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Determination of Glycemic index and the consumer preference of *Borassus flabellifer* treacle as an alternative sweetener among a selected group of undergraduates in Sri Lanka

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Abstract

The *Borassus flabellifer* treacle, commonly known as *Palmyrah* treacle in Sri Lanka, is a well-known local traditional sweetener. This study was performed to determine its glycaemic index (GI) and assess consumer preferences among undergraduate students at KAATSU International University, Sri Lanka. A self-administered questionnaire (n=281) was used to survey participants' knowledge of diabetes mellitus (DM) and *Borassus flabellifer* treacle, to collect information regarding consumer purchasing trends, health status, and preferences. For the GI study, 30 healthy undergraduate students from KAATSU International University were selected as subjects. Each participant consumed a food containing 50g of carbohydrates after fasting. Capillary blood was taken at fasting,15,30,45,60, and 120 min after the meal. The GI was calculated by dividing the incremental area under the curve for the treacle by the glucose and multiplying by 100. The study revealed that the majority of respondents (39.9%) have good knowledge regarding treacle consumption, 26.0% of respondents have average knowledge and 34.2% number of respondents have poor knowledge. The GI value of *Borassus flabellifer* treacle was 61.72±17.44, which belonged to the medium GI category, highlighting its potential role in managing and preventing DM and other non-communicable diseases.

Keywords: *Borassus flabellifer* treacle, Consumption, Glycemic Index, Undergraduates

1. Introduction

Diabetes mellitus (DM) is currently the third most dangerous chronic non-communicable endocrine disorder affecting almost 6% of the world's population. The prevalence of diabetes has been increasing globally, with an estimated 463 million adults living with diabetes in 2019. In Sri Lanka, the prevalence of diabetes is also high, with an estimated 10.3% of the adult population affected. Worldwide, the prevalence of the disease is continuously increasing, owing in part to rapid social economy developments, improved living standards, acceleration of urbanization, industrialization, and an increase in the proportion of aging individuals. The etiology and pathogenesis of DM are extremely complicated. At present, genetic factors, environmental factors, and the interaction of these two factors have been established as increasing the risk of type 2 diabetes mellitus [1-3]. Many metabolic studies show that food sources of carbohydrates vary greatly in their absorption rate and effects on blood glucose and insulin concentrations. The glycemic index (GI) is one way of quantifying this variation in response to dietary carbohydrates [4].

The GI is a rating system that measures how rapidly blood glucose will rise with different foods containing carbohydrates. The blood glucose-raising ability of carbohydrates is compared against a standard food (white bread or glucose). Foods with a high GI increase blood sugar very rapidly while a low GI gradually increases blood sugar levels [5], which may contribute to improving glycaemic control. Currently, medicinal plants and herbs are being used in extract forms for their anti-diabetic activity. Traditional treatments have been an extremely valuable source of medicine all over human history. As in most Asian countries, Sri Lankans consume more sugary foods that are made using naturally available treacle. The treacle produced from

palmyra (*Borassus flabellifer*) is a well-known local traditional sweetener used in Sri Lanka in the preparation of many sugar-containing foods. It belongs to the family of "*Arecaceae*", genus "*Borassus*" and is grown in the Asian region including north and east Sri Lanka, South India, and other tropical countries [6].

There was less evidence regarding consumer preferences and the effects of *B. flabellifer*/ Palmyra treacle on blood glucose levels. Therefore, the present study aimed to determine the consumer preferences and the GI of *B. flabellifer* treacle. Further, it seeks to explore the potential of *B. flabellifer* treacle as a low-glycemic alternative sweetener for individuals with DM. The potential implications of this study include identifying a new low-glycemic sweetener that can be used in diabetes management and prevention.

2. Methodology

B. flabellifer treacle was collected from Palmyra development board Jaffna/Katpaham, 498 Colombo-Galle main road, Colombo.

2.1. Determination of consumer preference among undergraduate students

A descriptive cross-sectional study was conducted among a selected group of undergraduates at KAATSU International University (KIU). A total of 281 undergraduates (150 females and 131 males) were randomly recruited for the study. Data was collected using a pre-tested, self-administered questionnaire containing four sections and a total of 57 items including socio-demographic details, consumption habits, purchasing habits, knowledge, perception, and preferences regarding Palmyra treacle. Ethical approval was obtained from the Ethical Review Committee of KIU(KIU/ERC/23/027). Informed written consent was obtained from all volunteer participants prior to the study.

