Asian Journal of Clinical Nutrition

ISSN 1992-1470

science alert

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Asian Journal of Clinical Nutrition 4 (2): 67-76, 2012
ISSN 1992-1470 / DOI: 10.3923/ajcn.2012.67.76

Roles of Whole Grains-based Products in Maintaining Treatment Targets among Type 2 Diabetes Mellitus Patients

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ABSTRACT

Whole grain-based products are an excellent source of fiber and antioxidant. This study was attempted to determine relationship intake of whole grain-based products in maintaining treatment target among type 2 diabetes (DM) patients. A cross-sectional study, involving type 2 DM patients (30-75 years old) who were attending follow-up in the Diabetic Clinic at Ipoh, Perak selected based on convenience sampling. Data was collected using questionnaires by face-to-face interview, anthropometric measurements and patient's medical record. From that, 46 (41.8%) were male and 64 (51.8%) were female with mean age of 58.5 (SD = 9.5). Finding showed that three major sources of whole grain products were whole meal bread (21.1%), brown rice (8.9%) and oats (8.4%). This study significantly ($p<0.05$) indicated higher mean intake of oat (3.52±3.85 servings week^{-1}), brown rice (4.57±4.95 servings week^{-1}), vegetables (12.52±2.37 servings week^{-1}) and fruits (10.13±3.05 servings week^{-1}) were found among controlled FBG (<7 mmol L^{-1}) subjects. High intake of brown rice (4.14±5.98 servings week^{-1}) ($p<0.05$) also were found among LDL-C controlled subjects (<2.6 mmol L^{-1}). Mean intakes of oats (3.21±3.77 servings week^{-1}) and fruits (7.49±4.11 servings week^{-1}) were significantly higher among Total Cholesterol (TC) controlled (<5.2 mmol L^{-1}) subjects. Meanwhile intake of cornflakes significantly higher (1.01±2.25 servings week^{-1}) ($p<0.05$) among normal BMI patients compared to overweight/obese (0.08±0.28 servings week^{-1}). Additionally, total fruits and vegetables revealed medium relationship with FBG level ($r = -0.415$, $n = 110$, $p = 0.000$). In conclusion, intake of whole grain-based products showed best diet practices in maintaining FBG, LDL-C, TC level and BMI among type 2 DM patients. Thus, it is essential for diabetic patients to consume more whole grain products in daily meal intake.

Key words: Blood lipid control, glycemic control, type 2 diabetes mellitus, treatment targets, whole grains

INTRODUCTION

Type 2 diabetes mellitus also known as non-insulin-dependent diabetes mellitus or adult onset diabetes which can be defined as metabolic disorder and characterized by hyperglycemia and insulin resistance in the human body (Namazi *et al*., 2011). Nowadays, diabetes is a global problem with overwhelming human, social and economic impact. Diabetes is known as one the most severe

health problem in worldwide attacking men, women, children and elderly (Soni *et al.*, 2007). The incidence of diabetes for all age in worldwide was estimated to be 2.8% (171 million peoples) in 2000 and it expected become 4.4% in 2030 (366 million peoples) (Shaw *et al.*, 2010). The rate and progression of non-communicable diseases epidemic varies across the country (Mahajan *et al.*, 2009). In recent years, prevalence of diabetes mellitus in Malaysia for both type 1 and especially type 2 has increased to epidemic proportions (Mustaffa, 2004). According to National Health and Morbidity Survey (NHMS) III, the prevalence of diabetes among adult above 30 years has increased by 80% over a decade (8.3% in NHMS II vs. 14.9% NHMS III) representing 8% per year. This incidence and prevalence of diabetes have risen and become worst if there is no appropriate intervention.

Whole grain provides many health benefits to human. Over the past century there has been a dramatic increase in literature beneficial effects of whole grains. Most studies revealed that whole grain play an important role in reducing the risk of non communicable diseases such as coronary heart disease, diabetes, cancer and also functional in body weight management (Jonnalagadda *et al.*, 2011). Previous studies suggested whole grain intake was inversely associated with obesity, insulin resistance, inflammation and elevated fasting glucose (Lutsey *et al.*, 2007).

