Influence of rice and added sugar intakes on fasting plasma glucose and triacylglycerol levels amongst a population sample of Malaysian adults

Zhi Yee Lee[1], Joshua Chuan Yung Foo[1], Mei Qian Lim[1], Zheng Xian Koh[1], Wendy Hui Yi Wong[1], Tony Kock Wai Ng[2]

Introduction: A recently published meta-analysis showed that each additional serving of rice increased risk of type 2 diabetes mellitus (DM) by an alarming 11%. We investigated whether this phenomenon is seen in the Malaysian population by studying the effect of rice intake and added sugar consumption on fasting plasma glucose (FPG) and fasting triacylglycerol (TAG).

Methods: Ninety subjects (60 females, 30 males, aged 30-70 years), adequate to detect a weak-to-moderate Pearson correlation of r=0.26 at a=0.05 and power= 0.80, were recruited by convenience sampling from six communities in the Klang Valley, Malaysia. Fasting blood samples were collected by finger-prick and analysed for FPG (AccuCek, Roche) and TAG (Accutrend, Roche). Macronutrient intakes, including rice, were obtained by a single interview using a previously-evaluated food frequency questionnaire (FFQ) and quantitated as grams by the DietPLUS V2 programme. Added sugar intakes by subjects were estimated using an Added Sugar Intake excel programme.

Results: Rice contributed to 85% of dietary carbohydrates, accounting for 41.8 % kcal of the average 1750- kcal diet. Rice intakes or added sugar consumption did not have a significant correlation (p>0.05) with FPG nor fasting TAG. Added sugar consumption, which averaged 44g/person/day (5% kcal) was markedly lower than the 137g/person/day reported elsewhere for the Malaysian population.

Conclusion: High consumption of rice as a risk factor of type 2 DM was not indicated in the present study. Since white rice consumption varied 10-fold in the present subjects, the reduction in daily intake of this staple food represents a feasible option for cutting back on calorie intake for overweight or obese individuals.

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Key words: Rice intake, added sugar, fasting plasma glucose, triacylglycerol

Introduction

In Asia, rice is widely consumed and forms the staple food in many countries, contributing to 25-73% of dietary calories with a mean of about 32 % kcal.[1] In these Asian diets, rice contributes to the bulk of dietary carbohydrate and with a moderately high glycaemic index of 69.[2] This staple food is expected to have an important influence on plasma glucose levels and metabolism.

Several studies had reported that high-carbohydrate, low-fat diets induced higher FPG and plasma TAG concentrations in both healthy adults and diabetic patients.[3-5] From the dietary intake data of NHANES III, United States Yang *et. al.*[6] reported that carbohydrate intake is associated with diet quality and risk factors for cardiovascular disease in adults. Dietary carbohydrate intakes were inversely associated with BMI and serum total cholesterol concentration in men and BMI in women and positively associated with serum TAG concentrations in women. When total sugar intake was controlled, carbohydrate intakes were a stronger predictor of BMI and FPG in men and BMI in women. A high-carbohydrate diet (>57.4% kcal in men and >59.1% kcal in women) was associated with low serum HDL-cholesterol concentrations in men and high serum TAG in women.

According to the 2006 National Health and Morbidity Survey (NHMS) III[7], the overall prevalence of type 2 DM in Malaysia was 14.9%. The disease increased sharply from age 40 years in adults and peaking in the age range of 55-64 years. The marked increase in type 2 DM from 6.3% in 1986 (NHMS I), 8.2% in 1996 (NHMS II) to 14.9% in 2006 (NHMS III) paralleled the three-fold (4% to 12%) alarming rise in obesity in Malaysian adults during the same period.

