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EFFECTS OF MACRONUTRIENTS AND PHYSICOCHEMICAL PROPERTIES OF CARBOHYDRATES ON GLYCAEMIC INDICES (GI) OF SOME SRI LANKAN FOODS

By

Usha Pushkala Kumari Hettiaratchi

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DECLARATION

The work described in this thesis was carried out by me under the supervision of Dr. S. Ekanayake and Prof. J. Welihinda and a report on this has not been submitted in whole or in part to any University or any other Institution for another Degree/Diploma.

UHettiaratchi .... 22/01/2010 ....

U.P.K. Hettiaratchi Date

We certify that the candidate has incorporated all possible corrections, amendments and additions recommended by the examiners.

Ekanayake ....

Dr. Sagarika Ekanayake Prof. J. Welihinda

CERTIFICATION

We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation.

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Dr. S. Ekanayake   Prof. J. Welihinda

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ABBREVIATIONS

AUC	Area under curve
BMI	Body Mass Index
CV	Coefficient of variation
CHD	Coronary heart disease
CVD	Coronary vascular disease
DM	Diabetes mellitus
FAO	Food and Agricultural Organization
FFA	Free fatty acids
FSG	Free sugar glucose
GER	Gastric emptying rate
GDM	Gestational diabetes mellitus
GLP-1	Glucagons-like peptide 1
GIP	Glucose dependent insulinotrophic peptide
GI	Glycaemic index
GL	Glycaemic load
HDL	High density lipoprotein
HI	Hydrolysis index
IGT	Impaired glucose tolerance
IAUC	Incremental area under curve
IDF	Insoluble dietary fibre

IDDM	Insulin dependent diabetes mellitus
IGF-1	Insulin like growth factor-1
IR	Insulin resistance
II	Insulinaemic index
LDL	Low density lipoprotein
NIDDM	Non insulin dependent diabetes mellitus
RAG	Rapidly available glucose
RDS	Rapidly digestible starch
RS	Resistant starch
SCFA	Short chain fatty acids
SAG	Slowly available glucose
SD	Standard deviation
SDS	Slowly digestible starch
SDF	Soluble dietary fibre
SEM	Standard error of mean
TDF	Total dietary fibre
WAI	Water absorption index
WSI	Water solubility index
WHO	World Health Organization

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I dedicate this thesis to my family.

U.P.K. Hettiaratchi

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ABSTRACT

EFFECTS OF MACRONUTRIENTS AND PHYSICOCHEMICAL PROPERTIES OF CARBOHYDRATES ON GLYCAEMIC INDICES (GI) OF SOME SRI LANKAN FOODS

U.P.K. Hettiaratchi

The glycaemic index (GI) concept ranks basic foods and mixed meals according to the blood glucose response following ingestion of foods. Low GI foods with slow and prolonged glycaemic responses are reported to be beneficial for diabetic patients and in general for non-diabetic individuals. The recent reports imply a markedly high prevalence of diabetes mellitus (DM) in Sri Lanka among both urban (16.4%) and rural populations (8.7%) with one in five adults having either diabetes or pre-diabetes.

Currently, GI values of only basic foods are available with little or no information regarding frequently consumed Sri Lankan mixed meals. The availability of such data will be of value for clinicians and dieticians in planning meals for diabetic patients. The present study was therefore designed to determine the GI values of frequently consumed Sri Lankan foods and mixed meals with healthy individuals. Further, the physicochemical properties (factors) contributing to the differences in GI of foods and the effect of edible portion of fibre on GI were studied. An *in vitro* method was also used to predict the glycaemic responses of mixed meals. The present study further determined the glycaemic and insulinaemic responses to selected foods with type 2 diabetic patients and the second

meal effect of breakfast meals on a subsequent lunch meal as the data regarding glucose and insulin responses to Sri Lankan foods with diabetic patients are not available.