However, a major problem is whole grain intake is far low throughout the world. Previous study reported that average whole grain intake was one serving/day and this study also revealed that only 8% of them were met the recommendation to consume at least three servings of whole grains per day (Cleveland *et al.*, 2000). Moreover, little is known about the role of fiber on glycaemic control among Malaysian diabetic patients. Previous study done by Ju *et al.* (2010) indicated that up to 70.7% of diabetic patients at an outpatient clinic had poor glycaemic control and associated with low physical activity among the older age group. Instead of medication, diet practices play a major role and need to be emphasized as diet is an important environmental factor in the development of type 2 diabetes mellitus (Jinlin *et al.*, 2007). In addition, glycemic index content in the food become as tool in planning diet for diabetic patients and prevention of other chronic diseases (Farhat *et al.*, 2010).

Future research need to be conducted to examine the role of whole grain in disease prevention and management for better understanding of their mechanism and action (Jonnalagadda *et al.*, 2011). Therefore, this study attempt to determine relationship between intake of whole grain products, fruits and vegetables on glycemic control, blood lipid control and weight status among type 2 diabetes mellitus patients.

MATERIALS AND METHODS

Study design: This cross-sectional, approved by Ministry of Health Ethics Committee (KKM/NIHSEC/08/0804/P11-260) was conducted from January 2011 to November 2011 to determine the major sources of whole grain-based products intake in controlling treatment target among type 2 diabetes mellitus patients at Diabetic Clinic, Greentown Clinic, Perak, Malaysia.

Subjects: Total 110 diabetic patients aged 30 to 75 years old were participated in this study. Inclusion criteria were patients with type 2 diabetes mellitus (on medication only) aged 30 to 75 years old. While for exclusion criteria were patients aged <30 or >70 years old and type 2 DM (on insulin). Besides that, questionnaires on sociodemographic data including age, history of DM, working status, economic status was obtained from patients(Golmohammadi and Abdulrahman, 2006).

Anthropometric measurements: Anthropometric measurements including weight, height and waist circumference were carried out on subjects. The weight and height of subjects were measured by SECA digital weight scale and portable stadiometer (SECA, Germany) to nearest 0.1 kg and 0.1 cm, respectively. From the readings, Body Mass Index (BMI) was calculated as weight over height square (kg m^{-2}). An inelastic measuring tape (SECA, Germany) was used to measure waist circumferences to the nearest decimal.

Dietary assessment: Dietary intake was assessed through a face-to-face interview using semiquantitative Food Frequency Questionnaire (FFQ) and validated Diet History Questionnaire (DHQ) (Shahar *et al.*, 2000). Estimated whole grain based products intake was obtained using a set of FFQ consists of foods that are high in whole grain (USDA, 2009) products commonly consumed by the Malaysian population including fruits and vegetables. The pictures of foods were shown to subjects during interview session in order to help in portion size estimation. Subjects were asked to describe the frequency of consumed particular food per day, per week, per month or per year over the past year. All the foods consumed were quantified according to the Atlas of Food Exchange and Portion Sizes (Suzana *et al.*, 2009).

Biochemical profile: The recent biochemical profile of serum blood glucose and serum blood lipids were obtained from patient's medical record. For blood glucose profile, readings of Fasting Blood Glucose (FBG) were recorded. Whilst, for blood lipids profile, readings of Low-Density Lipoprotein Cholesterol (LDL-C), Total Cholesterol (TC), Triglycerides, (TG) and High Density Lipoprotein Cholesterol (HDL-C) were recorded (Afkhami-Ardekani *et al.*, 2008). All the readings were categorized into well controlled within the normal range recommended by American Diabetes Association and ATP III Guidelines (Lorenzo *et al.*, 2007). Any values more than that categorized as not well control.

