Public Health Nutrition: 16(5), 803–814 doi:10.1017/S1368980012004764

Meeting recommended dietary intakes in meal plans with ≥4 servings of grain-based foods daily

Yasmine Probst* and Linda Tapsell
Smart Foods Centre, University of Wollongong, Wollongong, NSW 2522, Australia

Submitted 18 August 2011: Final revision received 7 February 2012: Accepted 26 August 2012: First published online 16 November 2012

Abstract

Objective: To develop meal plans using grain-based foods demonstrating how to incorporate wholegrain foods into a balanced diet for weight maintenance for different cuisines. The present study examines the ability of meal plans with ≥4 grain-based servings daily to meet nutrient recommendations using lacto-ovo vegetarian and rice-based cuisines.

Design: Eighteen plans from each cuisine for three age brackets for both genders were developed. Plans aimed for ≥4 servings of grain-based foods daily, with separate plans for all wholegrain, all refined-grain and half wholegrain–half refined-grain foods. Meal plans followed an isoenergetic approach and were designed to meet specific Australian nutrient reference values and serving sizes.

Results: All plans met the Recommended Dietary Intake or Adequate Intake for targeted nutrients except for Fe in the rice-based meal plan for females aged ≥19 years (17 mg). In the plans for 14–18 year and ≥19 year age groups, four servings of grain-based foods could be accommodated. In the plans for 9–13 years, increasing the number of grain-based food servings to four reduced micronutrients levels delivered by the total diet. Specific food choices were made to ensure nutrient targets were met across each category for wholegrain and refined-grain plans. The major difference in nutrients between wholegrain and refined-grain foods was found in the vegetarian cuisine, where the meal plans containing whole grains produced on average 30 % higher fibre (38–53 g) levels than those with refined grains (27–40 g).

Conclusions: With careful food selection, meal plans with ≥4 servings of grain-based foods daily can meet nutrient reference values for lacto-ovo vegetarian and rice-based cuisines.

Keywords
Whole grains
Dietary modelling
Cuisine

A significant body of research shows that a higher consumption of whole grains is associated with reduced risk of disease[1–3]. When considering refined grains, however, the strength of these associations is reduced and inconsistent[4,5]. For example, in the Atherosclerosis Risk in Communities Study, Steffen *et al.* found that consumption of refined-grain foods – median intake of two servings of grain-based foods daily – was associated with lower educational attainment, unhealthy behaviours and an unbalanced diet ($P < 0{\cdot}001$)[4]. At this level of consumption there was a trend for increased risk of disease compared with those who consumed 0·5 servings daily ($P < 0{\cdot}001$). On the other hand, Liu *et al.* found no evidence for the association between consumption of refined grains and risk of CVD in the Nurses' Health Study[5].

One of the issues in research on grain-based foods, however, is the classification of wholegrain and refined-grain foods. FFQ may not always differentiate wholegrain food items from refined-grain food items. For example, the term 'rice' often includes white rice, brown rice and wild rices; the latter two being whole grains.

The amount of a food also needs to be considered to determine this impact on health. Serving sizes for grain-based foods are inconsistent[6,7]. For example in Australia, reference standards for one serving of grain food is equivalent to two slices of bread[8], while it is equivalent to only one slice of bread in other published material[9]. To add to this problem, the *Australian Guide to Healthy Eating* (AGHE)[10] defines a sample serving of breads and cereals (including rice, pasta and noodles) as equivalent to 600 kJ or two slices (60 g) of bread. When different types of grain-based foods from different cultural cuisines are considered these serving sizes create further analytical challenges.

The term 'cuisine' can be described as a set of food-related practices, particularly in relation to a cultural group. This concept covers not only particular types of foods eaten and their characteristic flavours, but also the symbolic and social contexts of eating, processing techniques, as well as the nutritional value of these foods[11].