In the meta-analysis of Hu et al. which included cohorts from Chinese and Japanese populations[8], each additional serving of rice increased risk of type 2 DM by an alarming 11%. The influence of high carbohydrate diets on FPG and TAG concentrations in Malaysians remain a grey area and warrants investigation

[1]ND1/11 Student Cohort, Bachelor of Science (Honours) Dietetics with Nutrition Programme, International Medical University (IMU), Bukit Jalil, 57000 Kuala Lumpur, MALAYSIA
[2]Department of Nutrition and Dietetics, IMU, Kuala Lumpur, MALAYSIA

Address for Correspondence:

Associate Professor Dr Tony Ng Kock Wai, Department of Nutrition and Dietetics, International Medical University, 126, Jalan Jalil Perkasa 19, Bukit Jalil, 57000 Kuala Lumpur, MALAYSIA

Email: tony_ng@imu.edu.my

because of the importance of diet quality on health. Therefore, it would be both important and interesting to investigate whether this phenomenon exists in the local population whose staple food is rice.

Methods

Study population(s):

About 125 individuals participated in the subject recruitment exercise in six study sites- five residential communities in the Klang Valley, Selangor and the International Medical University (IMU) campus population at Bukit Jalil, Kuala Lumpur. Finally, 90 adults subjects (30 males, 60 females) were recruited based on the inclusion criteria- aged 30-70 years old, with body mass index (BMI) 18-29 kg/m^2, able to provide a fasting blood sample, able to speak and comprehend either English or Bahasa Malaysia, and not on diabetic, high blood TAG or hypertension medication.

The study design was cross-sectional and subjects were recruited by convenience sampling. Posters were displayed at strategic sites at least a week in advance in the study venues to inform interested individuals to come fasting for free blood screening and counselling. All participants at the study venues were informed of the nature and purpose of the research study, and all signed a Consent Form. This research study [Project ID: BN &D 101/11(04)2013] was approved by the Joint Research and Ethics Committee of the IMU in September 2013.

Sample size:

The sample size of 90 subjects was estimated to be necessary to detect a weak-to-moderate Pearson correlation of r=0.26 at α=0.05 and power=0.80 between two variables measured on a numeric scale and which exhibited an approximate normal distribution.[9]

Anthropometry and blood biochemistry:

All subjects were measured for weight and height (SECA apparatus) and blood pressure with an OMRON HEM 7200 digital meter (OMRON Healthcare, Singapore). Blood collection was performed by finger-prick in the presence of a registered Sister/ nurse, and analysed for FPG (AccuCek, Roche, USA) and fasting TAG (Accutrend, Roche, USA). Control samples for glucose were performed at the beginning of each screening session. In our hands, the AccuChek Performa plasma glucose analysis yielded a coefficient of variation (CV) of 7% which was higher that the ≤5.0% reported for the Roche Instrument.[10] Nutrition counselling at all six study venues was provided by Ng TKW who is the senior author of this study.

Dietary assessment:

Macronutrient intakes, including rice, were obtained by a single interview using a previously-evaluated semi-quantitative FFQ[11] and quantitated as grams by the DietPLUS V2 programme developed at the IMU.[12] Added sugar intakes by subjects were estimated using an Excel Database for Added Sugar developed at the Institute for Medical Research, Kuala Lumpur.[13]

Statistical analysis:

All statistical analysis were performed by SPSS Version 18. Correlation analysis for two variables measured on a numerical scale and each approximating a normal distribution was done by Pearson's correlation test at significance level $p<0.05$.

Results

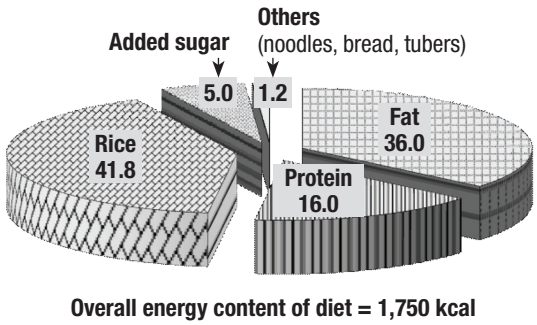
The mean age of the 90 participants is 45.56 ± 10.76 years and their gender, age and ethnic profiles are shown in Table 1. Two-thirds of the subjects were females and the majority (77%) of participants were Chinese, while Malays formed 10%, Indians 8% and other ethnic groups, 5%.

