

**NUTRITIONAL EVALUATION AND
INFLUENCE ON CARBOHYDRATE AND
LIPID METABOLISM OF PORRIDGE
MADE WITH GREEN LEAFY
VEGETABLES**

**Senadheera Pathirannehelage Anuruddhika
Subhashinie Senadheera**



Ph.D

2014

**NUTRITIONAL EVALUATION AND
INFLUENCE ON CARBOHYDRATE AND
LIPID METABOLISM OF PORRIDGE
MADE WITH GREEN LEAFY
VEGETABLES**

By

**Senadheera Pathirannehelage Anuruddhika
Subhashinie Senadheera**

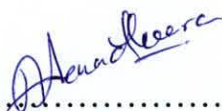
Thesis submitted to the University of Sri Jayewardenepura for the
award of the Degree of Doctor of Philosophy in Biochemistry

2014

DECLARATION BY THE CANDIDATE

The work described in this thesis was carried out by me under the supervision of Prof. Sagarika Ekanayake (Department of Biochemistry, Faculty of Medical Sciences, University of Sri Jayewardenepura) and Dr. Chandanie Wanigatunge (Department of Pharmacology, Faculty of Medical Sciences, University of Sri Jayewardenepura) 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.


21-10-2014
.....
Date


.....
Signature of the candidate

CERTIFICATION BY SUPERVISORS

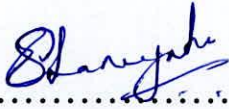
We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation.


.....
Prof. Sagarika Ekanayake

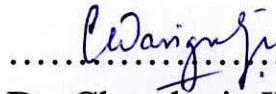

.....
Dr. Chandanie Wanigatunge

CERTIFICATION BY SUPERVISORS

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



.....
Prof. Sagarika Ekanayake



.....
Dr. Chandanie Wanigatunge

ACKNOWLEDGEMENT

One looks back with appreciation to the brilliant teachers, but with gratitude to those who touched our human feelings. Dear Madam, Professor Sagarika Ekanayake (Supervisor), I would like to express my special appreciation and thanks to you. Words cannot express how grateful I am to my co-supervisor, Dr. Chandanie Wanigatunge, whose priceless advice and for being a tremendous mentor for me. Both of you, not only became compasses that activated the magnets of curiosity, knowledge and wisdom of mine, but also kept me on path and gave the courage to withstand steadily at every pitfall of my life.

I immensely thankful to all the doctors of the 14th Batch and the other volunteers of the Faculty of Medical Sciences, University of Sri Jayewardenepura and all the volunteers who participated for the clinical trial for their support and kindness which encouraged me in achieving the goals of the study. I would like to show my greatest appreciation to Mr. Sanghasena Kaludewage and the staff of Plenty Foods (Pvt) Ltd. for their valuable assistance provided me in production of porridge packets. I am grateful to Ms. Nandani and Mr. Gayan of Anuradhapura for their constant support and help in providing green leaves for the clinical trial.

Financial supports provided by the ASP/06/PR/2010/12 and PhD/08/2012 grants of University of Sri Jayewardenepura are highly appreciated.

My sincere thanks go to Prof. U.G Chandrika (Coordinator, Animal House, FMS, USJ) for granting me permission to utilize the facilities in Animal House, Dr. Mayuri Thammitiyagoda for furnishing me with the knowledge of animal handling, Dr. Menuka at Industrial Technology Institute, Colombo for sharing her valuable practical knowledge with me on animal studies, Dr. Sarath and Dr. Amitha Benthota at the

Regional Rice Research Institute, Bombuwala for providing me the rice samples, Ms. Nadeeka at National Herbarium, Royal Botanical Gardens, Peradeniya and Prof. Singhakumara for the support in making herbarium specimens. I would especially like to thank Dr. Wathsala and all the lecturers and staff of the Dept. of Community Medicine for their support on statistical analysis and the staff of the Dept. of Food Science and Technology for providing me some chemicals and equipments when necessary.

