Kithul (Caryota urens) treacle: A healthy natural sweetener?

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(Key words: *Kithul* treacle, glycaemic index, natural sweetener, table sugar, *aluwa*)

Abstract

Introduction: Incidence of non-communicable diseases such as diabetes, cardiovascular disease (CVD), several forms of cancer, hypertension, obesity etc is increasing in our country. It is suggested that these diseases can be moderated, in part, by consuming foods that produce a low blood sugar response. It is presumed that *kithul* treacle is comparable to simple sugars for sweetness, although currently the beneficial effects are not widely known.

Objectives: To assess the chemical composition and glycaemic indices (GI) of *kithul* treacle and confectionary (*aluwa*) made using table sugar and *kithul* treacle.

Methods: Chemical composition was analysed with standard AOAC methods. FAO/WHO guidelines were used to determine the glycaemic responses with glucose as the standard.

Results: The moisture, crude protein, crude fat, total carbohydrate, starch and glucose and total dietary fibre contents of treacle were 28%, 0.3%, 7.9%, 81%, 28% and 2.20% (DM) with negligible ash content. Similarly both *aluwa* had negligible ash contents. Total carbohydrate (88-89%), fat (2.9%), protein (3.7-4.2%) and total dietary fibre (7.78-8.32%) contents of both *aluwa* were not significantly different. However, the digestible carbohydrate contents of treacle (67%) and sugar *aluwa* (59%) were significantly different ($p<0.05$). The GI of *kithul* treacle, *aluwa* made with treacle and sugar were 35, 55 and 63 respectively.

Conclusion: Kithul treacle was categorized as a low GI sweetener whereas both *aluwa* were categorized as medium GI foods. In comparison to *aluwa* made with table sugar, the glycaemic response of *aluwa* made with treacle was lower proving that replacing sugar with treacle leads to lower glycaemic response.

Introduction

Globalization, commercialization and westernization in Asian countries has significantly contributed to change the dietary habits with more wholesome traditional foods and sweeteners being replaced by more refined easily accessible foods [1,2]. As in most Asian countries Sri Lankans have also drifted away from consuming fresh homemade meals, fruits, vegetables and thus are predisposed to consume fast or more refined food. Consequences of such dietary transitions and insufficient physical activities are the development of non-communicable diseases (NCD) such as type 2 diabetes, cardiovascular disease (CVD), several forms of cancer, hypertension, cerebrovascular strokes, obesity, dental caries, osteoporosis [3, 4, 5, 6] etc. Diabetes prevalence in the World is related to consumption of refined carbohydrate foods that readily release glucose to blood [7]. WHO attributes 83% of deaths in Sri Lanka to NCDs such as cancer, CVD, diabetes etc and to reduce the incidence, dietary and other life style modifications are advocated [8].

In Sri Lanka, starchy foods are consumed as the staple and per serving accounts for approximately two-third of the meal [1]. The recommendation for carbohydrate foods including sugar accounts for 6-11 servings/day [9] but actual consumption is significantly higher than recommended among Sri Lankan adults [10]. Consumption of sugar or sugar incorporated products has increased globally during the past decades and is partly implicated in the increased incidence of NCDs due to contribution to high glycaemic load [11]. In this context glycaemic index (GI) is a useful tool to study how starchy foods contribute to increase blood glucose following consumption of carbohydrate rich foods. Based on the blood glucose response, foods are categorized as high (>70), medium (56-69) or low (<55) glycaemic index (GI) foods [12]. Foods with a low GI are considered beneficial for controlling the glycaemic response [13, 14, 15].

The treacle produced from *kithul (Caryota urens)* is a local traditional sweetener used in Sri Lanka in the

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preparation of many traditional confectionaries as an alternative for sugar. It is made from pure sap extracted from *Caryota urens* inflorescence, boiled down to sweet, dark brown syrup, thick and sweet in flavour, with a slight hint of caramel. Treacle is widely used to prepare traditional sweets, drinks and also used in indigenous medicine as an ingredient. It is claimed in folklore that *kithul* treacle possesses antioxidant and antidiabetic properties. The sap used to produce *kithul* treacle has moderate antioxidant activity both *in vitro* and *in vivo* [16]. Free amino acid profile indicates flavour enhancer glutamateis prominent in treacle [17]. In addition, jaggery produced by further heating of treacle contains heat resistant alpha amylase and alpha glucosidase enzyme inhibitors [18].

However, adequate scientific evidence on anti-glycaemic effect of *kithul* treacle available in Sri Lanka and sweetmeats prepared with treacle is not available. Favourable effects of honey in both healthy and diabetic individuals have been reported [19, 20, 21, 22, 23]. Thus, present study determined the chemical composition and the glycaemic indices of *kithul* treacle and the nutrient composition and glycaemic indices (GI) of a popular Sri Lankan sweetmeat (*aluwa*) made with both *kithul* treacle and table sugar to evidence if treacle contributes to antiglycaemic effect.