Table 1: Characteristics of the participants (N=90)

Variables	Number	Percentage
Gender:		
Males	30	33.3
Females	60	66.7
Ethnicity:		
Malay	9	10.0
Chinese	69	76.6
Indian	7	7.8
Others	5	5.6
Age (yrs):		
30 – 39	32	35.6
40 – 49	22	24.4
50 – 59	28	31.1
60 – 69	8	8.9

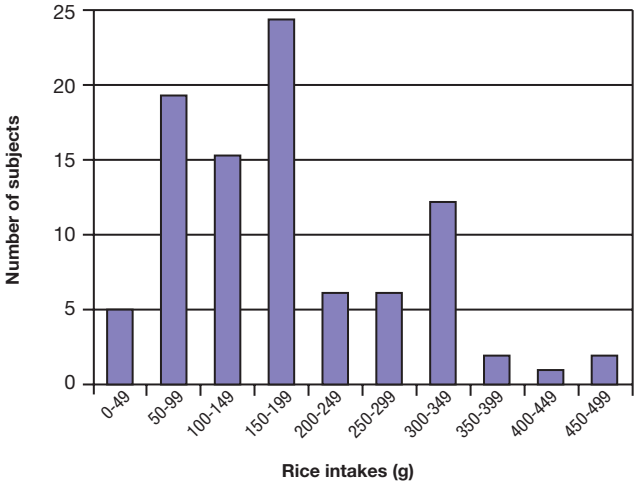
The overall macronutrient composition of the diets of the subjects is shown in Figure 1. Dietary carbohydrates contributed to 48.0% kcal (mean= 210g/day), protein 16.0% kcal and fat, a high 36.0% kcal. Rice made up the bulk (85%) of dietary carbohydrates (CHO), added sugar 10% of CHO or 44g/day, with noodles, bread and tubers making up the rest (5% of CHO).

Figure 1: Macronutrient composition (% kcal) of the overall diet of subjects



Rice intakes varied greatly amongst the 90 subjects from 0 g/day to 486 g/day. Based on a basic unit of one-third serving size of 50 g rice, the variance of daily rice intakes in the subjects represented a 10-fold difference from lowest to highest daily intake (Figure 2). The estimated mean rice intake was 178 mg/day while the median intake was 160 mg/day, reflecting an approximate normal distribution for rice intakes by the subjects.

Figure 2: Distribution of daily rice intakes



The FPG concentrations of the 90 subjects are shown in Table 2. Male and female subjects had comparable FPG means of 5.77±0.59 mmol/L and 5.58±0.51 mmol/L, respectively. Applying the guidelines of the World Health Organisation14 for definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia, 80% of subjects were normal, 17.8% had impaired glucose tolerance and 2.2% could be considered as diabetic. It must be emphasised that none of the participants were on diabetic medication and therefore, the inclusion criteria were not compromised.

As for fasting TAG concentrations, 72.2% were normal, 17.8% borderline high and 10% high, according to the Guidelines of the National Cholesterol Education Program (NCEP). Adult Treatment III.[15,16] The overall mean fasting TAG for all subjects was 1.55±0.74 mmol/L (Table 2).

Table 2: Blood biochemistry of subjects (N=90)

Plasma index	Number of subjects	Percentage	Mean±SD (mmol/L)
FPG:			
Males	30	33.3	5.77±0.59
Females	60	66.7	5.58±0.51
All subjects combined:	90	100.0	5.62±0.55
Normal[a]	72	80.0	
Impaired fasting glucose[b]	16	17.8	
Diabetic[c]	2	2.2	
Fasting TAG:			
All subjects combined	90	100.0	1.55±0.74
Normal[d]	65	72.2	
Borderline high[e]	16	17.8	
High[f]	9	10.0	

FPG = fasting plasma glucose ; TAG = triacylglycerol
Interpretative guidelines for FPG and TAG (NCEP, 2001; WHO, 2006):
[a] = <6.1 mmol/L [b] = 6.1-6.9 mmol/L [c] ≥ 7.0 mmol/L
[d] = <1.7 mmol/L [e] = 1.7-2.3 mmol/L [f] = 2.3-5.64 mmol/L

The results of correlation analysis shown in Table 3 showed that both rice intakes and added sugar consumption were not significantly ($p>0.05$) correlated with either FPG or fasting TAG concentrations.