2.2. Proximate analysis of *B. flabellifer* treacle

The moisture and ash contents were measured using AOAC official methods [7]. Total carbohydrate content was determined using the in-house method- B&B/SOP/FB/027, while crude fiber content was analyzed following the in-house method- B&B/SOP/FB/022. Total protein content was assessed using the in-house method- B&B/SOP/FB/018. Total ash content was determined according to SLS 772:1987, Appendix E, and acidity, expressed as acetic acid was measured following SLS 772:1987, Appendix D [8]. Total sugar content was analyzed using Lane and Eynon's constant titer method [9].

2.3. GI of *B. flabellifer* treacle

The GI of the *B. flabellifer* treacle was determined using a standard method. Determination of the GI was carried out as a cross-over study. Thirty apparently healthy volunteers aged 20-30 years with BMI ranging from 18.5-25.5 kg m^{-2} were selected. The height and weight were measured to calculate the BMI, and participants were asked to refrain from smoking and drinking alcohol and to restrict vigorous physical activity the day before. Following an overnight fast (10 hours), a finger-prick capillary blood sample was obtained [5,10].

Glucose was used as the standard food (GI=100). The test foods and the standard food were served to the same individual on separate occasions. Each subject was served with test food containing 50 g of available digestible carbohydrate portions to be consumed within 2-3 minutes with 150 ml of drinking water. With regard to the test food, participants consumed 72 ml of *B. flabellifer* treacle, which contains 50 g of carbohydrate. Glucose that contained dextrose monohydrate was used as the standard. 50 g of glucose corresponding to 50 g of available carbohydrate was dissolved in 150 ml water and was consumed by the same individual on a different occasion. Capillary blood samples were collected at 0(fasting), 15-, 30-, 45-, 60-, and 120-minute intervals. The treacle samples were given on three different days to the same participants to allow a wash-out period. Serum glucose concentrations were determined with a calibrated Accu check active glucometer. The GI was calculated using the mean of the individual incremental area under the curve of the test food and of the standard food [11]. The glycaemic load (GL) values of foods were calculated (GL= GI digestible starch preserving (g)/100).

2.4. Statistical analysis

The data were analyzed using the Statistical Package for Social Science (SPSS) Software (version 26), GraphPad Prism software, and Microsoft Office Excel 2019. Chemical compositions and GI are presented as means and standard deviations. The results were analyzed using an independent sample t-test. Pearson Chi-square tests were done between total knowledge level and sociodemographic data. The analysis was conducted using 0.05 significant levels.

3. Result and Discussion

Palmyra plants are widely distributed in the North and East provinces of Sri Lanka and are known to be a valuable economic plant. Palmyra treacle is one of the most popular products and is used by Sri Lankans as a traditional sweetener due to its health-promoting factors and consumer demand for palmyra treacle has increased. Palmyra treacle is believed to have various health benefits, including anti-inflammatory, anti-microbial, and anti-cancer properties [6]. However, there is a lack of research about its GI, which is a measure of how quickly carbohydrates in food are broken down into glucose and enter the bloodstream. Carbohydrates in foods are digested at different rates depending on several factors including the amount of carbohydrates, the nature of the monosaccharide components and starch, cooking or food processing, and other food components. Thus, foods are categorized into low (55 or less), medium (56-69), and high (70 or above) GI foods [12].

Understanding the glycemic impact of palmyra treacle is important for consumers, health practitioners, and the food industry. This information can empower consumers to make better dietary decisions and regulate their blood sugar levels,

particularly beneficial for those managing diabetes. Healthcare professionals can utilize this understanding to develop dietary guidelines and recommendations for individuals with diabetes or other metabolic disorders. Additionally, the food industry can utilize this knowledge to create healthier, low-glycemic options that align with consumers' preferences for nutritious and sustainable food choices.