Words cannot express how grateful I am to my mother, father and two sisters for all of the sacrifices that you've made on my behalf. Your blessings for me were what sustained me thus far. I would also like to thank all of my research colleagues who supported me in various ways especially Madhura, Wasundara, Samantha, Asanga, Peshala, Nisanka, Randika and Kasuni who incited me to strive towards my goal. Finally, I would like to thank all the academic and non academic staff of the Dept. of Biochemistry, FMS, USJ for helping me in various ways to make this effort a success.

Table of Contents

1	INTRODUCTION	1
2	LITERATURE REVIEW	5
2.1	Diabetes mellitus	5
2.1.1	Classification of diabetes	7
2.1.2	Predisposing factors for diabetes type 2	8
2.1.3	Complications due to diabetes	14
2.1.4	Major risk factors associated with development of type 2 diabetes among Sri Lankans	16
2.1.5	Role of diet in management of diabetes.....	20
2.1.5.1	Low glycaemic index diet.....	21
2.1.5.2	Low carbohydrate- high protein diet.....	28
2.1.5.3	High fiber diet	29
2.1.5.4	Paleolithic diet	30
2.1.5.5	Vegan diet	30
2.1.5.6	Herbal dietary remedies	31
2.2	Leaves used for the study	34
2.2.1	<i>Murraya koenigii spreng</i> (Karapincha)	34
2.2.2	<i>Asparagus racemosus</i> (Haathawariya)	38
2.2.3	<i>Hemidesmus indicus</i> (Iramusu).....	41
2.2.4	<i>Clitoria ternatea Linn</i> (Ela katarolu)	45

2.2.5	<i>Aegle marmelos</i> (Beli)	48
2.2.6	<i>Cassia auriculata</i> Linn (Ranawara)	51
2.2.7	<i>Cardiospermum halicacabum</i> (Wel penela)	54
2.2.8	<i>Aerva lanata</i> (Polpala)	57
2.2.9	<i>Scoparia dulcis</i> (Wal koththamalli)	60
2.2.10	<i>Atlantia ceylanica</i> Linn. (Yaki naran)	66
2.2.11	<i>Osbeckia octandra</i> (Heen bovitiya)	66
2.2.12	<i>Cephalandra indica</i> (Kowakka)	68
2.3	Beneficial effects of green leaves	71
3	MATERIALS AND METHODS	76
3.1	Chemicals Solvents and water	76
3.2	Materials	76
3.3	Preparation of porridge	77
3.4	Methods	78
3.4.1	Estimation of nutrient composition of porridges	79
3.4.1.1	Moisture content	79
3.4.1.2	Ash content	80
3.4.1.3	Digestible carbohydrate content	80
3.4.1.4	Fat content	81
3.4.1.5	Crude protein content	84

3.4.2	Estimation of antioxidant potential and total phenolic content of porridges	85
3.4.2.1	Antioxidant potential of green leafy porridges (ABTS free radical scavenging assay).....	85
3.4.2.2	Total polyphenol content	86
3.4.3	Estimation of GI and GL of porridges	87
3.4.3.1	Normal individual sample selection.....	87
3.4.3.2	Glycaemic Indices (GI) of porridges in normal individuals	88
3.4.3.3	Glycaemic Load	89
3.4.3.4	Ethical approval	89
3.4.4	Estimation of hypoglycaemic and hypolipidaemic effects of selected porridges – animal bioassay.....	90
3.4.4.1	Animal Bioassay	90
3.4.4.2	Animals	90
3.4.4.3	Induction of diabetes in test rats	90
3.4.4.4	Diets	91
3.4.4.5	Weights and behaviour of rats	92
3.4.4.6	Serum parameters.....	92
3.4.4.7	Organ weights	93
3.4.4.8	Ethical approval	93

