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Glycemic index and glycemic load of edible jackfruit parts

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Abstract
Dietary guidelines recommend increased intake of dietary fibre for better control and proper management of chronic diseases such as diabetes mellitus, cardiovascular diseases and cancer. Fruits and vegetables are valued for their complex carbohydrates, dietary fibre and micronutrients. Jackfruit is reported to have good quality fibre and possesses many medicinal properties as well. The present study investigated to determine the GI and GL of different parts of jackfruit cultivars (*koozha and varikka*). The bulbs, perigones, seeds, rind, core and testa were used as the test parts of the fruits Ten healthy individuals, who offered consent, were requested to consume cooked test fruit parts and reference food (glucose) after an overnight fasting on separate occasions. The test fruit part and glucose contained 50g of carbohydrates. Finger-prick blood samples were obtained at 0 (fasting), 15, 30 60, 90 and 120 min after consuming each jackfruit part. The blood glucose response was obtained by calculating area under the curve (AUC). The AUC ranged between 111.82 mmol.min/L and 245.23 mmol.min/L, and was significantly higher for glucose (p<0.05) compared to all fruit parts tested. Jackfruit cv *koozha's* rind reported lowest glycemic index and glycemic load (45.26±0.52 and 1.30±0.06). The highest glycemic index was observed in *varikka* seeds (69.31±0.99) and highest glycemic load was obtained in *koozha* seeds ((12.42±0.16).

Keywords: glycemic index, glycemic load, Auc, jackfruit, *Koozha, Varikka*, bulbs, perigones, seeds, rind, core, testa

Introduction

Different carbohydrate foods produce different blood glucose response. Jenkins *et al.* (1981) [8] developed the concept of GI to classify CHO. The GI classifies foods based on the postprandial glycemic response, following consumption of that food. Post-prandial glycemia is influenced by both the amount and the type of carbohydrates in the foods. The nature of carbohydrates is best described by their glycemic indices (GIs) (WHO, 2010). Recent evidence suggests that high GI/ GL diets may increase the risk for cardiovascular diseases (Liu *et al.*, 2000; Amano *et al.*, 2004) [9, 1] and type 2 diabetes (Hodge *et al.*, 2004; Schulze *et al.*, 2004) [7, 12]. Three decades ago, the concept of a dietary Glycemic index came under discussion as a factor that should be controlled to prevent chronic diseases.

Jackfruit or *panasa* scientifically known as *Artocarpus heterophyllus* Lam. belongs to the family Moraceae. The fruit is the gigantic syncarp and is known as the largest fruit of the world. Jackfruit is a popular fruit ranking next to mango and banana. The fruit is considered as the poor man's food owing to the numerous culinary uses of unripe, ripe and tender immature fruit. In south India, jackfruits are categorized into two broad types: *koozha chakka* which have little, stringy, cushiony, mushy but very sweet, and the commercially most valuable cultivar, with distinct carpels of high quality known as *varikka chakka*. Jackfruit is reported to possess many medicinal properties. Various jackfruit plant parts, including the bark, wood, leaves, fruit, and seeds, may exhibit a broad spectrum of antibacterial activity (Swami *et al.* 2012) [13]. It has various beneficial nutritional parameters including low glycemic index. This could be due to the collective contributions of dietary fibre and slowly available glucose. Raw jackfruit flesh is regarded as a good source of carbohydrate (25%), vitamin A and a fair source of protein (1.6%). The postprandial glycemic response to raw and ripe jackfruit elicits low glycemic index (Hettiaratchi *et al.*, 2011) [6]. The flavonoids present in jackfruit extract has been identified to be responsible for the non-toxic hypoglycemic action. The functional components of jackfruit help to reduce various diseases such as blood pressure, heart diseases, strokes and bone loss.

Hence, in the present study an effort has been taken to explore the glycemic Index and glycemic load of the different parts of jackfruit cultivars, which is largely consumed by people in Kerala. Though the different parts of jackfruit cultivars have been used widely, yet there is no affirming data to recommend these cultivars of jackfruit to the diabetic population. Therefore, the objective of this study is to determine the glycemic index and glycemic load of different parts of jackfruit cultivars on healthy adults.