Materials and methods

Treacle and other ingredients

The most popular and widely available brand of *kithul* treacle was purchased from a leading supermarket after an unstructured market survey and white rice flour and table sugar were purchased from retailed outlets in Thalawathugoda, Sri Lanka.

Sweetmeat (aluwa) preparation

White rice flour (500 g) was roasted under medium heat until golden brown. *Kithul* treacle (500 mL) was boiled until a thick line formed on pouring and removed from heat. While continuously stirring, roasted rice flour was added and mixed well. Mixture was then quickly spread on a tray lined with waxed paper to a thickness of 1cm and cut into square shaped pieces (4cm × 4cm). Once cooled the pieces were removed from the tray and dusted with roasted rice flour. To make *aluwa* with sugar, white rice flour (500 g) was roasted under medium heat until golden brown. Sugar (500 g) and water (250 mL) were boiled in a non-stick pan until a thick line was formed on pouring and *aluwa* pieces were made as with treacle above. These were used for determination of proximate composition and glycaemic indices. Samples of *aluwa* were made freshly each day prior to GI testing.

Analysis of proximate composition of treacle and aluwa

Treacle sample and *aluwa* made with *kithul* treacle and table sugar were used for proximate analyses. Freshly made *aluwa* was broken into small pieces and dried in the oven (55 °C, REMI™ Laboratory, India) and milled (A11 Basic, Brazil). The samples were stored in the refrigerator until analyses. Moisture and ash contents of treacle and *aluwa* were determined by drying to a constant weight in an oven (105°C) and by incineration (550°C) respectively. The Kjeldhal method was used to estimate the protein [24]. Fat contents were determined according to Croon and Guchs [25] and total dietary fibre assay kit (TDF 100A-1KT, Sigma Aldrich, USA) for fibre analysis. Digestible carbohydrate content of samples was determined using enzymatic assay with Megazyme total starch assay procedure (K-TSTA-50A/K-TSTA-100A 06/17; Megazyme, Ireland) without washing off simple sugars present in the samples. Total carbohydrate was also determined by phenol sulphuric method [26].

Glycaemic index study

Healthy normal volunteers (n=10, 5 males and 5 females, 20-30 years) who are not under any medical treatment and with BMI range of 18.5-23 kg/m^2 were selected for the study.

Volunteers were advised to undergo 8-10 hour fast the day before each test day. A dietary recall of the previous night was taken from each volunteer on each test day and palatability of meals recorded. Fasting blood sugar was checked on arrival. They were given a portion of 50g glucose (gsk Glaxco Welcome Ceylon Ltd, Sri Lanka) in 250 mL of water and blood glucose level was measured at 30, 45, 60, 90 and 120 minutes following ingestion of glucose. The procedure was repeated twice for every volunteer in the beginning and middle of the study. Same procedure as above was carried out for all food items. Food portions containing 50g carbohydrate were given to be consumed within 15 minutes with 250 mL of water. Blood samples (100 µL) were obtained from the participants by finger prick (Accucheck pricking device). Blood glucose was analyzed using a glucose kit (Biolabosa, France). Treacle and *aluwa* were given on different days to same participants by keeping three days wash out period.The GI value for each food item was calculated and average of 10 values was taken as the GI of the food [27, 28].

Statistical analysis

Proximate and glycaemic index data are expressed as mean ± SD. Proximate data, GI and data comparisons were analyzed with the Microsoft office excel 2010. Significances were calculated at 95% confidence interval.

Results

Proximate data of treacle and both *aluwa* are presented in Table 1. The dry matter contents of treacle, aluwa made with treacle and sugar were 72%, 85% and 90% respectively. The major nutrient of treacle was carbohydrate (over 80%) on dry weight basis (DM) of which enzymatically digestible carbohydrate comprised only one third (glucose, maltose and/or starch). The soluble dietary fibre (1.34%) contributed more to total dietary fibre in treacle. The ash and protein were negligible with comparatively high content of crude fat. When considering *aluwa* made with sugar and treacle, both contained significantly high ($p<0.05$) total and digestible carbohydrate than *kithul* treacle. Protein, fat, ash and dietary fibre contents of both *aluwa* were not significantly different. However, both aluwa had significantly high ($p<0.05$) protein compared to treacle.

Peak blood glucose level, time taken to reach the peak and basal level of blood glucose by standard (glucose), test foods and glycaemic loads are stated in Table 2. Postprandial blood glucose level of both glucose and treacle recorded the peak time at 30 minutes. However, treacle elicited a lower blood glucose response following consumption at each point of glucose measurement and reached the basal value within 90 min following consumption whereas following glucose ingestion the blood glucose did not reach the basal level even after 120 min. A blood glucose peak reduction of 16% was observed in treacle when compared to standard glucose.

