Effects of Common Sri Lankan Dinner Foods on Fasting Blood Glucose and Triglyceride Levels: A Pilot Study

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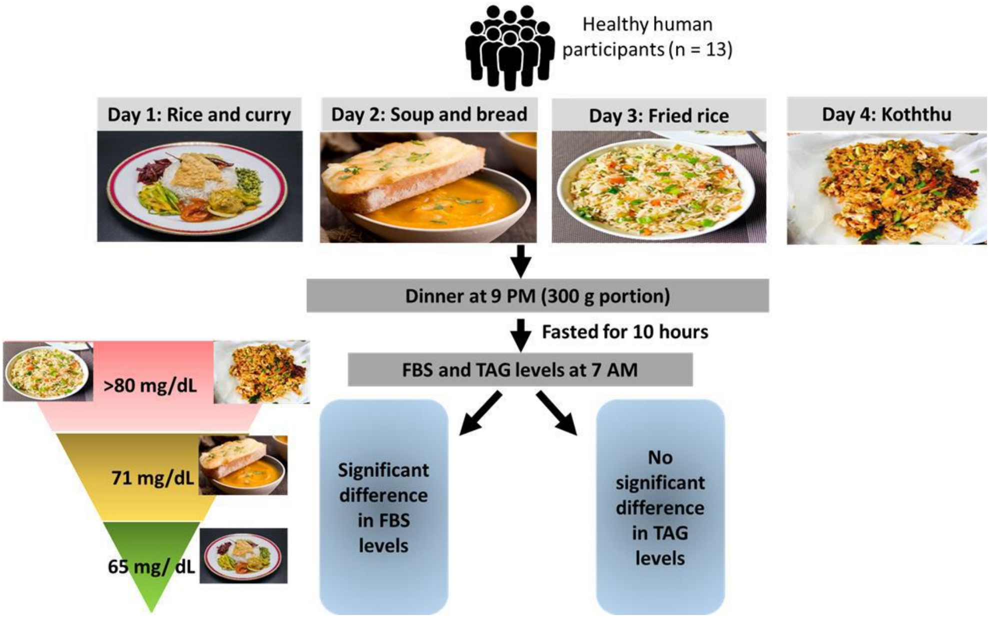

Abstract

Among the blood glucose assessing parameters, fasting blood sugar (FBS) plays a key role in screening, diagnosis, management and monitoring of diabetes mellitus. Diet is a crucial factor which alters the FBS and especially the dinner foods might interfere with the FBS the next day. Our objective was to assess the effect on FBS and TAG of healthy individuals with the consumption of common Sri Lankan dinner foods (rice and curry, fried rice, *kottu* and soup with bread). A randomized crossover experimental study was conducted with 13 healthy individuals (age :22-26 years, BMI :18 – 23kg/m^2, FBS <110mg/dl, TAG < 150mg/dl), selected by simple random sampling. Participants were provided with four dinner foods (portion size= 300g) 1) rice and curry (838kcal), 2) fried rice (932 kcal), 3) *kottu* (937kcal) and 4) soup with bread (422kcal) on four different days keeping a 3-4 day gap between test days. Participants were requested to fast for 8-10 hours and FBS and TAG levels were assessed the next day morning using glucose oxidase assay kit, and TAG colorimetric assay kit respectively. Data were analysed using repeated measures ANOVA and Tukey's post hoc test and the presence of significant differences were determined at 95% confidence interval. Obtained results show that rice and curry meal showed significantly lower ($p<0.05$) mean FBS (65 mg/dL) compared to all other

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foods. Compared to *kottu* and fried rice, a significantly lower FBS value was obtained for soup meal ($p<0.005$) while there was no significant difference ($p=0.666$) between *kottu* and fried rice. TAG levels did not show any statistical significance among meals. The present pilot study concluded that the rice and curry meal for dinner has the lowest effect on FBS. Even within the normoglycemic range, fried rice and *kottu* taken for dinner significantly elevate the FBS levels compared to a soup meal or a rice and curry meal. None of the tested meals for dinner significantly changed the TAG.