3.1. Determination of consumer preference for *B. flabellifer* / Palmyra treacle

Among the total undergraduates (n=281), 53.4 % (n=150) were female students and 131 (46.6 %) were males. Consumer age ranged from 18 to 26 years, and all were unmarried. Among the population 77.7% of the participants were Sinhalese.

Based on the results, most of the students were living with their parents (51.2 %), followed by boarding places (30.1%), a university hostel (10.5%), relatives, homes (4.8%), and other places (3.3%) like staying at a friend's place during the undergraduate period. The majority 77.9%, (n=219) of the students were from the Department of Biomedical Science, and the least contribution (1.4%) was from the Department of Medical Science in Acupuncture. Of the above-mentioned biomedical science undergraduates, most participants were fourth-year students (23.8%). According to the study population, the highest number of unemployed (77.5%) students can be seen in each and every degree program, and (22.5%) were employed. Regarding employment status, 12.5% were full-time employed, 5.7% were part-time employed, 4.3% were engaged in training/internships, and 77.5% were unemployed. The majority (63.7%) of participants consume *B. flabellifer* treacle as a sweetener, with 59.8% considering it as a healthy product. Some participants express dislike towards the treacle, due to its smell, excessive sweetness, runniness, crystallization, and difficulty in extraction from the jar or bottle. Of the participants, 59.5% consume the treacle rarely, while 39.1% consume it once a month. Interestingly, 79.7% of the participants thought that the use of *B. flabellifer* treacle was promoted as a way to prevent diabetes or other health issues related to high blood sugar (Annexure 1). Table 1 illustrates the consumer's knowledge of the consumption of *B. flabellifer* treacle as an alternative sweetener for diabetic control. The mean knowledge scores among male and female students were 49.70±15.62 and 52.97±13.98, respectively.

The consumption of palmyra treacle is influenced by a number of variables, including product attributes, sociodemographic factors, and consumer preference, perception, and knowledge. The quality of the treacle is the main consideration when deciding to consume it. Health benefits, brand reputation, packing, and price are additional important factors that affect purchasing decisions. The strongest motives for the purchase of treacle are its taste, cost, and the perception of palmyra treacle as a healthy food. The results revealed that the majority of the undergraduates had adequate knowledge regarding the medicinal properties and health benefits of palmyra treacle and a larger proportion of participants followed healthcare-related degree programs such as biomedical science. According to the data, the knowledge of palmyra treacle consumption reflected that the majority of respondents (39.9 %) have a good knowledge regarding treacle consumption.

3.2. Proximate analysis and GI of *B. flabellifer* treacle

The proximate composition of the treacle was analyzed following standard AOAC procedures, expressed as a percentage of dry mass. The moisture, total carbohydrate, total protein, crude fiber, and total ash contents were 30%, 68.1%, 0.3%, 0.1%, and 1.1%, respectively, with a crude fat content of 0.1%. The acidity, expressed as acetic acid, was 0.03%, and the pH was 5.7. Based on the proximate analysis, the digestible carbohydrate was determined as 72 g per 100 g *B. flabellifer* treacle (Table 2).

3.3. GI of *B. flabellifer* treacle

The mean age of the participants was 24±2 years and the mean body mass index (BMI) was 21.39±3.2 kg/m^2. Among the participants, 15 were males and 15 were females.

The GI value of *B. flabellifer* treacle was found as 61.72±17.44 which belonged to the medium GI category. GL was found to be 42.03 which is high. Figure 1 shows the glycemic response of glucose and, *B. flabellifer* treacle. GI values did not significantly ($P>0.05$) differ in height, weight, and BMI of volunteers. Nevertheless, significant differences were observed ($P<0.05$) with the age and gender of the volunteers (Table 3). The responses to the questions for the participants of the GI study, related to health and physical activities, are shown in Annexure 2.

