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Short communication

Effects of grass jelly on glycemic control: hydrocolloids may inhibit gut carbohydrase

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Background and Objectives: The aim of this study was to investigate (1) the hydrocolloid properties of grass jelly on reducing glycaemic response, (2) the impact of phenolic compounds in *Mesona chinensis* L. on glycaemic response. **Methods and Study Design:** A total of 15 healthy Chinese men were recruited to this study. On each visit, subjects consumed one of the following three treatments, i.e. glucose solution (T1), grass jelly (*Mesona chinensis* L.) solution with glucose (T2) or grass jelly gel with glucose (T3). Capillary blood glucose and venous plasma insulin were analysed over a period of 180 min. **Results:** The incremental area under the curve for capillary glucose and venous plasma insulin for glucose group, grass jelly solution group and grass jelly gel was found to be statistically not significant (p>0.05). In a previous study the co-ingestion of grass jelly with complex carbohydrate was found to reduce glycaemic response. The key difference between the two studies was the use of monosaccharide glucose in the present study, compared to complex carbohydrates in the other. The present study suggests that the glycaemic lowering effect of grass jelly may be dependent on the inhibition of carbohydrase enzymes. **Conclusions:** The co-ingestion of *Mesona chinensis* L. appears to reduce glycaemic response of only complex carbohydrates through the inhibition of carbohydrase. This conclusion was arrived at by the lack of any effect of *Mesona chinensis* L. on the monosaccharide glucose.

Key Words: diabetes, grass jelly, glycaemic response, gel, viscous fibre

INTRODUCTION

Gelatine based jellies are a popular desert in many parts of the world, notably in Europe and North America. Similarly, in Asia, one of the most popular gel based dessert is derived from agar. Recent research has demonstrated that the co-ingestion of agar from red algal with carbohydrate rich foods can attenuate glycaemic response.[1] With this observation, a series of studies have emerged that have explored the role of ingesting gels and hydrocolloid based food systems to alter appetite, satiety and glycaemic response.[2] A less well known hydrocolloid is called 'grass jelly'. Grass jelly is derived from extracts of *Mesona chinensis* L..[3] Leaves and branches are used for this extraction.[3] The gum polysaccharide comprises of galactose, glucose and rhamnose sugar residues.[4] The gum exhibits low viscosity in solution when dissolved in water and forms a gel when a minute amount of starch is added, thereby increasing viscosity.[5] The gum extract also carries phenolic compounds.[6] Some of the phenolic compounds reported include protocatechuic acid (major polyphenol metabolite), vanillic acid, hydroxycinnamic acids, syringic acid and flavonoids.[6,7]

The grass jelly is commonly consumed in the southern parts of China, Taiwan and South East Asia.[3,5] In a previous study, it was demonstrated that *M. chinensis* powder extract, presented as a capsule (0.5-1.0 g) reduced glycaemic response to a mixed meal comprising of complex carbohydrates.[3] In addition, the same investigators performing an in-vitro study demonstrating that the extract inhibited maltase and sucrase activity.[3] It was therefore proposed that *M. chinensis* reduced glycaemic response through inhibition of carbohydrase activity. The enzyme inhibitory properties of *M. chinensis* when co-ingested with a monosaccharide (glucose) has not been investigated.

In this study, we aim to investigate (1) the hydrocolloid properties of grass jelly on reducing glycaemic response, (2) the impact of phenolic compounds of *Mesona chinensis* L. on glycaemic response.

A report by International Diabetes Foundation has documented an estimated global diabetes rate in 2015 of 1 in 11 adults.[8] Diabetes has a direct impact on the individual

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quality of life and economic cost. Diabetes, was associated with increased cardiovascular risk,[9] cancer,[10] dementia rates and amputations of limbs.[11,12] The use of food based interventions to manage glycaemia by the use of foods rich in polyphenols or viscous dietary fibre has been investigated.[13-16] The consumption of these products in diets has been associated with a reduction in the incidence of diabetes[13] and lower fasting blood glucose.[14]

In short-term Randomised Controlled Trials (RCT), a polyphenol-rich diet was associated with improved oral glucose tolerance.[17] Similarly, a RCT on tea polyphenol has also shown to reduce fasting and postprandial glucose level.[18] In acute postprandial studies, tea polyphenol has shown to reduce glycaemic response and an increase insulin sensitivity.[19,20] The mechanism of action proposed include the inhibition of carbohydrase during digestion.[21-23] Consumption of viscous fibres such as fenugreek and guar gum reduces glycemic response due the alteration in gastric emptying.[2,24] Asian food are characterised by the consumption of high carbohydrate, high glycaemic index (GI) food. The consumption of high GI foods has been associated with the increased risk of type 2 diabetes.[25,26] The present study was prompted by our quest to identify locally available food ingredients that may be used to attenuate glycaemic response of carbohydrate rich foods.