Table 3: Pearson correlation analysis for rice intake or added sugar consumption with FPG and fasting TAG

Independent variable	Dependent variable	
	FPG	Fasting TAG
Rice intake	$r = 0.053$	$r = 0.046$
	p = 0.622	p = 0.667
Added sugar intake	$r = 0.092$	$r = 0.037$
	p = 0.394	p = 0.729

Discussion

We had estimated white rice and added sugar intakes of 90 individuals recruited by convenience sampling from largely the community and investigated the relation between these two dietary components with FPG and fasting TAG concentrations. Due to budget constraints, we were unable to include plasma insulin determinations and used FBG and TAG as simple surrogate markers of risk of metabolic syndrome in this study. The influence of rice and added sugar intakes on weight gain was not the objective of this study and as such, body mass index data of subjects were not analysed.

We are aware that different varieties of rice can have a different influence on the glycaemic response. However, due to the time and budget constraints in this study, we were unable to investigate this interesting aspect.

The variance of the independent variable- rice intakes, had to be large and this represented the main challenge faced by the authors in the present study especially so when the subjects were recruited by convenience sampling. We investigated individuals from a small Malaysian sample, unlike the meta-analysis of Hu *et. al.*[8] which examined seven prospective cohorts of Asian and Western populations. Using 50g rice or one-third serving as a basic unit, we were able to obtain a 10-fold difference between the lowest and highest daily rice intakes by subjects. Rice contributed to 85% of dietary carbohydrates or 48% kcal in this study. Despite this, there was no significant correlation between rice intake and FPG nor fasting TAG concentrations. This was unexpected as high consumption of carbohydrates was reported to raise FPG[17] and TAG concentrations.[18]

Of the 90 subjects who participated in the study, only 2.2% had raised FBG levels (≥ 7.0 mmol/L) as individuals on diabetic medication were excluded from the present study. In addition, almost 18% of the subjects exhibited impaired fasting glucose (FPG = 6.1-6.9 mmol/L) which underscores the potential danger of these cases developing into the "diabetic range" (FPG ≥ 7.0 mmol/L) in the near future.

In this study, the mean TEI was only 1750 kcal which might be explained by the fact that two-thirds of the subjects were females whose daily energy intakes are lower than males (data not shown). Another explanation could be that dietary assessment in this study was performed by the FFQ method which had often been reported to underestimate macronutrient intakes due to respondent bias.[19, 20]

Despite the limitations of the FFQ method[21], it has become a well-accepted method for the quantitative assessment of usual nutrient intake and represents the only dietary intake measure to minimise the very high intra-individual, day-to-day variability in nutrient intake without relying on multiple-day assessments of actual foods consumed (e.g. 24-hr recalls, 7-day dietary records).[22] In this regard, the FFQ method has been reported to reproducible and adequate to estimate macronutrient intakes of individuals in Singapore[23], Korea[24] and South Asians in the United Kingdom.[25]

The semi-quantitative FFQ method was used in the present study because the meeting with the study participants was one-off, the FFQ was culturally-suitable, the time-constraint of the study which was limited to two months, the diet assessment tool involved less respondent burden than multi-day assessments, and the FFQ data recorded could easily be quantitated with the nutrient-calculator used- DietPlus V2.[11]

Mean dietary carbohydrate intake in the present study amounted to 48% kcal (210g/day) which was substantially lower than the mean of 59% kcal (221g/day) reported for the MANS Study 2003.[26] However, the present study data and that of the MANS Study 2003 are strictly not comparable due to the extremely low mean TEI reported for males and females in the latter study, as well as the different male:female subject ratios of the two data sets.

