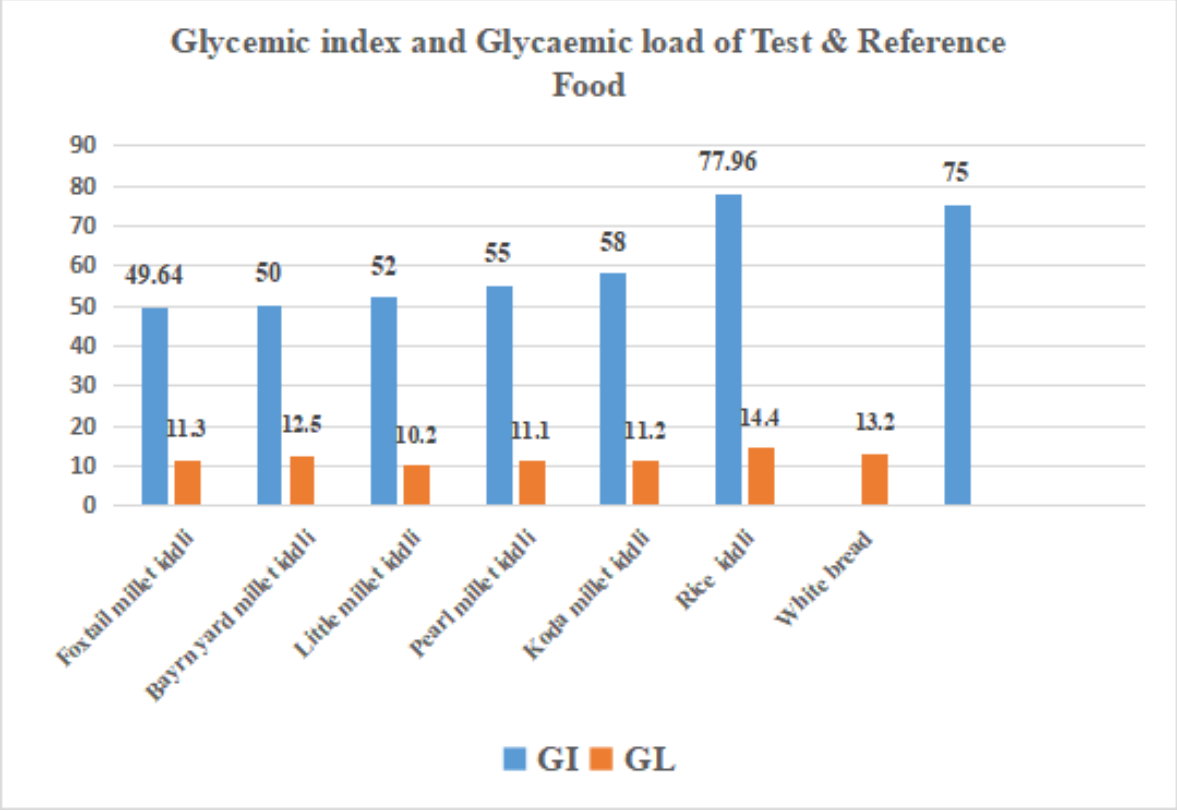
Table 5 : Mean Glycemic index and Glycemic load of Test and Reference Food

S.NO	NAME OF THE MILLET	GI	SD	GL	SD
1	Foxtail millet idli	49.64	± 1.5	11.3	± 1.2
2	Bayrn yard millet idli	50	±2.4	12.5	± 1.4
3	Little millet idli	52	± 2.4	10.2	±1.7
4	Pearl millet idli	55	± 2.4	11.1	± 1.6
5	Koda millet idli	58	± 2.7	11.2	± 1.4
6	Rice idli	77.96	± 2.1	14.4	± 1.3
7	White bread	75	± 1.8	13.2	± 1.5

In table 5 the mean GL of millet idlies ranged from 10.2± 1.7to 13.2± 1.5 (low GL category) compared to rice rice idli 14.4± 1.3 (high GL category) . Among the millet idlies the mean GL of little millet idli is less (10.2± 1.7) compare to other millet idlies. The mean GI values for millet idlies ranged from 49.64±1.5 to 58.0 ±2.7 against rice idli 77.96±2.1 . The GI of foods are classified as low,moderate and high depends on its blood glucose raising property.The GI with ≥ 70 categorized as high, GI with 56–69 is moderate and GI with ≤ 55 is low **(**Milleret a l2012).The GI of millet idlies,foxtail (49.64),baynyard millet (50), little millet (52), and pearl millet (55) are under the category of low GI food.Koda millet idli with GI of 58 categorized as moderate GI food.The GI of white bread and rice idli was 75 and 77.96 respectively , categorized as high GI food. Millet are rich in fibre which provides bulk to gastro intestinal tract contents and slows transit time of matter through the tract (Katsirma, et al2021) .Soluble

fibre also decreases the rate of starch digestion by pancreatic amylase in vivo, probably by delaying the interaction between enzymes and substrates (Elizondo-Montemay et al 2020), causes low post-prandial blood glucose., little millet (Panicum sumatrense), defatted soya (Glycine max) flour, whole green gram (Vigna radiata), fenugreek seeds (Trigonella foenum-graecum), flax seeds (Linum usitatissium), curry leaves (Murraya koenigii), bitter gourd (Momoradi cacharantia) and skimmed milk powder. All the ingredients used for the study were procured from local market of Bengaluru. Fresh bitter gourd and curry leaves were washed thoroughly, blanched for one min and oven dried. Further finger millet, little millet, whole green gram, fenugreek seeds and roasted flax seeds were made into flour. Millet based mix was developed by mixing the flour with skimmed milk powder, defatted soya flour and kept airtight. Region specific traditional recipes were prepared from the developed mix to assessed

Figure 1: Glycemic index and Glycaemic load of Test & Reference Food



CONCLUSION

As per the GI classification, foxtail millet idli with GI of (49.64),baynyard millet with (50), little millet with (52), and pearl millet with (55) are falls under the category of low GI food. Koda millet idli with GI of 58 categorized as moderate GI food.The GI of white bread and rice idli was 75 and 77.96 respectively and categorized as high GI food. Considering the Glycemic Load of standardized millet and rice idlies, kodo millet idli with GL of (10.2) was found to be low, followed by little millet (11.1), pearl millet (11.2), barnyard millet (11.3) and foxtail millet idli (12.5) and higher in white bread (13.2) and and rice idli(14)

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