Materials and Methods

By convenient sampling 10 non-diabetic, non-smokers, who were not on any medication and were healthy were selected. The purpose and protocol of the study were explained to the subjects and written consent was obtained. Subjects were requested to maintain their usual daily food intake and activity throughout the study period. They were asked to assemble on a fixed day with empty stomach in the early morning. The fasting blood glucose levels of the volunteers were determined using glucometer and test strips. Fifty grams of glucose was diluted in 150 ml of water and given to them for drinking. The blood glucose levels at fasting state and there after following administration of glucose, at 30, 60, 90 and 120 minutes were determined and recorded. With the same volunteers, the study was continued by feeding them with weighed quantities of raw cooked jackfruit parts on the following day. The Raw jack fruits (12 weeks maturity) of cv *koozha* and cv *varikka* were collected from the Instructional farm, College of Agriculture, Vellayani. The bulbs, perigones, seeds, rind, core and testa were separated from the fruit. Each of the fruit parts were cooked with minimum embellishments and the cooked parts containing 50 grams of carbohydrate was fed to the subjects. The blood glucose levels were again determined as given above and recorded.

Data Analysis

The blood glucose values for each point of time over two hours were used to calculate the area under the curve (AUC) for each subject. The AUC calculation used was as described by the Food and Agriculture Organization of the United Nations (FAO, 1998) [3]. Then the data collected were analysed using R programming software.

Using these values, the Glycemic index of the recipe was determined using the standard formula given by Miller (2004).

$$GI = \frac{\text{Incremental area of the test food}}{\text{Incremental area of the glucose}} \times 100$$

The Glycemic load was calculated using the value of Glycemic index and the available carbohydrate content in one serving of the food. The GL was calculated using the formula.

$$GL = \frac{GI \times \text{Available carbohydrate content per Serve size}}{100}$$

Results were expressed as mean ± SEM. Blood glucose value at each time, AUC and blood glucose responses were subjected to one way ANOVA, followed by treatment comparisons based on least square difference criteria.

Result and Discussion

The mean blood glucose at different time point, area under curve (AUC), glycemic index (GI) and glycemic load (GL) of the jackfruit varieties (*koozha* and *varikka*) different with respect to bulbs, seeds, perigones, testa, rind and core were noted after consuming the fruits and is presented in Table.1. There was no significant difference in initial blood glucose response of each subject in the group (p>0.05). Significantly different patterns of blood glucose response was observed during 30 to 120 minutes of the dietary regime (p<0.05). Jackfruit *koozha* and *varikka* parts reached peak blood glucose values at 30 minutes, the lowest blood glucose response was observed in *koozha* rind (5. ±0.04) followed *by koozha* testa, *varikka* perigones, *varikka* rind and *varikka* testa (5.03±0.8, 5.06±0.06, 5.07±0.06, 5.08±0.07) respectively. The highest blood glucose response was observed in *varikka* bulb (6.1±0.8), which was on par with *varikka* seeds (6.08±0.04) and *koozha* bulbs (5.9±.06), a significant difference was observed between each part compared to glucose. At 60 minutes, the least value was reported in *varikka* rind (5±0.05) followed by *koozha* rind (5.03±0.04) and highest blood glucose response was obtained in *varikka* bulbs (5.8±0.15) which was on par with *koozha* seed (5.6±0.08). *Koozha* rind (4.8± 0.09) had the lowest blood glucose response at 90 minutes, which was followed by *varikka* testa (4.9± 0.12), highest glucose response was observed in *varikka* bulb (6.06± 0.02) which was on par with *koozha* seed (6.04± 0.04). There was a significant difference observed between the parameters of each part compared with that of glucose. The highest blood glucose value was reported *koozha* bulb (5.8± 0.03) at 120 minutes and lowest value was observed in *koozha* rind (4.6±0.03). This study showed that the blood glucose response produced after consuming the test fruits of jackfruit parts was significantly lower when compared with glucose and the tested fruits gave varying effects on blood glucose responses. There are several factors that may affect the digestion and absorption of fruits and thus the blood glucose response. Factors such as the degree of ripeness, the type of sugars present, the presence of fibre and antinutrients and the physical state of the fruits, that have contributed to the response of glucose levels (Guevarra and Panlasigui, 2000) [5]. The presence of antinutrients such as phytic acid, tannins, lectins and saponins have been known to delay the rate of digestion and absorption (Miller *et al*., 1997) [11]. Jackfruit contains tannins and phytic acids that are found to inhibit intestinal enzymes lowering the rate of absorption thus, producing low glucose response (Guevarra & Panlasigui, 2000) [5].