Added sugar consumption per day averaged 44g or 5% kcal which amounted to 10% (w/w) of dietary carbohydrates. This daily consumption of added sugar was well within the 10% kcal upper limit recommended by WHO (2014) but was much lower than expected when compared with the mean intake of about 137g/day or 35% kcal estimated from the data of the MANS Study.[27] The predominantly Chinese subjects in this study probably contributed in part to this lower overall mean for added sugar intake compared to the national average.

In a recent systemic review on intake of sugar-sweetened beverages and weight gain, Malik *et. al.*[28] reported evidence which indicated that a greater consumption of sugar-sweetened beverages was associated with weight gain and obesity. The consumption of sugar-sweetened beverages in the above studies most likely contributed to excess energy intake. In view of the rising trend in overweight and obesity in Malaysia, it is pertinent that the consumption of added sugar which represents "empty calories", be limited.

Conclusion

High consumption of rice as a risk factor of type 2 DM or metabolic syndrome as reflected by the surrogate markers- FPG and fasting TAG, was not indicated in the present study. The absence of a significant correlation between rice (which formed 85% of dietary CHO) consumption and FPG or fasting TAG concentrations was unexpected.

Since white rice consumption varied 10-fold in the present study, the reduction in rice intake may be considered together with the usual messages to cut down on sugar-sweetened drinks/snacks, and to increase physical activity in order to tackle the problem of overweight and obesity in the country.