3.4.5	Studies with diabetic patients	93
3.4.5.1	Questionnaire study - Observation of the dietary patterns and usage of leafy porridges/ herbal remedies by type 2 diabetic patients	93
3.4.5.2	Preparation of <i>Scoparia dulcis</i> porridge according to commercial production procedure	93
3.4.5.3	Estimation of GI and GL.....	96
3.4.5.4	Ethical approval	97
3.4.5.5	Estimation of hypoglycaemic effects of herbal porridge made of <i>Scoparia dulcis</i> leaves – clinical trial	98
3.4.5.6	Ethical approval	103
3.4.6	Statistical analysis.....	103
4	RESULTS	105
4.1	Nutrient composition of porridges.....	105
4.2	Antioxidant potential of porridges.....	110
4.3	GI and GL of porridges	116
4.3.1	Fasting blood glucose values of individuals	116
4.3.2	GI and GL values	117
4.3.3	Glycaemic response	121
4.3.4	Correlation between GI and macronutrients	124
4.4	Animal Bioassay.....	124

4.4.1	Food, water intake and change in weight	124
4.4.2	Behavioral changes and mortality rate.....	126
4.4.3	Blood glucose concentration.....	127
4.4.4	Lipidaemic measurements and CRP	128
4.4.5	Liver and kidney related measurements	130
4.4.6	Appearance and weights of internal organ	132
4.5	Observation of dietary patterns of T2DM patients.....	133
4.5.1	Study population	133
4.5.2	Awareness on overweight or obesity	133
4.5.3	Consumption of main and other meals	133
4.5.4	Consumption of sweetened foods	136
4.5.5	Prevalence of diabetes related complications	136
4.5.6	Physical exercises	137
4.6	Development of <i>S. dulcis</i> porridge (with a medium GI) in commercial scale	137
4.6.1	GI and GL of the porridge	137
4.6.2	Particle size distribution of porridges	140
4.7	Clinical trial with <i>S. dulcis</i> porridge.....	142
4.7.1	Study population	142
4.7.2	Glycaemic measurements	142
4.7.3	Lipid measurements.....	144

4.7.4	Liver enzymes.....	147
4.7.5	Other serum measurements.....	149
4.7.6	BMI and W:H ratio.....	151
5	DISCUSSION.....	153
6	CONCLUSIONS	186
7	REFERENCES	190
8	APPENDICES	i
	Appendix I	i
	Appendix II	v
	Appendix III.....	vi
	Appendix IV.....	vii
	Appendix V	viii
	Appendix VI.....	ix
	Appendix VII.....	x

List of Tables

Table.2-1 Risk of T2DM, CVD and hypertension according to the BMI and waist circumference.....	9
Table.2-2 Health risk based only on waist: hip ratio (WHR)	10
Table 3-1 Cut-off values of serum measurements	100
Table 3-2 Cut-off values of anthropometric measurements	101
Table 4-1 Proximate compositions of porridges (g/ 100 g \pm SD on dry weight basis*)	107
Table 4-2 Antioxidant potential (TEAC (μ g)/100g, Vit C Eq(μ g)/100g) and total phenols in porridges (FW = fresh weight)	111
Table 4-3 Fasting blood glucose values \pm SD of volunteers in GI study.....	116
Table 4-4 GI values, category and glycaemic load.....	118
Table 4-5 Sufficiency of the porridge portion used for GI determination (with 25 g digestible carbohydrate) on volunteer aspect.....	119
Table 4-6 Mean basal blood glucose, glucose peaks, peak blood glucose reduction compared to glucose and time taken to reach to basal level	123
Table 4-7 Mean Feed intake, water intake and weight changes with \pm SD of the groups	125
Table 4-8 Changes in blood glucose levels \pm SD within 3 months	128
Table 4-9 Weight changes, serum cholesterol measurements and CRP \pm SD at the end of 3rd month	129
Table 4-10 Mean serum antioxidant capacity \pm SD of the groups.....	130
Table 4-11 AST, ALT, gamma GT and creatinine levels \pm SD in rats.....	131