METHODS

Sample extraction

Dried whole Mesona chinensis were bought from herbal drug stores in Bangkok, Thailand and extracted by Dr. Sirichai Adisakwattana. The plant extraction process has been describe previously by Chusak and Adisakwattana (2014).[3] Briefly, the whole dried plant was boiled in distilled water at 90℃.[3] The aqueous extract was then spray dried at 178-180℃.[3]

Sample preparation

At each visit, subjects consumed one of the following three treatments (Table 1), with a washout period of 1 week; i.e. glucose solution (T1), grass jelly (*Mesona chinensis* L.) solution (T2) or grass jelly gel (T3). Each treatment contained 50g of glucose. Briefly, the glucose solution was prepared by dissolving 50g of glucose in 150mL of distilled water. Grass jelly solution was prepared by dissolving the grass jelly powder and glucose powder (Table 1) in distilled water, the mixture was then heated to 90℃ for 1 min. Grass jelly gel was prepared by dissolving grass jelly powder, starch and glucose in water (Table 1), and was then heated to 90℃ for 1 min.

Subject

A total of 15 healthy Chinese men were recruited. Potential subjects underwent a screening visit, where height, weight, blood pressure and fasting blood glucose were obtained. Those who fulfilled the criteria (age, 21 to 40 years old; BMI, 18 to 25; blood pressure ≤140/90 mmHg, fasting capillary blood glucose <6.0 mM) were included in the study (mean age, 26.7 years old; mean BMI, 21.8; mean blood pressure, 122/ 73.5 mmHg; mean fasting capillary blood glucose, 4.36 mM). On the day before the study, subjects were asked to refrain from strenuous physical activity. Subjects were required to fast overnight for 10 h before the study day.

The study was carried out in concordance to the guidelines laid out by the Declaration of Helsinki. All the procedure involving human subjects were reviewed and approved by the National Healthcare Group Domain Specific Review Board Singapore (case reference: DSRB 2015/01098). All participants provided written consent before their participation in the study.

Study procedures

A randomised, cross-over, within subject, repeated measure non-blind design was adopted.

Participants arrived at the research centre between 08 00 and 09 00 hours after 10 h of overnight fast. Before the consumption of test meal, a baseline (t0 min) lood (capillary and venous blood) were obtained. After the consumption of the test meal, blood was sampled at the following time points; i.e. 10, 20, 30, 45, 60, 90, 120, 150, 180 min.

Whole capillary blood was obtained through finger prick using Abbott SF Single Use™ lancing device. Whole capillary blood was collected into HemoCue™ cuvette and analysed by HemoCue 201 RT™. Venous blood was obtained by inserting a cannula into the antecubital fossa by a state registered nurse and was kept in place throughout the 180 min. Venous blood was collected into a Potassium EDTA vacutainer™ tube and was spun down by Thermo Fischer Scientific™ centrifuge at 1500 g, 4℃ for 10 min. Plasma was then analysed for insulin using electrochemilluminescence immunossay by Cobas E411™, Roche Diagnostics.

Statistical analysis

The glycaemic and insulin response were express as Incremental Area Under the Curve (IAUC), which measures the area under the curve for the change in glucose (Δ[Gluc] and insulin (Δ[Ins]) over time; by using the trapezoidal rule, ignoring values below the baseline.[27] IAUC of glucose and insulin are expressed as mM•min and μU•min/mL. The IAUCs were calculated based on a 120 min period.

The differences in glycaemic and insulin response between each treatment were analysed using one-way repeated measure ANOVA with post-hoc Least Significant

Table 1. Ingredient composition of test meals

	Glucose solution	Grass jelly solution	Grass jelly
Wheat starch (g)	0	0	3.12
Grass jelly (g)	0	3.12	3.12
Water (g)	150	147	147
Glucose (g)	50	50	46.9
Total mass (g)	200	200	200

Difference (LSD) for multiple comparison without adjustment using SPSS version 23 (SPSS Inc.).[28-31]

RESULTS

The IUAC at 120 min for whole capillary glucose for the glucose control group , grass jelly solution group and the grass jelly gel was 229±21.3, 243±18.1, 236±18.4 mM•min (Figure 1) respectively and was not found to be statistically different ($p>0.05$). The IUAC at 120 min for venous plasma insulin for glucose control, grass jelly solution and grass jelly gel was 5620±741, 5800±892, 5400±663 µU/mL (Figure 2) respectively, and was found not to be statistically significant. Grass jelly when consumed as a solution or a solid gel does not appear to affect glycaemic and insulinaemic response of glucose.