Table 1: The mean blood glucose, AUC, GI and GL (%) of fruits under study

Sl. No	Test fruits	0 (min)	30 (min)	60 (min)	90 (min)	120 (min)	AUC (mmol.min/L)	GI (%)	GL (%)
Jack fruit koozha									
1	T1	5.01±0.07	5.9±0.06^{b}	5.1±0.10^{e}	5.2± 0.11^{de}	5.8± 0.03^{a}	158.69±0.87^{d}	63.29±1.21^{b}	11±0.21^{ab}
2	T2	5.0±0.07	5.4±0.08^{c}	5.6±0.08^{b}	6.04± 0.04^{a}	5.1±0.07^{bc}	167.31±1.31^{c}	67.74±0.87^{a}	12.42±0.16^{a}
3	T3	4.8±0.05	5.08±0.05^{de}	5.1±0.06^{de}	5.3±0.06^{d}	5.1± 0.02^{bc}	119.76±0.71^{f}	48.52±0.75^{de}	2.19±0.03^{e}
4	T4	4.9±0.06	5.03±0.04^{e}	5.1±0.06^{de}	5.1±0.14^{de}	5.04± 0.11^{cd}	114.22±0.61^{gh}	46.24±0.57^{f}	1.66±0.02^{e}
5	T5	4.8±0.05	5 ±0.04^{e}	5.03±0.04^{e}	4.8±0.09^{f}	4.6±0.03^{e}	111.82±0.88^{h}	45.26±0.52^{f}	1.30±0.06^{e}
6	T6	5.0±0.07	5.2±0.06^{cd}	5.5±0.10^{bc}	5.3±0.14^{d}	5.2± 0.05^{bc}	131.77±0.77^{e}	53.37±0.76^{c}	2.81±0.04^{e}
Jack fruit varikka									
7	T7	5.02±0.07	6.1±0.06^{b}	5.2±0.14^{de}	6.06± 0.02^{a}	5.2± 0.08^{bc}	167.49±1.04^{c}	67.82±0.90 ^{a}	8.27±0.11^{bc}
8	T8	5.01±0.07	6.08±0.04^{b}	5.8±0.15^{b}	5.8± 0.05^{ab}	5.7±0.02^{a}	171.13±0.80^{b}	69.31±0.99^{a}	11.81±0.17^{ab}
9	T9	4.9±0.06	5.06±0.06^{e}	5.1±0.04^{de}	5.8±0.05^{ab}	5.6± 0.03^{a}	121.86±0.68^{f}	49.37±0.62^{d}	1.44±0.02^{e}
10	T10	4.9±0.07	5.08±0.07^{e}	5.1±0.07^{e}	4.9± 0.12^{ef}	5.6 ±0.04^{a}	114.22±0.83^{gh}	46.53±0.63^{ef}	6.45±4.79^{e}
11	T11	4.9±0.06	5.07±0.06^{e}	5±0.05^{e}	5.2± 0.12^{de}	4.8 ±0.11^{de}	116.75±0.76^{g}	47.27±0.62^{def}	2.12±0.02^{cd}
12	T12	5.01±0.07	5.1±0.06^{cd}	5.3±0.12^{cd}	5.6± 0.12^{bc}	4.9± 0.08^{d}	133.79±0.48^{e}	54.19±0.69^{c}	1.29±0.01^{de}
13	Glucose	4.9±0.11	6.8 ±0.11^{a}	6.07±0.11^{a}	6.12±0.06^{a}	5.9± 0.02^{a}	245.23±2.04^{a}	100	50
CD		0.206	0.1902**	0.272**	0.2718**	0.204**	2.771**	2.216**	3.893**

** Significant at 0.05 level of significance.

T_1 - T_6 - cv Koozha

T_7 - T_{12} - cv Varikka

T_1 & T_7 - Bulb, T_2 & T_8 - Seed, T_3 & T_9 - Perigones, T_4 & T_{10} - Testa, T_5 & T_{11} - Rind, T_6 & T_{12} - Core.

Mean area under the curve (auc) for blood glucose response over 2 hours for test fruit parts and glucose

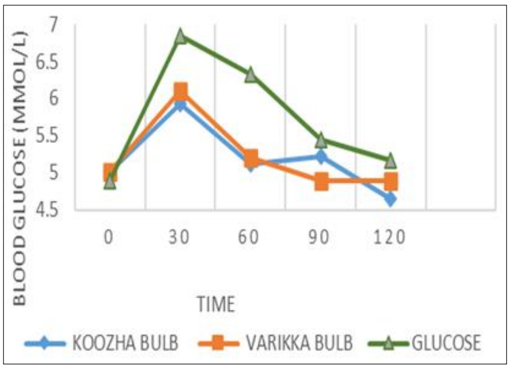

Fig 1: Comparison of blood glucose response of *koozha* and *varikka* bulbs with Glucose