Table 4-12 Body weight: liver weight ratio and Liver weight: pancreas weight ratio \pm SD of the groups	132
Table 4-13 Fasting blood glucose values of diabetic and normal individuals in GI study	138
Table 4-14 GI values \pm SEM of porridges for normal and diabetic individuals.....	139
Table 4-15 Particle size distribution of porridges	141
Table 4-16 Proximate composition of porridge 2	142
Table 4-17 Glycaemic measurements \pm SEM of groups 1 and 2.....	143
Table 4-18 Total cholesterol, triglycerides, LDL and HDL concentrations (mg/dL) of groups 1 and 2	145
Table 4-19 Total cholesterol: LDL, total cholesterol: HDL and LDL: HDL ratios.....	146
Table 4-20 Atherogenic index of test and control from 0 to 3 month	147
Table 4-21 AST, ALT and ALP concentrations \pm SEM (0-3 months) of groups 1 and 2	148
Table 4-22 Creatinine, urea, CRP, cortisol and ferritin measurements \pm SEM of groups 1 and 2	150
Table 4-23 BMI and W:H ratio.....	152

List of Figures

Figure 2-1 Development of AGEs	15
Figure 2-2 Potential mechanisms whereby high-glycaemic-load diets	25
Figure 2-3 Actions of GLP-1 on various organs.....	26
Figure 2-4 Blood glucose lowering mechanisms of <i>Scoparia dulcis</i>	62
Figure 2-5 Effect of polyphenols on glucose absorption and utilization	73
Figure 2-6 Effect of polyphenols on storage of glucose in adipose tissues	74
Figure 4-1 Standard curve for glucose (each point represents an average of 6 values)	109
Figure 4-2 Standard curve for Trolox (each point represents an average of 6 values) .	112
Figure 4-3 Standard curve for Vitamin C (each point represents an average of 6 values)	113
Figure 4-4 Standard curve for Gallic acid (each point represents an average of 6 values)	114
Figure 4-5 Correlation between total phenolics and antioxidant potential	115
Figure 4-6 (A) Porridges with GI between 25 – 35	120
Figure 4-7 Mean weight changes of each group throughout three months (12 weeks)	126
Figure 4-8 Glycaemic responses of normal and diabetic individuals for porridge 1(each value represents an average of 10).....	139
Figure 4-9 Glycaemic responses of normal and diabetic individuals for porridge 2(each value represents an average of 10).....	140
Figure 4-10 (A) particles remained on 0.5 mm mesh; (B) particles filtered through 0.5 mm mesh; (C) particles filtered through 0.1 mm mesh; (D) filtered through 0.05 mm mesh.....	141

List of Plates

Plate 2.1 Leaves of <i>Murraya koenigii</i>	34
Plate 2.2 Leaves of <i>A. racemosus</i>	38
Plate 2.3 Leaves of <i>H. indicus</i>	41
Plate 2.4 Leaves of <i>Clitoria ternatea</i>	45
Plate 2.5 Leaves of <i>Aegle marmelos</i>	48
Plate 2.6 Leaves and flowers of <i>Cassia auriculata</i>	51
Plate 2.7 Leaves of <i>Cardiospermum halicacabum</i>	55
Plate 2.8 Leaves of <i>Aerva lanata</i>	57
Plate 2.9 Leaves of <i>Scoparia dulcis</i>	60
Plate 2.10 Leaves and flowers of <i>Atalantia zeylanica</i>	66
Plate 2.11 Leaves and flowers of <i>Osbeckia octandra</i>	67
Plate 2.12 Leaves and flower of <i>Cephalandra indica</i>	69
Plate 3.1 Cages of rats at the Animal House.....	92
Plate 3.2 (A) Contents in porridge 2; (B) and (C) Porridge packets	95
Plate 3.3 0.5 mm, 0.1 mm and 0.05 mm meshes	97

List of Equations

Equation 2-1 Calculation of GL.....	28
Equation 3-1 Calculation of moisture content	79
Equation 3-2 Estimation of Ash Content	80
Equation 3-3 Estimation of starch content.....	81
Equation 3-4 Estimation of Fat content	82
Equation 3-5 Estimation of Insoluble Fibre Content	83
Equation 3-6 Estimation of soluble dietary fibre content	84
Equation 3-7 Estimation of crude protein content	85
Equation 3-8 Estimation Weight of the test food.....	88
Equation 3-9 Estimation of GI	89
Equation 3-10 Calculation of Glycaemic Load.....	89