Statistical analysis: Statistical tests were conducted using Statistical Packages for Social Sciences (SPSS) version 17.0. Descriptive data were presented as mean and percentage. In order to determine the difference between whole grain products intake with blood glucose and lipid profile, BMI, and waist circumferences, Independent sample t-test were used. The differences were considered significant if $p<0.05$. Pearson correlation was used to look the relationship between total intake of whole grain, fruits and vegetables with treatment targets. The differences were considered significant if $p<0.01$.

RESULTS

Table 1 shows characteristics of 110 diabetic patients by sex, age, ethnicity and other health related characteristics. 46 (42%) were male and 64 (58%) were female. The mean age of subjects was within 58.5±9.5 years old. Classification by ethnicity shows that majority of subjects are Malays (59%) followed by Indians (28%) and Chinese (13%). Most of the subjects come from middle socioeconomic class. Apart from that, 54% of the subjects had family history of type 2 DM whereas 46% subjects not had family history of diabetes. The mean waist circumference and Body Mass Index (BMI) of subjects were 91.2±12.12 cm and 27.5±4.6 kg m^{-2}, respectively. Most of the subjects were classified as overweight/obese (68%) while subjects with normal BMI only 32%. The mean of serum Fasting Blood Glucose (FBG) were 8.10±2.65 mmol L^{-1} with 40% subjects have well controlled FBG (<7 mmol L^{-1}) while 60% were have FBG not controlled (>7 mmol L^{-1}). Mean LDL-C among subjects were 3.07±0.81 mmol L^{-1}. Thirty seven percent subject were controlled LDL

Table 1: Socio-demographic and health-related characteristics of subjects

Characteristic	n	%
Sex		
Male	46	42
Female	64	58
Ethnicity		
Malays	65	59
Chinese	14	13
Indian	31	28
Educatiou level		
Lower	45	41
Higher	65	59
Household income (RM)		
<1000	27	25
1000-2000	65	59
>2001	18	16
Family history of type 2 DM		
Yes	59	54
No	51	46
Age (years)		
58.5±9.5		
Waist circumfereuce (cm)		
91.2±12.1		
Body mass index (BMI) (kg m^{-2})		
27.5±4.6		
BMI status		
Normal	35	32
Overweight obesity	75	68
Fasting blood glucose (FBG)		
Controlled (<7 mmol L^{-1})	44	40
Not controlled (>7 mmol L^{-1})	66	60
Low deusity lipoprotein (LDL-C)		
Controlled (<2.6 mmol L^{-1})	41	37
Not controlled (>2.6 mmol L^{-1})	69	63
Total cholesterol (TC)		
Controlled (<5.2 mmol L^{-1})	70	64
Not controlled (>5.2 mmol L^{-1})	40	36

n: No. of subjects, % values, mean ±SD

(<2.6 mmol L^{-1}) and 67% were not controlled LDL (>2.6 mmol L^{-1}). The mean total cholesterol of subjects was within 4.90±0.82 mmol L^{-1}. From that, 64% of the subjects were have (<5.2 mmol L^{-1}) whereas other 36% subjects were have (>5.2 mmol L^{-1}) of serum total cholesterol.

Mean intake as expressed by servings per week of whole grain products, fruits and vegetables varies depends on type of food were oat (2.63±3.38 servings week^{-1}), barley (1.52±2.42 servings week^{-1}), brown rice (2.80±5.00 servings week^{-1}), whole meal bread (6.61±7.08 servings week^{-1}), cornflakes (0.37±1.35 servings week^{-1}), fruits (6.85±4.24 servings week^{-1}) and vegetables (10.59±3.77 servings week^{-1}). From that, our study found that major sources taken by subjects were vegetables (33.7%), fruits (21.8%), whole meal bread (21.1%), brown rice (8.9%), oats (8.4%), barley (4.8%) and cornflakes (1.9%). Thus, it shows that whole meal bread, followed by brown rice and oat were three major sources of whole grain products frequently consumed. Additionally, total intake of whole grain products and total fruits and vegetables were (13.94±11.39 servings week^{-1})