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REFERENCES

1. Food and Agricultural Organization (FAO). Rice is life. FAO Fact Sheet 3, 2004 @ www.rice2004.org.
2. Powell KF, Holt SHA & Brand-Miller JC. International table of glycemic index and glycemic load values: 2002. Am J Clin Nutr 2002; 76: 5-56.
3. Ginsberg H, Olefsky JM, Kimmerling G, Crapo P & Reaven GM. Induction of hypertriglyceridemia by a low-fat diet. J Clin Endolcrinol 1976; 42(4): 729-35.
4. Coulston AM, Hollenback CB, Swislocki ALM & Reaven GM. Persistence of hypertriglyceridemia effect of low-fat high-carbohydrate diets in NIDDM patients. Diabetes Care 1989; 12(2): 94-101.
5. Gannon MC, Nuttall FQ, Westphal SA, Fang S & Ercan-Fang N. Acute metabolic response to high-carbohydrate, high-starch meals compared with moderate-carbohydrate, low-starch meals in subjects with type 2 diabetes. Diabetes Care 1998; 21(10): 1619-26.
6. Yang EJ, Chung HK, Kim WY, Kerver JM & Song WO. Carbohydrate Intake Is Associated with Diet Quality and Risk Factors for Cardiovascular Disease in U.S. Adults: NHANES III. J Am Coll Nutr 2003; 22(1): 71-7.
7. Zanariah Hussein. Prevalence of diabetes mellitus in Malaysia 2006 - Results of the 3rd National Health and Morbidity Survey. A Report by the NHMS Diabetes Study Group, Ministry of Healthy Malaysia, Putrajaya; 2008.
8. Hu EA, Pan A, Malik V, et al. White rice consumption and risk of type 2 diabetes: meta-analysis and systematic review. BMJ 2012; 344: 441-54.
9. Statstodo.com. Sample size for Correlation Tables @ https://www.statstodo.com/ SSizCorr_Tab.php
10. Carrington N. Roche Diagnostics. ACCU-CHEK Performa Blood Glucose @ http://www.accessdata.fda.gov/cdrh_docs/pdf13/K133741.pdf.
11. Chong SY. Comparison of daily macronutrient intakes by adult volunteers determined by two different methods- a semi-quantitative FFQ and the 24-hr food recall as reference. Submitted in partial fulfillment of the B.Sc Hons Nutrition and Dietetics degree, International Medical University, May 2013.
12. Ng TKW. DietPLUS- a User-friendly '2 in 1' Food Composition Database and Calculator of Nutrient Intakes. Mal J Nutr 2010: 16(1): 125-30.
13. Ng TKW and Zawiah H. An excel database for added sugar. IMR Annual Report 2004, Institute for Medical Research, Kuala Lumpur.
14. World Health Organization (WHO). Defination and diagnosis of diabetes mellitus and intermediate hyperglycemia: Report of a WHO/ IDF Consultation, 2006. Geneva, WHO Documenation Production Services.
15. National Cholesterol Education Program (NCEP). Adult Treatment III, Executive Summary. JAMA 2001; 285: 2468-97.
16. National Cholesterol Education Program (NCEP). Adult Treatment III, 2004 Update, Circulation 2004; 110: 227-39.
17. Wolever TMS and Miller JB. Sugars and blood glucose control. Am J Clin Nutr 1995; 62: 212S-27S.
18. Mittendorfer B and Sidossis LS. Mechanism for the increase in plasma TAG concentrations after consumption of short-term, high-carbohydrate diets. Am J Clin Nutr 2001; 73: 892-9.
19. Schaefer EJ, Augustin JL, Schaefer MM, Rasmussen H, Ordovas JM, Dallal GE & Dwyer JT. Lack of efficacy of a food-frequency questionnaire in assessing dietary macronutrient intakes in subjects consuming diets of known composition. Am J Clin Nutr 2000; 71(1): 746-51.
20. Subar AF, Kipnis V, Troiano RP, Midthune D, Schoeller DA, Bingham S, Sharbaugh CO, Trabulsi J, Runswick S, Ballard-Barbash R, Sunshine J & Schatzkin A (2003). Using intake biomarkers to evaluate the extent of dietary misreporting in a large sample of adults: the OPEN study. Am J Epidemiol 2003; 158(1): 1-13.
21. Sempos CT, Invited commentary: some limitations of semi-quantitative food frequency questionnaires, Am J Epidemiol 1992; 135: 1127-32.
22. Kristal AR, Shattuck AL and Williams AE. Food Frequency Questionnaires for Diet Intervention, In: Proceedings of the 17th National Nutrient Databank Conference, June 7-10, 1992, Baltimore, Maryland. Washington, DC. International Life Sciences Institute, 1994: 110-25.
23. Yap MD, Li T, Tan WL, Van Staveren WA and Deurenberg P, Validation of a semi-quantitative food frequency questionnaire for estimation of intakes of energy, fats and cholesterol among Singaporeans. Asia Pacific Clin Nutr 2000; 9(4): 282-8.
24. Kim J, Kim DH, Ahn YO, Tokudome Y, Hamajima N, Inoue M, and Tajima K. Reproducibility of a Food Frequency Questionnaire in Koreans. Asian Pacific J Cancer Prev 2003; 4, 253-7.
25. Sevak L, Mangtani P, McCormack V, BhakTa D, Kassam-Khamis T and Dos Santos S. Validation of a food frequency questionnaire to assess macro- and micro-nutrient intake among South Asians in the United Kingdom. Eur J Nutr 2002; 43(3): 160-8.
26. Ministry of Health Malaysia (2008). MANS- Malaysian Adult Nutrition Survey 2003: Dietary intake of adults aged 18 to 59 years, ISBN 978-983-44156-2-4.
27. Family Health Development Division. Food consumption statistics of Malaysia 2003; For adult population aged 18 to 59 years. Volume 1. Family Health Development Division and Food Safety and Quality Division, Ministry of Health Malaysia, 2006; ISBN: 978-983-40537-1-0.
28. Malik VS, Schulze MB & Hu FB (2006). Intake of sugar-sweetened beverages and weight gain: a systemic review. Am J Clin Nutr 84(2): 274-88.