Abbreviations

ABCC8	ATP-binding cassette transporter sub-family C member 8
ABTS	2,2'-azino bis 3-ethylbenzthiazoline-6-sulfonic acid
ADA	American Diabetes Association
ADIC	Alcohol and Drug Information Center of Sri Lanka
ADP	Adenosine Diphosphate
AGE	advanced glycation end product
AI	Atherogenic Index
Alk	Alkaloids
ALP	Alkaline Phosphatase
ALT	Alanine Transaminase
AMPK	activated protein kinase
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
AR	<i>Asparagus racemosus</i> porridge
AST	Aspartate Transaminase
ATP	Adenosinetriphosphate
BHT	Butylated Hydroxy Toluene
BMI	Body Mass Index
BW	Body Weight
CALPN10	or Calpain10
CAPN10	
CCH	cell culture extract of <i>H. indicus</i>
CCK	Cholecystokinin
CKD	Chronic Kidney Disease
CE	Catechin equivalence
CHD	coronary heart disease
CM	Coconut milk porridge
CRP	C- Reactive Protein
CSTH	Colombo South Teaching Hospital
CV	coefficient of variation
CVD	Cardio Vascular Diseases

DLA	Daltons lymphoma ascites
DM	Diabetes mellitus or Diabetic control group of rats
DPPH	di(phenyl)-(2,4,6-trinitrophenyl)iminoazanium
DW	Dry Weight
EC50	half maximal effective concentration
eGFR	Estimated Glomerular Filtration Rate
ELISA	Enzyme Linked Immuno Sorbant Assay
FAO	Food and Agriculture Organization
FBG	Fasting Blood Glucose
Flav	Flavanoids
FW	Fresh Weight
GAE	Gallic Acid Equivalent
GFR	Glomerular Filtration Rate
GGT	Gamma Glutamyl Transferase
GI	Glycaemic Index
GL	Glycaemic Load
GLP	Green Leafy Porridges
GLP-1	Glucagon Like Peptide-1
GLUT4	Glucose Transporter 4
GPx	glutathione peroxidase
GSH	reduced glutathione
GST	glutathione-S-transferase
HbA1c	Glycated Haemoglobin
HC	Hip circumference
HDL	High Density Lipoprotein
HepG2	Hepatic G2 cells
HI	<i>Hemidesmus indicus</i> porridge
HMG Co-A	3-hydroxy-3-methylglutaryl Coenzyme A
IAUC	Incremental Area Under the Curve
IC50	half maximal inhibitory concentration
IDF	International Diabetes Federation
IDF	Insoluble Dietary Fibre

IFN	Interferon
IL	Interleukine
KCNJ11	potassium inwardly-rectifying channel, subfamily J, member 11
KDOQI	<i>Kidney Disease Outcomes Quality Initiative</i>
LBW	Low Birth Weight
LCAT	lecithin cholesterol acyl transferase
LD 50	50% concentration of the lethal dose
LDL	Low Density Lipoprotein
MBG	Mean blood glucose
MCF-7	Michigan Cancer Foundation-7
MIDD	Maternally inherited diabetes and deafness
MN	Moderately negative
MP	moderate positive
mRNA	Messenger Ribo Nucleic Acid
NADPH	Nicotinamide Adinine hydrogen Phosphate
NATA	National Authority on Tobacco and Alcohol
NHLBI	National Heart, Lung, and Blood Institute
NHSL	National Hospital of Sri Lanka
NO	Nitric Oxide
NR	Blood glucose level not reached to basal level after 120 minutes
Ob	Obese
OGTT	oral glucose tolerance test
OW	Overweight
Phen	Phenolic compounds
PPAR	peroxisome proliferator-activated receptors
PUFA	Polyunsaturated fatty acids
PYY	Peptide YY
RINm5F	rat insulinoma m5F
ROS	reactive oxygen species
SD	Standard Deviation
SDC	<i>Scoparia dulcis</i> porridge
SDF	Soluble Dietary Fibre