Table 2: Mean total whole grain products and total fruits and vegetables intake between male and female subjects

Total (Servings week^{-1})	Male (n=46)	Female (n= 64)	p- value
Whole grain products	14.30±10.14	13.67±12.28	0.775
Fruits and vegetables	17.36±6.85	17.50±6.95	0.916

n: No. of subjects, p<0.05, Independent sample t-test

Table 3: Mean intake of whole grain products, fruits and vegetables effect on glycemic control among subjects

Type of foods	n	Serving week (controlled FBG n = 44)	Serving/week (not controlled FBG n = 66)	p-value
Oat	72	3.52±3.85	2.03±2.91	0.023*
Barley	75	1.72±1.83	1.38±2.75	0.469
Brown rice	38	4.57±4.95	1.63±4.71	0.003*
Whole meal bread	90	7.09±6.18	6.29±7.65	0.563
Cornflakes	19	0.27±1.10	0.44±1.50	0.533
Fruits	105	10.13±3.05	4.67±3.44	0.000*
Vegetables	110	12.52±2.37	9.30±4.00	0.000*

n: No. of subjects, *p<0.05, Independent sample t-test

Table 4: Mean intake of whole grain products, fruits and vegetables effects on blood lipid profile among subjects

Type of foods	n	Servings/week (controlled LDL n = 41)	Servings/week (not controlled LDL n = 69)	p-value	Servings/week (controlled TC n = 70)	Servings/week (not controlled TC n = 40)	p-value
Oat	72	3.04±3.96	2.38±2.99	0.326	3.21±3.77	1.61±2.27	0.006*
Barley	75	1.85±2.82	1.32±2.14	0.274	1.60±2.46	1.38±2.37	0.654
Brown rice	38	4.14±5.98	2.01±4.16	0.049*	3.24±5.25	2.04±4.46	0.229
Whole meal bread	90	6.64±6.66	6.60±7.37	0.976	6.32±6.38	7.12±8.22	0.569
Cornflakes	19	0.25±1.13	0.44±1.47	0.481	0.32±1.22	0.46±1.57	0.599
Fruits	105	7.44±4.03	6.51±4.36	0.267	7.49±4.11	5.75±4.30	0.038
Vegetables	110	10.71±3.33	10.51±4.05	0.788	10.66±3.51	10.45±4.27	0.788

n = number of subjects, *p<0.05, Independent sample t-test

and (17.44±6.88 servings week^{-1}), respectively. However, there was not statistically difference between intake of total whole grain products and total of fruits and vegetables for both male and female (p>0.05) in Table 2.

This study showed, mean intake of whole grain products, fruits and vegetables were inversely significant towards glycemic profile, blood lipid profile and also weight status. Intake of oat (3.52±3.85 servings week^{-1}) (p = 0.023), brown rice (4.57±4.95 servings week^{-1}) (p = 0.003), fruits (10.13±3.05 servings week^{-1}) (p = 0.000) and vegetables (12.52±2.37 servings week^{-1}) (p = 0.000) were significantly higher (p<0.05) among subjects with controlled FBG (<7 mmol L^{-1}) than not well controlled FBG as listed in Table 3.

Besides that, this study showed mean intake of brown rice (4.14±5.98 servings week^{-1}) [p = 0.049, 95% CI 0.013, 4.247] significantly higher among subjects with controlled LDL (<2.6 mmol L^{-1}). Additionally, we found that mean intake of oats (3.21±3.77 servings week^{-1}) and fruits (7.49±4.11 servings week^{-1}) were significantly higher among subjects with controlled total cholesterol (<5.2 mmol L^{-1}) (p<0.05) (Table 4). Meanwhile, intake of cornflakes was significantly higher among normal BMI patients (1.01±2.25 servings week^{-1}) as compared to overweight or obese patients (0.08±0.28 servings week^{-1}) [p = 0.020, 95% CI 0.156, 1.704] as listed in Table 5.