Keywords: *Dinner food, Fasting blood sugar, Triacylglycerol*

Introduction

International diabetes federation indicates that globally, 589 million adults suffer from diabetes mellitus (IDF, 2025). The prevalence of DM is 14.2% for men and 13.5% for women in Sri Lanka (Wijewardene et al., 2010). Fasting blood glucose is an important indicator in diagnosis and monitoring DM (Islam, 2011). Fasting blood glucose level is associated with diet, behavioural changes and exercise (Brown, Upchurch and Acton, 2003). Therefore, nutritional components in foods can affect fasting blood sugar level (Ghaderian, 2007).

Dyslipidemia is common among patients with DM as diabetes is a metabolic disorder which alters carbohydrate, protein and lipid metabolism in the body (Wu and Parhofer, 2014; Thapa et al., 2017). Thus, according to the clinical practice guidelines of Sri Lanka for the management of DM, serum lipid parameters have to be monitored at the diagnosis and annually, in all diabetic patients (Diabetes Mellitus Management Guidelines, 2018).

Effect of a meal on blood glucose and TAG remain for 8 - 10 hours (Wolever et al., 1988). Therefore, according to WHO guidelines, 8-10 hours fasting is mandatory prior FBS testing and 10-12 hours fasting is recommended prior lipid profile ('Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus', 1997; American Diabetes Association, 2010). Therefore, when measuring both FBS and lipid profile, 10 hours of fasting would be ideal, which will be convenient for patients as blood drawing is done only once for both testing procedures.

Although the recommendation is to fast for 10 hours, certain foods can affect the fasting glucose and lipid parameters even after 10 hours, depending on the nutrients present in these food items (Yu et al., 2011). As most of the people sleep within 2 hours after dinner, high glucose and triacylglycerol levels remain in serum for a long period compared to the levels during the active day time (Knutson, 2007). This sleeping behaviour after high energy meals could lead to metabolic disorders. Thus, recent research evidence suggest to consume low energy dinners or omit dinners and to consume adequate amount of energy during the early period of the day to prevent metabolic disorders (Paoli et al., 2019).

With the busy stressful lifestyles, Sri Lankans tend to consume the most energy rich meal of the day for dinner, skipping or paying less concern on breakfast and lunch which they consume during busy schedules (Jayasinghe and De Silva, 2014). Nearly 20% of the Sri Lankan urban population (18.2%) tend to consume commercially available 'take-away' food items for dinner (Weeraratne, 2016). Compared to food prepared at home, commercially available food items have more energy and fat (Anna Bona, 2017) and can thus alter FBS and fasting lipid parameters. This can cause many health issues in healthy individuals and could also alter the serum parameters of diabetic patients, if they have used such foods for dinner on the previous day of the FBS test. Rice and curry, koththu, fried rice and soup (with or without toast bread) are such commonly consumed dinner foods by Sri Lankans. Moreover, many studies have proven the adverse health issues that arise with commercially available junk food as they contain high amounts of energy, fat, sugar and salt. These unhealthy components increase the biomarkers that trigger oxidative stress and inflammation in the human body and further

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contribute to long-term postprandial hyperglycemia, paving the path to non-communicable diseases, including psychological diseases (Adjibade et al., 2019).

As long-term postprandial hyperglycemia is associated with many health complications, alterations in the postprandial blood glucose have been assessed related to several Sri Lankan foods, through glycemic index studies. Mixed rice meals have shown the lowest glycemic index compared to string hoppers and manioc when a study was conducted with 10 healthy human participants (Hettiaratchi et al., 2009). Lowering of the glycemic index of the tested Sri Lankan foods has been achieved mainly by the addition of curries, which increases the fibre content in the meal (Ekanayake, 2019). Although published data are available on the glycemic index of mixed meals and the second meal effects, data are lacking on the effect of dinner foods on fasting blood glucose level the next day. Therefore, the aim of the present pilot study was to assess the effect of frequently consumed dinner food items of the Sri Lankans, which are also commercially available, on FBS and TAG levels of healthy individuals.

Methods

The study was a randomized crossover experimental study and aimed to determine the effects of different types of popular and frequently consumed Sri Lankan dinner food items on Fasting Blood Sugar (FBS) and Triacylglycerol (TAG) levels.