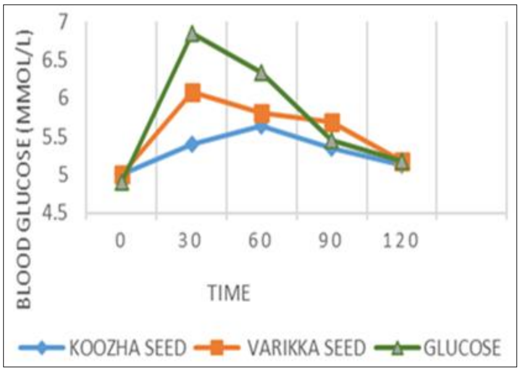

Fig 2: Comparison of blood glucose response of *koozha* and *varikka* seed with Glucose

Net incremental AUC (net AUC) includes all incremental area below the curve, including the area below the fasting concentration. Since it is calculated by applying the trapezoid rule to both positive and negative blood glucose increments, the effect is to subtract the area below the fasting level from that above. (Wolever, 2004) [14]. In the present study the AUC ranged between 111.82 mmol.min/L and 245.23 mmol.min/L, and was significantly high for glucose compared to all fruit parts tested. Among different jackfruit parts, the mean AUC was highest for *varikka* seed (171.13±0.80) and followed by varikka bulb (167.49±1.04) and koozha seed (167.31±1.31) while the lowest was obtained in *koozha* rind (111.82±0.88) which was on par with T_4 and T_{10} (Rinds of *varikka and koozha*) (133.79±0.48).

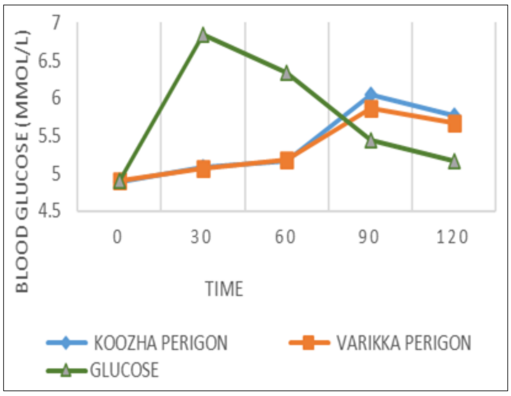

Fig 3: Comparison of blood glucose response of *koozha* and *varikka* perigones

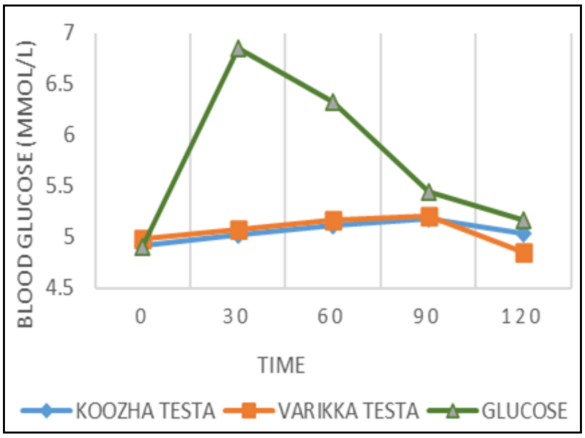

Fig 4: Comparison of blood glucose response *koozha* and *varikka* testa with

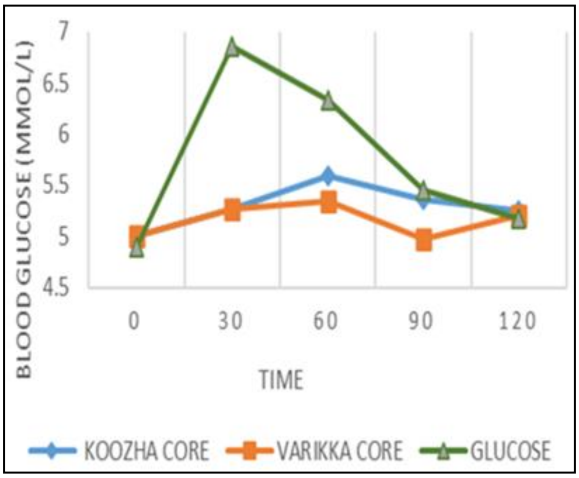

Fig 5: Comparison of blood glucose response *koozha* and *varikka* core with Glucose