Table 5: Mean intake of whole grain products, fruits and vegetables between body mass index (BMI) status

Type of foods	n	Servings/week (normal n = 35)	Servings/week (overweight/obesity n = 65)	p-value
Oat	72	3.15±3.83	2.39±3.15	0.272
Barley	75	2.10±3.50	2.83±3.93	0.175
Brown rice	38	2.83±3.93	2.79±5.45	0.966
Whole meal bread	90	6.77±6.46	6.54±7.39	0.878
Cornflakes	19	1.01±2.25	0.08±0.28	0.020*
Fruits	105	6.43±4.81	7.05±3.97	0.474
Vegetables	110	9.81±4.48	10.95±3.39	0.190

n = No. of subjects, *p<0.05, Independent sample t-test

Table 6: Relationships between intake of whole grain products, fruits and vegetables with treatment targets among subjects

		Total whole grain products (servings/week)		Total fruits and vegetables (servings/week)	
Relation	Parameters	R value	p-value	R value	p-value
Anthropometry	Body mass index (BMI)	-0.145	0.131	0.024	0.801
	Waist circumference (WC)	0.005	0.955	0.100	0.297
Biochemical	Fasting blood glucose (FBG)	-0.031	0.746	-0.415	0.000**
	Low-density lipid (LDL)	-0.080	0.409	0.091	0.347
	Total cholesterol (TC)	-0.090	0.349	-0.062	0.519
	Triglycerides (TG)	0.020	0.833	-0.099	0.302
	High density lipid (HDL)	0.053	0.581	0.019	0.846

**Correlation is significant at level p<0.01

Table 6 showed the relationships between total whole grain intake, fruits and vegetables with treatment targets among diabetic patients. Pearson correlation test was conducted to investigate the relationship between total intake of whole grain, fruits and vegetables and effect on glycemic profile, lipid profile and also weight status. This study indicated that only total fruits and vegetables shows medium relationship with FBG level (r = -0.415, n = 110, p = 0.000).

DISCUSSION

This study showed that mean intake of total whole grain products, fruits and vegetables low than current Recommendation Dietary Intake (RDI) which at least three servings per day. Mean intake of total whole grain and total fruits and vegetables among subjects were (13.94±11.39 servings week^{-1}) and (17.44±6.88 servings week^{-1}), respectively. Overall mean intake were about 1-2 serving/day. An early study reported that only 15% or one serving per day of whole grain intake among adults (Cleveland *et al*., 2000). Similar observation from NHANES noted that the average whole grain intake was 1 serving/day with 95% of American people not meet the recommendations (Good *et al*., 2008; Jonnalagadda *et al*., 2011). However, a cohort study by (Lutsey *et al*., 2007) noted that mean whole grain consumption was 0.54 servings/d which less than entire American population.

This study also found that whole meal bread, brown rice and oats were three major sources frequently consumed by subjects. Furthermore, previous study by Cleveland *et al*. (2000) stated that yeast bread and breakfast cereals provided almost a third of whole grain servings.

Additionally, McKeown *et al.* (2009) study among older adult reported that major sources of whole grain as expressed servings week^{-1} were dark bread (40%), cold breakfast cereal (33%), hot breakfast cereal (19%) and brown rice (7.5%). The intake of whole grain intake are depends on food preference and availability of the foods. Besides that, differences intake also resulted from health conscious and knowledge on benefits of whole grain, fruits and vegetables as most subjects comes from quite higher background of education. Our finding showed that higher mean total whole grain intake among male subjects while higher means total fruits and vegetables intake among female subjects. Similar observation in other study noted higher cereal fiber intake were more often male while higher fruits and vegetables fiber intake were more often female (Du *et al.*, 2010). In addition, a study by Makamto *et al.* (2005) supported that higher intake of nutrient density dietary fiber among men and women diabetic subjects compared non diabetic subjects.