This study was conducted at the Research Laboratory of the Department of Biochemistry, Faculty of Medicine and Allied Sciences (FMAS), Rajarata University of Sri Lanka (RUSL). Approval for the study was obtained from the Ethics Review Committee, RUSL (ERC approval No. ERC/2020/04).

Thirteen participants with Body Mass Index within the normal range (18.5 – 22.9 kg/m^2), age between 22 - 26 years, FBS less than 110 mg/dl and TAG less than 150mg/dl were recruited for this study and this sample size was determined (effect size 0.48; $\alpha = 0.05$; power = 0.80) based on a previously published study which assessed the effect on fat metabolism after breakfast the next day with consumption of dinner early (Nakamura et al., 2021). Participants, who were having acute or chronic illness, diabetes mellitus, hypertension, psychiatric disorders, pregnancy, vegetarians/vegans and who took any medication for any illness on the testing day or on the previous day of the study were excluded. Participants volunteered and who were within the inclusion criteria were selected by the simple random sampling method. Informed written consent was taken from each participant at the recruitment to the study.

Four commonly consumed dinner foods with a portion size of 300 g were selected and the meals were prepared according to table 1.

Table 1: Ingredients of the meals

Meal	Ingredients	Preparation method
Rice and curry	*White rice (200 g), gotukola (*Centella asiatica*) (20 g), fish (40 g), red dhal (20 g), spices and coconut milk ~10 g	Rice was boiled. Red dhal and fish were mixed with spices and coconut milk and cooked under medium heat. Gotukola was served freshly as a salad.
Chicken fried rice	*White rice (200 g), carrots (20 g), leeks (20 g), onions (10 g), deviled chicken (40 g), ginger (5 g), garlic (5 g), dry red chilies and other spices (5 g)	Chicken was fried with oil and sauces, spices were added. Onion, ginger, garlic and other spices were fried with oil and vegetables and boiled rice were added to it.

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Kottu	Flour (200 g), chicken (40 g), egg (10 g), onion (10 g), carrots (10 g), leeks (10 g), oil (10 g), garlic (5 g), ginger (5 g) chilies (5 g)	Ginger, garlic and onions fried with oil and egg, vegetables and chicken curry were added to it. A dough was made with flour, salt, water and oil. It was spread on an oil pan and fried. The flat bread was cut it in to little pieces and added to the chicken vegetable mixture.
vegetable soup with 2 bread slices	Potatoes (40 g), green beans (40 g), carrot (40 g), cabbages (40 g), ladies finger (40 g), onions (40 g), red dhal (5 g), margarine (25 g), white bread (50 g)	Vegetables were boiled with onion and red dhal . Mixture was stirred and chopped to obtain the texture of a soup. Salt and pepper were added. Bread slices were toasted with margarine.

*weight after cooking

Participants were asked to fast for 8-10 hours. Participants were advised not to consume junk food or heavily sugar containing food especially after lunch, on the days being tested. On each test day, all the participants were provided with the relevant test food (dinner) at 9 pm. The participants were requested to have 6 – 7 hours of sleep. The next day morning at 7 am, blood samples (1 mL) were obtained from the cubital vein of the participants, and a sodium fluoride tube was used to collect blood for FBS analysis whereas a normal tube was used to collect blood for the TAG analysis. Serum was separated and FBS and TAG levels were measured using glucose oxidase assay colorimetric assay kit and TAG colorimetric assay kit, respectively. A 3 – 4 day washout period was maintained between test days.

The amount of calories, protein and fat content in each meal type was calculated using Food Composition Tables of Sri Lankan foods (De Silva, 2009). The presence of significant difference in mean FBS and mean TAG levels relevant to the food types, at 95% CI were measured using repeated measures. ANOVA and Tukey's post hoc test was used for pairwise comparison.

Results

The amounts of calories, protein and fat content in each meal type are shown in Table 2.