DISCUSSION

In this study, we have demonstrated that grass jelly when consumed with glucose did not affect glycaemic and insulinaemic response. In contrast, in the previous study, consumption of grass jelly with complex carbohydrate reduced glycaemic response.[3] When a carbohydrate load of 79 g was presented with and without the 1 g of *M. chinensis* L. extract, the IAUC of glucose was reduced by about 40%.[3] The observation from the in-vitro study showing a clear inhibition of carbohydrase in the presence of extract clearly supports the view that the inclusion of *M. chinensis* L. extract inhibits the carbohydrase, resulting in a reduction in IAUC.

The strategy by which 'gels and hydrocolloid' reduces glycaemia may be due to 3 different mechanisms. Firstly, in the case of alginates, the reduction in glycaemia is due to the ability of alginate to alter gastric emptying and transit time, due to the increased viscosity of the alginate gel.[32] Secondly, in the case of beta-glucan the mechanism of action is due to complex formation with the carbohydrate molecule, thereby reducing glycaemic response.[33] Finally, the mechanism by which polyphenols reduce glycaemic response is believed to be due to its ability to chelate with carbohydrate and also to the inhibition of both amylase and glucosidase activity.[34]

As the rate and degree of starch break down is a major determinant of blood glucose response, our study clearly demonstrates that when grass jelly is consumed in conjunction with a monosaccharide namely glucose, the polyphenol constituents of grass jelly appears to have no effect on influencing glycaemic response. This is supported by the observation that no attenuation of glycaemic response was observed when grass jelly was consumed with glucose. When a direct comparison was made between glucose and complex carbohydrate in the presence of *M. chinensis* L. an attenuation in glycaemic response was only observed in the complex carbohydrate matrix. This result suggest that *M. chinensis* L. has the ability to inhibit carbohydrase. Our results suggest that *M. chinensis* L. is effective in reducing the glycaemia only when co-ingested with complex carbohydrates. Further research in underway to examine whether grass jelly may be used to reduce the glycaemic response of rice and wheat based noodles. If successful, the addition of *Mesona chinensis* L. to these products would be a useful method to reduce the glycaemic load of these popular foods in this region.

AUTHOR DISCLOSURES

The authors declare no conflict of interest. This study was supported by the Singapore Institute for Clinical Sciences, A*STAR.