GI values of foods were determined according to Brouns *et al.,* (2005), FAO/WHO, (1998), physicochemical factors by AOAC, standard methods and rapidly and slowly available glucose and starch fractions using a modified method of Englyst *et al*., (2000). *In vitro* starch hydrolysis was carried out according to Granfeldt *et al*., (1992).

GI of foods with healthy individuals were as follows: bread varieties [wholemeal bread (103±11), ordinary bakery bread (114±9)], mixed meals [wholemeal bread & lentil curry meal (87±6), red rice & *kiri hodi* meal (99±10), red rice mixed meal (60±5), string hopper meal (wheat flour) (104±7), string hopper meal (red rice flour) (103±11), manioc meal (120±9), jackfruit meal (75±11)], and bananas [*kolikuttu* (61±5), *embul* (61±5), *anamalu* (67±7), *seeni kesel* (69±9)]. The red rice mixed meal, jackfruit meal and bananas can be categorized as low GI, wholemeal bread & lentil curry meal as medium GI and all other foods as high GI foods. The rice mixed meal yielded the lowest GI among the foods analyzed.

The GI values obtained using a bread of Sri Lankan origin as the standard can be converted to GI values expected against glucose by a conversion factor of 1.34. This enables reporting GI data with respect to glucose for comparison with the internationally reported values.

The GI values determined with the conventional enzymatic kit method were not significantly different ($p>0.05$) to that of the GI values calculated using a glucometer

(Accu-Check Active, Roche Diagnostics GmbH, Germany) thus indicating the potential to use this particular glucometer when determining GI values.

Significant negative correlations ($p<0.05$) were observed with GI & insoluble dietary fibre (IDF) ($p=0.032$), soluble dietary fibre (SDF) ($p=0.010$) and total dietary fibre (TDF) ($p=0.038$) contents of 50 g available carbohydrate portions of basic foods and mixed meals.

Protein and amylose contents of portions given for determination of GI indicated non significant negative relationships ($p=0.165$ and $p=0.054$ respectively) with GI values.

The wet heat processed foods analyzed in this study that elicited high GI values had disintegrated starch granules compared with the raw flour. The observed effect on the starch granules of the foods studied in this thesis was due to the gelatinization of starch granules during wet processing highlighting the impact of processing methods on GI for the foods concerned.

When the rapidly available glucose (RAG), slowly available glucose (SAG), rapidly digestible starch (RDS) and slowly digestible starch (SDS) contents of portions given for determination of GI in basic foods and mixed meals were correlated with GI values, significant positive correlations ($p<0.05$) were observed with RAG ($p=0.023$), RDS ($p=0.011$) fractions and significant negative correlation with SAG/RAG ($p=0.036$) ratio. This indicates that the rapidly available carbohydrates of a food/meal could be taken as a food related determinant of GI.

As a novel approach a standard *in vitro* method was used to predict GI values of mixed meals by estimating the hydrolysis indices (HI) of composite meals. The *in vitro* HI values indicated a significant positive correlation ($p=0.0001$) with *in vivo* GI values of both basic foods and mixed meals.

The GI of a rice meal declined by 9% with an increase of 7.2% TDF content as meal accompaniments of a part of a rice meal.

Three breakfast meals (chickpea, red rice meal, atta *roti*) were given to type 2 diabetics. GI values of three meals were 40 ± 7 (low GI), 64 ± 11 (low GI), 88 ± 9 (medium GI) and the insulinaemic indices (II) were 76 ± 13, 90 ± 20 and 115 ± 28 respectively. The glycaemic responses of the meals analyzed indicated a positive linear relationship ($r=0.9838$) with the corresponding insulinaemic responses. The GI values of the meals with diabetic patients were not significantly different ($p>0.05$) from healthy individuals but slightly higher than the values reported with healthy individuals. The peak serum glucose levels of chickpea, rice and *roti* declined by 27%, 13%, 4% respectively compared with the standard (bread).

The effects of above breakfast meals on the glycaemic and insulinaemic responses of a standard rice lunch meal (second meal effect) were analyzed. According to the results obtained none of the breakfast meals elicited an effect on the subsequent lunch.