Table 2: Types of food and amount of calories

Food type	kcal/300g	Protein (g)/ 300g	Protein %	Fat (g)/ 300g	Fat %
Rice and curry	838	26.1	8.6	4.9	1.6
Chicken fried rice	932	23.4	7.8	15.6	5.2
Kottu	937	32.9	10.9	18.6	6.2
Vegetable soup with 2 bread slices	422	8.3	2.8	21.4	7.1

The mean FBS was highest in chicken fried rice (86 mg/dL) while the lowest mean FBS was observed for rice and curry (65 mg/dL) (Table 3). FBS, when rice and curry was used for the dinner was significantly lower than that of chicken fried rice ($p = 8.2 \times 10^{-5}$), *kottu* ($p = 1.25 \times 10^{-6}$) and vegetable soup with 2 bread slices (p = 0.02). FBS, when soup and bread was used for dinner was significantly lower than *kottu* (p = 0.0002) and chicken fried rice (p = 0.004). Consumption of *kottu* or fried rice

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has increased the FBS significantly in almost all individuals, compared to rice and curry and vegetable soup with 2 slices of bread (Table 3 and Figure 1).

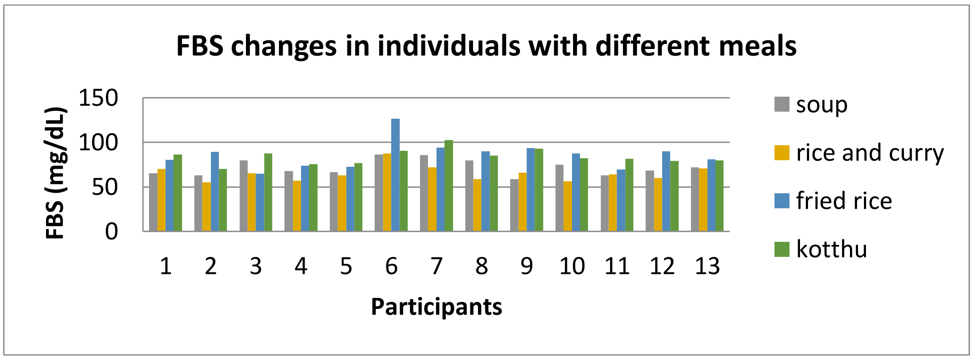

Figure 1: FBS changes in individuals with different meals

The mean TAG value is highest in *kottu* (54 mg/dL) and vegetable soup with 2 bread slices (54 mg/dL) while the lowest mean TAG value was observed for rice and curry (50 mg/dL) (Table 3 for mean TAG values). TAG with rice and curry meal was not significantly lower than that of chicken fried rice, *kottu* and vegetable soup with 2 bread slices. Similarly, TAG after soup and bread meal was also not significantly lower than chicken fried rice or *kottu.*

Table 3: Mean FBS and TAG values

Food item	FBS (mg/dL)±SD; n=13	TAG (mg/dL) ±SD; n=13
Basal level (with a regular meal on the previous night)	71 ± 6^{ab}	$56 \pm 26^{*}$
Rice and curry	65 ± 9^{ab}	$44 \pm 19^{*}$
chicken fried rice	86 ± 16^{c}	$50 \pm 14^{*}$
kottu	84 ± 8^{c}	$52 \pm 15^{*}$
vegetable soup with 2 bread slices	72 ± 9^{a}	$51 \pm 17^{*}$

*Same superscript in a column show no significant difference at 95% CI. a – no significant difference with basal FBS, b – no significant difference with rice and curry meal, c – no significant difference with fried rice or koththu, * - no significant difference in TAG levels*

Discussion

FBS of all individuals with all tested meals were within the normal range. Yet, having high FBS values for a long period, even within the normoglycemic range, can contribute to pre-diabetes, overweight/ obesity, dyslipidemia and cardiovascular diseases (Shaye et al., 2012). Furthermore, the elevated FBS within the normal range is an early indicator of insulin resistance (Hsieh et al., 2006). Therefore, avoiding dinner foods that will elevate the FBS is crucial, especially for patients with diabetes mellitus.

Although a meal of soup and bread is considered as a light diet it showed significantly higher ($p<0.05$) mean FBS (72mg/dL) compared to a rice and curry meal. Compared to either a soup meal, kottu meal or fried rice meal, a significantly lower FBS value was obtained for rice and curry meal ($p<0.005$) while there was no significant difference ($p=0.666$) between kottu and fried rice. No statistical significance was observed in TAG levels among the meals.