The mean IAUC and GI values of treacle and both *aluwa* are presented in table 3 and blood glucose curves obtained for standard and test foods are shown in Figure 1. *Kithul* treacle was categorized as a low GI product with a mean GI of 35. When considering *aluwa*, highest values for both IAUC and GI (62 and 63) were observed for *aluwa* made with table sugar (Table 3) and the peak blood glucose was higher than that of glucose. However, for *kithul* treacle *aluwa* the peak blood glucose level was similar to that of standard glucose. Both *aluwa* elicited medium GI. Even though statistically insignificant, *kithul* treacle *aluwa* had a lower GI value (55) than that of *aluwa* made with table sugar (63). When considering the glycaemic load, *kithul* treacle provided medium GL, while *kithul* treacle *aluwa* and sugar *aluwa*(SA) had high GL values per 50 g digestible carbohydrate containing portions (Table 2).

Table 1. Proximate compositions of treacle and *aluwa* (g/100 g on dry weight basis; mean ± SD)

Food Item	*Total carbohydrate*	*Starch + glucose*	*Protein*	*Fat*	*Ash*	*IDF*	*SDF*
Kithul treacle	81±0.6[a]	28±2.8[a]	0.3±0.2[a]	7.9±0.2[a]	0.24±0.1[a]	0.86±0.2[a]	1.34±0.1[a]
Kithul treacle *aluwa*	89±0.6[b]	67±2.7[b]	3.7±0.2[b]	2.9±0.3[b]	0.20±0.1[b]	2.42±0.1[b]	5.90±0.1[b]
Sugar *aluwa*	88±0.9[b]	59±0.8[c]	4.2±0.4[b]	2.9±0.3[b]	0.18±0.1[b]	2.19±0.3[b]	5.59±0.2[b]

n=6; SD = standard deviation; IDF = insoluble dietary fibre; SDF = soluble dietary fibre; different superscripts along a column indicate significant differences at 95% confidence interval

Table 2. Peak blood glucose level, time taken to reach the peak, reach the basal level of blood glucose by standard (glucose) and test foods and glycaemic load

Food Item	*Peak mg/dL*		*Peak Time*		*Time taken to reach basal*	*GL*
	Glucose	*Food tested*	*Glucose*	*Food tested*		
Kithul treacle	129	108	30	30	90	18
Kithul aluwa	129	129	30	30	NR	29
Sugar *aluwa*	129	133	30	30	NR	32

n=10; NR-blood glucose not reached the basal level after 120 mins; GL – glycaemic load

Table 3. Incremental area under the curve (IACU), portion sizes and glycaemic indices (GI) of food items

Food item	*IAUC*		*Portion size (g)*	*GI*			
	Glucose	*Test food*		*Min*	*Max*	*Mean*	*SD*
Kithul treacle	100	34	86	13	66	35	14
Kithul treacle *aluwa*	100	56	76	26	89	55	18
Sugar *aluwa*	100	62	76	45	85	63	14

n = 10; Min = minimum; Max = maximum; SD = standard deviation

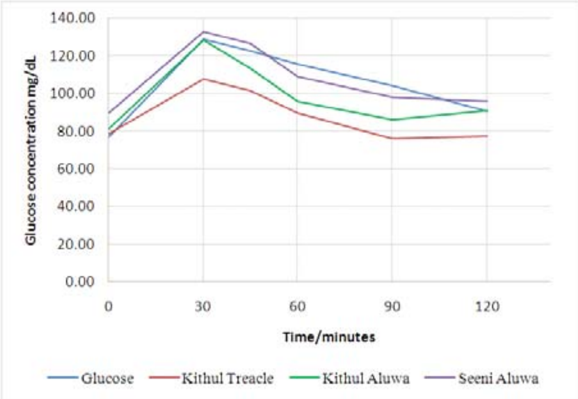

Figure 1. **Blood glucose response to *kithul* treacle, *kithul aluwa*, sugar (seeni) *aluwa* and glucose.**

Discussion

Treacle made of *kithul* inflorescence is a sweetener endemic to Sri Lanka and has been used from ancient times in food preparation and in ayurvedic treatment. This study was undertaken to scientifically study *kithul* treacle in order to determine the suitability as a sweetener compared to table sugar.

Treacle contained over 80% of carbohydrate (DM) of which one third was digestible carbohydrate (glucose, maltose and/or starch) whereas contribution from protein, dietary fibre and minerals (ash) was less than 3%. High fat content of treacle could be attributed to the formation of large insoluble organic molecules due to sugar caramalization during heating of the sap to obtain the viscous sweet product. Compared to sugar, a refined product and almost a pure substance, treacle similar to honey has a complex composition [19].