SEM	Standard Error of Mean
SLCTR	Sri Lanka Clinical Trials Registry
SOD	Super Oxide Dismutase
SP	strong positive
SR-B1	scavenger receptor type B1
STZ	Streptozotocin
T2DM	Type 2 Diabetes Mellitus
Tann	Tannins
TBARS	thiobarbituric acid reactive substances
TC	Total Cholesterol
TEAC	Trolox equivalent antioxidant capacity
Terp	Terpinoids
TG	Triglycerides
TNF	Tumour Necrosis Factor
USA	United States of America
VLDL	Very Low Density Lipoprotein
W:H or WHR	Waist to Hip ratio
WC	Waist circumference
WHO	World Health Organization
WN	weak negative
WP	weak positive

Nutritional evaluation and influence on carbohydrate and lipid metabolism of porridge made with green leafy vegetables

Senadheera S.P.A.S

ABSTRACT

Among Sri Lankans, 20% are diagnosed as disglycaemic and 27.1% suffer from metabolic syndrome (MS). Along with western medical treatments, 90% of Sri Lankan patients consume herbal remedies owing to their nutritive value, natural origin, availability and less side effects. Rice-based herbal porridge (*kola kenda*) is a popular method of consumption of herbal extracts due to high palatability and high satiety compared to water extracts. Most leaf extracts used for porridges have scientifically proven anti-diabetic effects. However, the potency when these leaves are incorporated in to porridges is not known. The endeavor of the present study was to evaluate the nutrient composition, glycaemic indices (GI), antioxidant potential and toxic effects and hypoglycaemic effects of herbal porridges, with the intention of developing a marketable herbal porridge suitable for diabetics.

Rice: leaves: scraped coconut were used in 20-30g: 5-20g: 10-15g [w/w/w] ratio for the porridge preparation. The leaf varieties used were *Murraya koenigii spreng* (Karapincha), *Asparagus racemosus* (Haathawariya), *Hemidesmus indicus* (Iramusu), *Aegle marmelos* (Beli), *Cassia auriculata* Linn (Ranawara), *Cardiospermum halicacabum* (Wel Penela), *Aerva lanata* (Polpala), *Clitoria ternatea* Linn. (Ela katarolu), *Scoparia dulcis* (Walkoththamalli), *Atlantia zeylanica* Linn. (Yaki narang), *Osbeckia octandra* (Heen bovitiya) and *Coccinia grandis* (previous name: *Cephalandra indica*) (Kowakka). Porridge made with rice only and coconut milk and rice only were

used to evaluate the effects of other ingredients of the porridge other than the leaf extract. Digestible carbohydrate, fat, insoluble and soluble dietary fibre, crude protein, ash and moisture contents of the porridges were estimated by accepted standard methods. GI, antioxidant effects (ABTS free radical scavenging assay) and total phenol content were estimated for all 14 porridges. Using the porridges with lowest GI [*A. racemosus* (AR), *H. indicus* (HI) and *S. dulcis* (SDC)] an animal bioassay was conducted with Streptozotocine-induced diabetic male albino Wistar rats for 3 months to evaluate the hypoglycaemic and toxic effects of these porridges. *S. dulcis* porridge which elicited a significant hypoglycaemic effect in the above study was prepared in large scale (GI for normal 58 ± 11 , diabetics 61 ± 11). A crossover clinical trial with type 2 diabetic patients ($n=35$; group 1=16; group 2=19) was conducted to observe the hypoglycaemic effects and capability of this porridge on lowering risk factors of diabetes. Dietary habits of Sri Lankan type 2 diabetics were assessed by an interviewer administered questionnaire.

Moisture was the major component in all porridges (89% - 93%). Digestible carbohydrate contents in leafy porridges were not significantly different ($p \geq 0.05$). Total dietary fibre contents, crude protein content and fat content varied between 5% - 10%, 4.1% - 9.5% and 2.5 % - 27%, respectively on dry weight basis. The lowest fat amount was in rice porridge due to absence of coconut milk. All porridges except *C. auriculata* were in the low GI category (31-50). The lowest GIs were found in coconut milk (31 ± 5), *Aerva lanata* (32 ± 5), *Hemidesmus indicus* (40 ± 8), *Scoparia dulcis* (39 ± 8) and *Asparagus racemosus* (37 ± 4). All leafy porridges elicited antioxidant effects (5 - 73 TEAC (μg)/ 100g) and high phenol contents (1.9 - 34.2 GAE g/ 100g) with lowest

values for rice and coconut milk porridges, indicating that antioxidant effect was mainly due to the leaf extract.