A study conducted with healthy human subjects revealed that the endogenous glucose production is inversely proportional to the dietary fat content. Insulin secreted after a meal inhibits hepatic gluconeogenesis, however, this inhibition is significantly low with high fat – low carbohydrate meals

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(Bisschop et al.2001). Furthermore, research evidence show that the high dietary fat stimulates gluconeogenesis by activating glucose 1,6- bisphosphatase, which is a key enzyme in the gluconeogenesis pathway (Song et al.2001). Compared to rice and curry, all other meals contained a significantly high fat content. Thus, the observed high FBS with a soup meal (with toasted bread with margarine), fried rice and kottu can be attributed to the high fat induced hepatic glucose production and insulin resistance exerted by circulatory free fatty acids (Song et al. 2001). This effect of dietary fat can be further described with the significantly high FBS level obtained for the soup and bread meal in the present study, despite the significantly low energy content in the meal. However, the FBS value in a soup meal which is significantly lower than fried rice and koththu meals, could be attributed to the low energy content (Fukuda et al., 1989). Low energy diets inhibit hepatic gluconeogenesis and improve insulin receptor signalling through PI3K/Akt pathway, which promotes GLUT4 translocation in muscle and adipocytes (McClenaghan, 2005; Huang et al., 2018).

Postprandial hyperinsulinemia after a high fat diet compared to low fat – high carbohydrate diets have been reported by many research studies (Bisschop et al. 2001). It is suggested that the hyperglycemia after high fat meals could be attributed to the peripheral insulin resistance caused by hyperinsulinemia. Furthermore, the suppression of hepatic gluconeogenesis cannot be exerted by this elevated insulin after a high fat meal (Brøns et al.2009).

The presence of free fatty acids in circulation is another crucial factor that leads to insulin resistance, thereby increasing the risk of hyperglycemia or type 2 diabetes mellitus and obesity. High fat diets significantly increase the nocturnal free fatty acids in circulation (Kim et al. 2007) that trigger hyperinsulinemia impeding the action of insulin.

The considerable amount of protein in koththu and chicken fried rice was expected to mitigate the postprandial blood glucose as research evidence suggests that high protein in meals controls postprandial blood glucose by inhibiting gluconeogenesis (Smedegaard et al., 2023). However, the expected control has not been achieved due to the presence of high fat content. A study conducted with children having type 1 diabetes mellitus revealed that the additive effect of protein and fat in 'high protein and fat meals' leads to prolonged postprandial hyperglycemia (Smart et al., 2013). Insulin resistance and delayed gastric emptying exerted by dietary fats might have overwhelmed the postprandial anti-hyperglycemic effects of protein.

Among the four tested meals, the two rice meals contained complex carbohydrate present in intact rice grains. White bread and kottu are prepared with refined wheat flour which has high digestibility. However, the type of carbohydrate present in these meals could not have affected the FBS as fried rice meal with complex carbohydrate also has elicited a significant increase in FBS. This further proves that the effect of fat in the meals might be the crucial factor for elevated FBS.

It can be concluded that, high fat meals, especially for dinner, leads to hyperinsulinemia causing insulin resistance, hyperglycemia and mitochondrial dysfunction (Brøns et al. 2009), that could trigger obesity and other non-communicable diseases. However, by decreasing the energy content in the meal (light diet such as a soup meal), the effect of fat in the meal on blood sugar can be attenuated to a certain extent. However, further studies are needed with an increased sample size to describe and to prove these effects further.

Conclusions

The present pilot study revealed that the rice and curry meal for dinner has the lowest effect on FBS of healthy human subjects. Fried rice and kottu for dinner significantly increase the FBS level compared to a soup and bread meal and a rice and curry meal. None of the tested meals for dinner significantly changes the fasting TAG in healthy human subjects.

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Conflicts of interest: The authors declare that there are no conflicts of interest.

Ethical statement: Ethical clearance for the study was obtained from the Ethics Review Committee, Faculty of Medicine and Allied Sciences, Rajarata University of Sri Lanka (ERC/2020/04).

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