In contrast to treacle, *aluwa* made with either sugar or treacle, contained significantly high ($p<0.05$) total and digestible carbohydrate. The chemical method for total carbohydrates, determines all sugars, starch and other hydrolysable carbohydrates thus producing higher values in contrast to the enzymatic method which will determine only starch, maltose and glucose present in a given sample. When compared, *kithul* treacle *aluwa* had higher ($p<0.05$) digestible carbohydrate than aluwa made with table sugar. However, as the total carbohydrate was high (chemical method) when compared to digestible carbohydrate, the presence of other sugars and/or resistant starch were proven in both *aluwa*. Both *aluwa* had similar total dietary fibre levels. This is due to the use of white raw rice flour in preparing *aluwa*. White rice contained 1.5% total dietary fibre [29]. However, the varietal variation and roasting of flour prior to preparing the sweetmeat may have contributed to increase the fibre level in both *aluwa*. In addition, protein, fat and ash contents of both *aluwa* were comparable. The protein in *aluwa* is due to contribution from white raw rice flour as both sugar and treacle were devoid of protein. White raw rice has 3.7% protein [30].

Treacle and both *aluwa* given for glycaemic index determination were considered as palatable by all volunteers. When the glycaemic response was considered, treacle elicited a lower blood glucose response and a lower peaking compared to glucose (Table 2). Based on the glycaemic index, *kithul* treacle was categorized as a low GI product (Table 3; Figure 1). The GI of treacle is relatively lower compared to GI of honey reported from different countries [20, 31, 32]. Honey increases insulin secretion and decreases blood glucose levels [33, 34]. The plasma glucose levels in response to honey peaked at 30-60 minutes and showed a rapid decline when compared to that of glucose [22] which is similar to what was observed with treacle in the present study. A high degree of tolerance to honey was observed in subjects with diabetes as well [22]. Thus, it is evident from the present investigation that treacle may prove to be a valuable sugar substitute for subjects with impaired glucose tolerance or pre-diabetes.

It was apparent from the study that *aluwa* made with table sugar (Table 3) elicited a higher glucose peak compared to *aluwa* made with *kithul* treacle. However, both *aluwa* were categorised as medium GI food. However, in comparison to *aluwa* made with table sugar, the glycaemic response of *aluwa* made with treacle was lower proving that replacing sugar with treacle leads to a lower glycaemic response. This could be due to the alfa-amylase inhibitory activity of treacle [18] as despite having high digestible carbohydrate, *aluwa* made with treacle had lower GI and better glycaemic response. The study thus illustrates the fact that using treacle with raw starchy ingredients lower the overall GI of a food which had not been studied earlier. Treacle thus has a potential use as a natural, healthy sweetener for consumption and in food industry.

Glycaemic load (GL) is an indication of overall glycaemic response of a portion of food. Treacle provided a medium GL, while *kithul* treacle *aluwa* and sugar *aluwa* had high GL values (Table 2). As GL is dependent on both the GI and the portion size of the food, by varying both or either of those variables, the GL value can be increased or decreased. When *kithul* treacle is used as a sweetener, the amount used per serving is less than the portion given for determination of glycaemic index (86 g) and thus the GL would be further lowered when used as a sweetener alone.

In addition to modulating the glycaemic response, natural honey also improves lipid profile, lowers normal and elevated C-reactive protein (CRP), lowers homocysteine, decreases triacylglycerol in patients with hypertriglyceridemia [34, 35] and provides the body with invaluable nutritional ingredients as well as antioxidant substances [35]. Thus long term usage of treacle made from the sap of the inflorescence which is a moderate source of antioxidants [16] in place of sugar may also contribute to decrease the risk of cardiovascular disease in diabetes patients. This data also increase the export potential of this traditional Sri Lankan product as a healthy sweetener.

Conclusions

A natural native sweetener, *kithul* treacle elicited a low GI which was lower than values reported for honey in different countries. Both *aluwa* made with table sugar and treacle elicited medium GI. However, it is noteworthy that *kithul* treacle *aluwa* elicited a lower glycaemic response throughout the study period of 2 hrs which is clinically important. Thus, the results highlight that whenever possible, treacle could be a better substitute for table sugar. In addition, *kithul* treacle as a sweetener can be recommended for individuals seeking to control blood glucose levels or reduce caloric intake.

Author contributions

PW: acquired data and analysed the data, SE; designed the study and drafted the manuscript. All authors read and approved the final manuscript.

Conflict of interest

There are no conflicts of interest.

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Ethics approval

Ethical clearance for the study was obtained from Ethics Review Committee, Faculty of Medical Sciences, University of Sri Jayewardenepura, Sri Lanka (Approval No: 35/15). Informed written consent was obtained prior to enrolling participants for the study.

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