Table 1. Total Knowledge Palmyra treacle Consumption among Undergraduates

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Poor	96	34.2	34.2	34.2
	Average	73	26.0	26.0	60.1
	Good	112	39.9	39.9	100.0
	Total	281	100.0	100.0	

Table 2. Proximate composition of *B. flabellifer* treacle

Parameters	Results (% by dry mass)
Total carbohydrate content	68.1
Total sugar content	68
Moisture content	30
Total ash content, on a dry basis	1.1
Total protein content	0.3
Crude fiber content	0.1
Acidity expressed as acetic acid	0.03
Crude fat	0.1
pH	5.7

Table 3. Correlation between GI and gender, age, height, weight and BMI

Pearson Correlations Sig.(2-tailed)	Gender	Age	Height	Weight	BMI
GI	0.038	0.037	0.900	0.437	0.677
N (*Correlation is Significant at the 0.05 level (2-tailed)	30	30	30	30	30

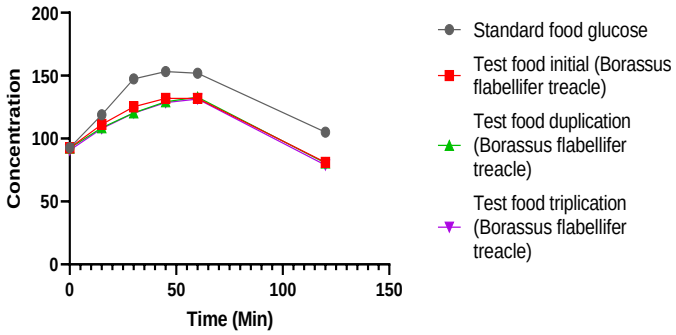

Fig. 1. Glycemic response of glucose and *B. flabellifer* treacle

The GI not only assesses the direct absorption of carbohydrates in the small intestine but also reflects the impact of various factors present in the test foods that can influence the rate of carbohydrate absorption in the small intestine [13]. Various nutritional and physiological elements play a role in affecting both the blood glycemic response and the GI value of traditional foods. These factors encompass the rate of starch digestibility, interactions between starch absorption and the quantities of fiber, fat heat, moisture, and protein present, as well as the methods employed in cooking [14,15]. In a study conducted by Livesey and Tagami, it was discovered that augmenting the intake of viscous soluble fiber has a significant impact on reducing the glycemic response [16]. Introducing fat and protein into foods containing carbohydrates has the ability to diminish the glycemic response [17]. Elevated protein levels result in increased gastric inhibitory peptides and insulin responses, leading to a lower postprandial glucose peak and reduced glycemic response from high-GI foods [18]. On the other hand, higher fat content has the potential to delay gastric emptying, slowing down digestion and glucose absorption. Therefore, the proximate composition of *B. flabellifer* treacle was detected, and the observed reduction in postprandial glycemic response for the treacle, as indicated by the incremental area under the curve, is attributed to its substantial fat, ash, protein, and fiber contents. These constituents play a role in influencing the GI value of the treacle.

The present study indicated the GI of palmyra treacle under the medium GI (61.72±17.44) category and GL was found to be 42.03. The glycemic response triggered by the consumption of a particular food is not solely dependent on its GI but is also influenced by the total quantity of carbohydrates ingested. This concept gives rise to the GL, which considers both the carbohydrate content and the impact of each gram of carbohydrate on blood glucose levels [19]. In the present study, the elevated GL was attributed to the high amount of available carbohydrate content of treacle. Consequently, achieving a low GL food can be accomplished by either reducing the GI of the food or by substantially reducing the overall carbohydrate intake from the diet.

More importantly, the result provides the GI value of a Sri Lankan traditional food that was not determined previously. This valuable information will be significant for the management and prevention of diabetes mellitus and other non-communicable diseases in Sri Lanka and other countries that have similar food traditions.

Further, the present study may have some limitations that should be acknowledged, such as the use of a small sample size. Therefore, future research should consider using larger sample sizes and recruiting individuals with metabolic disorders to better understand the glycemic impact of palmyra treacle on this population.

4. Conclusion

Among the participants, the majority of respondents (39.9%) demonstrated good knowledge, while 26.6% exhibited average knowledge, and 34.2% reflected poor knowledge of the consumption of *B. flabellifer* / palmyra treacle and belonged to the medium GI category (61.72±17.44), which lead to the management and prevention of diabetes mellitus and other non-communicable diseases. Further studies are recommended to study the adaptability of *B. flabellifer* treacle for the diet of diabetic subjects and subjects at risk.

Conflicts of Interest

No conflict of interest to be declared.

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