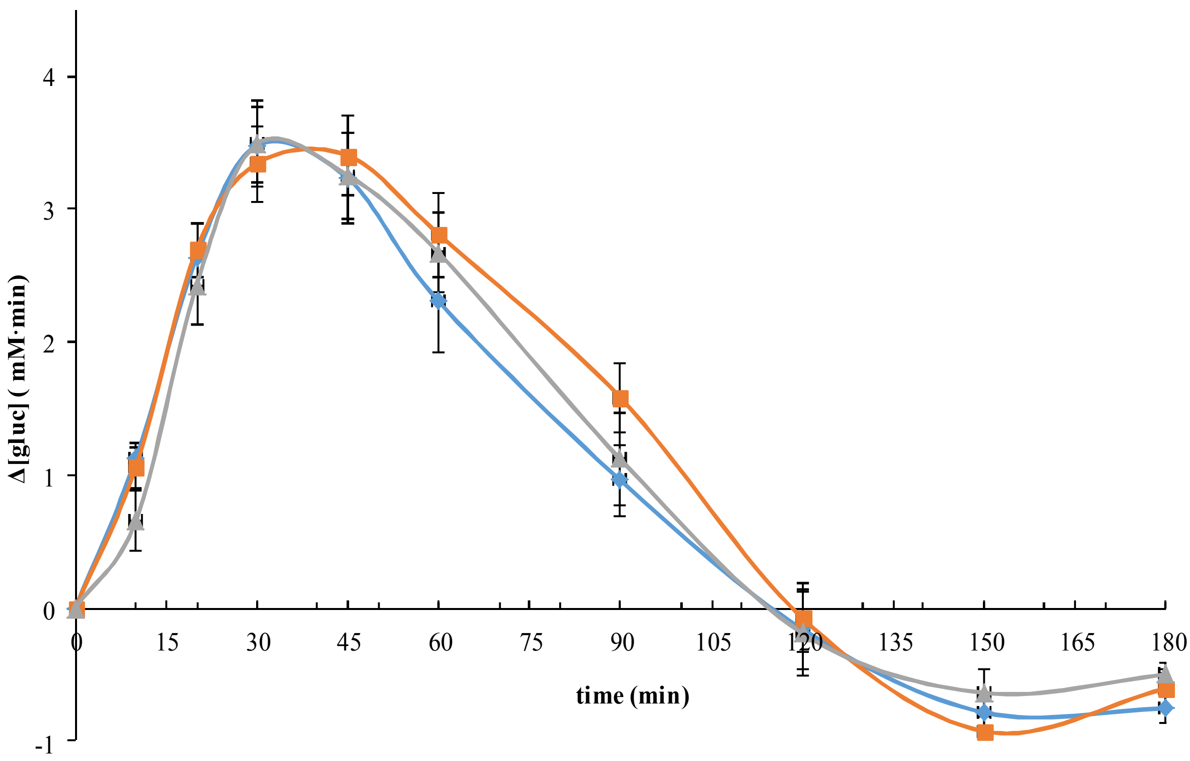

Figure 1. Glycaemic response of glucose ♦, grass jelly solution ■, grass jelly gel▲.

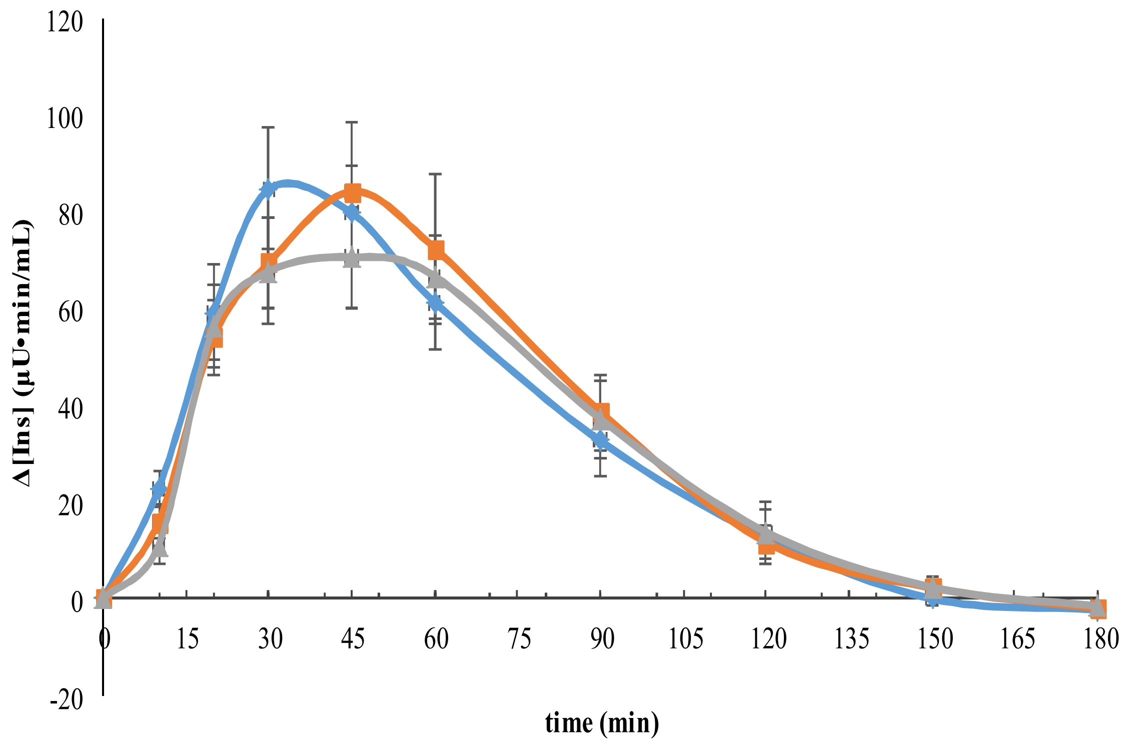

Figure 2. Insulinaemic response of glucose ♦, grass jelly solution ■, grass jelly gel▲.

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