In the animal study, although not significant ($p \geq 0.05$), SDC group had lower mean blood glucose levels (194 ± 73 , 283 ± 98 mg/dL in second and third months, respectively) compared to diabetic control group (298 ± 94 , 385 ± 55 mg/dL). A significantly higher ($p \leq 0.05$) mean weight gain was observed in SDC porridge fed group (39 g), when compared to the other diabetic groups (DM 3, HI -8, CM 7 g). HbA1c level in SDC group ($5.8 \pm 2.1\%$) was significantly lower ($p = 0.018$) than the DM group ($8.0 \pm 1.5\%$) while other porridge groups elicited no significant changes when compared with DM group. Although not significant ($p \geq 0.05$) when compared to other diabetic groups, the lowest total cholesterol (119 ± 20.6 mg/dL) and highest HDL (33 ± 6.3 mg/dL) against NC was also observed in SDC group. The CRP (< 6 mg/dL), creatinine (range - 0.41 ± 0.1 - 0.51 ± 0.1 mmol/L), AST (range - 69.7 ± 10.2 - 88.9 ± 15.1 IU/L), ALT (range - 23.7 ± 2.1 - 27.6 ± 3.6 IU/L) and gamma glutamyl transferase (GGT) (range - 3.0 ± 1.7 - 4.6 ± 0.9 IU/L) concentrations of the diabetic groups were comparable with the normal control group indicating no adverse effects on liver and kidney due to porridge consumption.

Mean age of patients who participated in the questionnaire study was 55 ± 9 years. In the study population 44 were males and 56 were females. Only 72% of the patients attended diabetes clinics regularly. Out of all, 44% of patients were either overweight or obese. Majority (83%) consumed red rice/ nadu/ parboiled rice which are suitable for diabetics. Only 67% consumed fruits at least once a day. High GI meals for 5 or more than five days/ week as the breakfast was consumed by 17.8% while for 3 or more than 3 days/

week as dinner was 13.3%. From the study population 87%, 93% and 92% did not consume pork, beef and mutton respectively. Thirty three percent consume high fat diets (fried foods) twice or more than twice/ week. Full cream milk was consumed by 71% and 22% consumed non fat milk. Normal sweetened foods were consumed by 99% and non caloric sweetener usage was nonexistent. From the population, 40%, 50%, 69% and 11% had been detected to have hypertension, high cholesterol, visual defects and heart diseases respectively. Only 14% exercised daily while 69% never exercised.

During the crossover clinical trial with commercially prepared SDC porridge being ingested three times per week, HbA1c of group 1 decreased from 7.9 ± 0.46 to 6.5 ± 0.30 ($p=0.003$) while HbA1c of group 2 decreased from 7.0 ± 0.31 to 6.7 ± 0.24 while they were in the test group. Therefore, both test groups (1 and 2) elicited a decrease in HbA1c compared to control groups. Likewise though not significant, both test groups elicited a decrease in FBG following the intervention (group 1 - from 174 ± 14 to 160 ± 10 mg/dL; group 2 - from 183 ± 13 to 160 ± 7 mg/dL). No significant differences ($p>0.05$) in insulin levels between or within groups were observed during study periods. When considering the lipidaemic measurements no significant differences between or within the groups 1 and 2 were observed for total cholesterol, triglycerides, LDL and HDL measurements and atherogenic index. All liver enzymes, creatinine, urea, cortisol, ferritin and CRP measurements were not significantly different between or within groups during both study periods (1 and 2) indicating absence of liver or kidney toxicity due to ingestion of SDC porridge.

Study revealed, all leafy porridges elicit low GI, have considerable antioxidant potential and therefore are suitable as a meal for diabetics. The *S. dulcis* porridge with positive anti-diabetic properties was commercially produced by changing the particle size of rice grains. The porridge contributed to decrease HbA1c significantly with a non significant decline in fasting blood glucose with no toxicity in diabetics, due to long term consumption.