This study also consistent with previous study which consumption of whole grain-based products inversely significant with fasting blood glucose (Pereira *et al.*, 2002; De Munter *et al.*, 2007; Lutsey *et al.*, 2007; Nettleton *et al.*, 2010; Jonnalagadda *et al.*, 2011), low density lipoprotein (Jensen *et al.*, 2006; Newby *et al.*, 2007), total cholesterol (Jensen *et al.*, 2006; Newby *et al.*, 2007) and BMI status (Newby *et al.*, 2007; Steffen *et al.*, 2003). It showed that intake of oats, brown rice, fruits and vegetables significantly higher among subjects with controlled FBG level. This supported by previous study noted for each one daily serving greater intake of whole grain foods, fasting glucose concentration were lower 0.021 units (Nettleton *et al.*, 2010). Besides that, high brown rice intake (≥2 servings week^{-1}) lowers 11% diabetes risk (Sun *et al.*, 2010). According to Malaysian Dietary Guidelines (NCCFN, 2010) one of the recommendations was to choose at least half grain products from whole grains. This supported by Sun *et al.* (2010) reported replacing 50 g/day (one-third servings/day) with brown rice lower 16% while replacement with whole grains lower 36% risk of type diabetes. This is because whole contains high in fiber, micronutrients and bioactive compounds. A study by Ikem *et al.* (2007) revealed that consumption of high fiber diet provide oral hypoglycaemic agent it functional improved glycemic and lipid profile. Therefore, whole grains have potential in improving glucose metabolism and insulin sensitivity. Nevertheless, a cohort study by Newby *et al.* (2007) stated no significant association between whole grain intake with blood pressure, insulin and fasting glucose.

From this study, it showed significantly higher mean intake of brown rice among subjects with controlled LDL level while higher mean intake of oats and vegetables among subjects with controlled total cholesterol level. This consistent with other study reported whole grain intake was inversely associated with total cholesterol and LDL-C (Newby *et al.*, 2007). Another study also supported total cholesterol and LDL-C decreased 0.1±0.08 and 0.3±0.1 mmol L^{-1}, respectively among subjects consuming oat β-glucan (Queenan *et al.*, 2007). Previous study by Rajasekaran *et al.* (2009) in tandem to this finding which fermented rice provide significant reduction of total cholesterol and triglycerides and this study confirm the potent antidiabetic property of fermented rice. Additionally, another case control studies by Maki *et al.* (2010) reported LDL-C and total cholesterol was reduced significantly more with whole grain ready-to-eat oat cereal vs control group. In contrast, another studies by Lutsey *et al.* (2007) noted that whole grain intake was not related to LDL-C, HDL-C and blood pressure.

Most previous studies suggested whole grain intake was inverse association with BMI and waist circumferences (Steffen *et al.*, 2003; Lutsey *et al.*, 2007; Newby *et al.*, 2007; McKeown *et al.*, 2009). However, this study only found higher mean intake of cornflakes among normal BMI. It also showed no significant difference of mean intake for waist circumferences variables.

CONCLUSION

In conclusion, consumption of whole grain products at least half from grain product whilst a total servings three or more servings of fruits and vegetables were the best diet practices in controlling glycemic profile, lipid profile and weight status among diabetic patients.

ACKNOWLEDGMENTS

This research was supported financially by Universiti Teknologi MARA through the Excellent Fund grant No. 600-RMI/ST/DANA 5/3/Dst (170/2011). The authors' appreciately acknowledge the support and help of patients, dietitian and nurses from Greentown Clinic Ipoh for their assistant. Special thanks to my colleagues, Noor Hasyimah Mohd Amnon, Nazirah Zuman and Nur Syuhada Zofiran Mohd Jamil for data collection assistance.

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