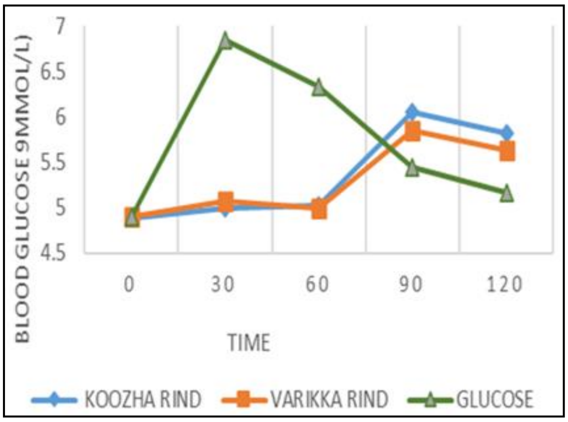

Fig 6: Comparison of blood glucose response *koozha* and *varikka* rind with Glucose

Mendosa (2003) gave a special classification of foods based on their respective glycemic index and glycemic load values as follows (GI: High > 70, Medium 56-69 and low < 55; GL: High > 20, Medium 11-19 and low < 10). Jack fruit variety *koozha* rind had reported lowest glycemic index value (45.26±0.52), which was on par with *koozha* testa (46.24±0.57), *varikka* testa, (46.53±0.63) *varikka* rind (47.27±0.62). The highest glycemic index value reported *varikka* seed (69.31±0.99) followed by *varikka* bulb (67.82±0.90), *koozha* seed (67.74±0.87) and *koozha* bulb (63.29±1.21). Fibre rich foods with a low postprandial glycemic response are generally considered valuable. High fibre is believed to be able to reduce the blood glucose response and hence lower the GI value (Augustin *et al*., 2002) [2]. Hettiaratchi *et al.* (2011) [6] reported that the high fibre content of the jackfruit meal (20 g) could be contributing to the lower GI of the meals.

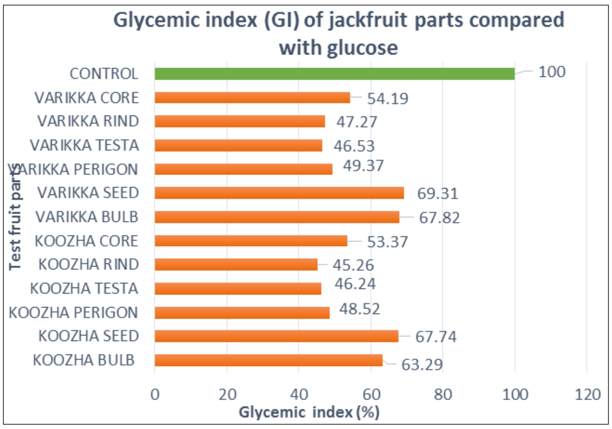

Fig 7: Glycemic index (GI) of test fruit parts when compared with glucose (reference food)

The glycemic load (GL) can be defined as the product of the glycemic index (GI) of a food and the amount of carbohydrate in a serving (Foster-Powell *et al*., 2002) [4]. Out of 12 jack fruit parts of *koozha* and *varikka* cultivars, low glycemic load was reported for *varikka* core (1.29±0.01), followed by *koozha* rind (1.30±0.06) and, *varikka* perigones (1.44±0.02), and *koozha* testa (1.66±0.02). The highest value was obtained for *koozha* seed (12.42±0.16), which was on par with *varikka* seeds (11.81±0.17) and *koozha* bulbs (11±0.21).

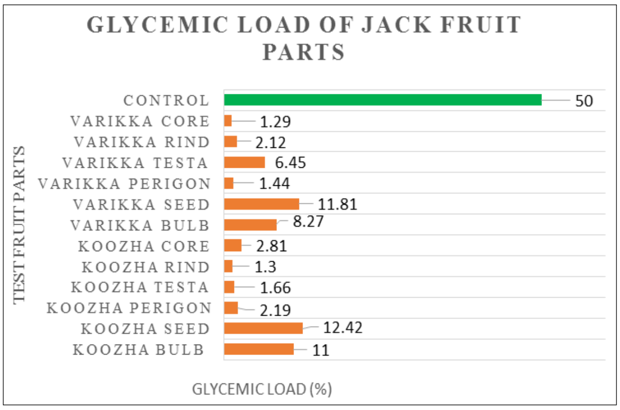

Fig 8: Glycemic Load (GL) of test fruits

Conclusion

Jackfruit has beneficial nutritional parameters and a low GI and GL. This could be due to the collective contributions of dietary fibre, slowly available glucose, intact starch granules and influence of different sources of carbohydrates. Our results revealed that there is a significant difference in blood glucose response and AUC among jackfruit varieties of koozha and varikka parts. Based on these results, the most suitable low GI jackfruit part to be recommended for diabetic patients without significantly increasing the blood glucose response is the *koozha* rind.

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