**Corresponding author:* Email yasmine@uow.edu.au

A lacto-ovo vegetarian diet, for example, means choosing from a variety of grain-based foods, legumes, vegetables, fruit, milk and other dairy foods plus eggs, while avoiding other animal foods. A well-planned vegetarian diet can be lower in saturated fat, cholesterol and animal protein while still containing greater amounts of beneficial nutrients including carbohydrate, fibre, Mg, folate and a variety of antioxidants[12], although there may be risk of some nutrient deficiencies – Fe, Zn and long-chain *n*-3 fatty acids – if the diet is not well planned[12]. Another example is the Asian cuisine, characterised by the use of rice as a staple food. This cuisine has become increasingly common in Australia, with Chinese the predominant cultural influence through migration from South-East Asia[13]. Rice is consumed in many forms, from foods based on whole grains and refined grains, to noodles, desserts, congee and sake. Rice used in Asian cuisine is typically milled white rice and the milling process removes fibre, protein, Fe, fat and B vitamins[14].

Determining the impact of specific food choices within different cuisines requires consideration of meal structure, nutrient bioavailability and combinations of food and availability, as well as the overall appropriateness of nutrient composition of the daily or weekly intake. This appropriateness may be determined through the use of nutrient reference values[15]; however, a number of different values exist and should be used carefully and for the correct purpose.

The Recommended Dietary Intake (RDI) value should be used for assessing the adequacy of diets for individuals, not for groups of people. When an RDI is unavailable, an Adequate Intake (AI) value may also be provided based on determined approximations and intakes for individuals. Values above these approximations are considered to have a low probability of an inadequate intake of the particular nutrient. Similarly for groups, the prevalence of this inadequacy may be assessed. The Acceptable Macronutrient Distribution Range (AMDR) allows for the adequacy of intake to be calculated for different age groups and genders[15].

Finally, to determine whether a dietary pattern might achieve nutrient reference values, good-quality food composition data are required. The data allow meal plans to be developed using specific food combinations and meal patterns.

The aim of the present study was to examine the ability of meal plans designed with ≥4 grain-based servings daily (refined and whole grains) to meet RDI, AI and AMDR[15] values within a weight management model for two different cuisine types, namely lacto-ovo vegetarian and rice-based (quasi-Asian). The objectives of the meal plans were to include a healthy balanced diet for both cuisine types, including all major food groups and their alternatives, for males and females aged 9 years and older. Australian guidelines suggest a minimum of four grain-based servings are required each day for optimal health and well-being, and to date Australia does not have a guideline stating the minimum amount of whole grains to be included in the diet for optimal health as is seen in the USA, Canada and some European countries. Furthermore, the term 'grains' may include both wholegrain and refined-grain foods. Therefore, the study sought to test the effect if all of these four servings were whole grains or refined grains or a combination of the two. Wholegrain meal plans were developed to test whether four wholegrain servings could be included each day. These meal plans were compared with refined grain and half refined grain/half wholegrain meal plans.

Methods

Thirty-six 7 d meal plans were developed in FoodWorks version 5·00 1324 (Xyris Software Ltd, Highgate Hill, Australia) using 1999 AUSNUT and 2001 AusFoods databases[16] with the aim of achieving as many of the RDI and AI values as possible[17] using the serving sizes and number of servings recommended by the National Health and Medical Research Council in *Food for Health: A Guide to Healthy Eating*[7] and the AGHE[10] where additional information was required. Meal plans were based on lacto-ovo vegetarian and rice-based cuisines for males and females aged 9 years and older, excluding pregnant and lactating women.

All plans were set at energy levels for weight maintenance and aimed to include as many grain-based food servings as possible. The meal plans represented planning of a balanced diet for an individual (hence RDI values were used as a comparator) and a specifically created template was used to map out the food pattern in FoodWorks. Energy requirements were based on a BMI of 22·5 kg/m^2, light physical activity (physical activity level = 1·6–1·7, as defined by FoodWorks) and the midpoint in years of each age group. BMI levels were determined using the average height and weight data for Australian males and females[18] and the 50th centile for age for children[19]. Energy requirements were calculated in FoodWorks based on the nutrient reference value requirements for age. Meal plans were developed for each age group using:

1. all wholegrain foods (100 % WG);
2. half refined-grain and half wholegrain foods (50/50); and
3. all refined-grain foods (100 % RG).

The 50/50 meal plans aimed to reach at least two servings each of refined grains and whole grains (i.e. 50 % of four servings daily).

Wholegrain models were developed based on the recommended serving sizes stated in the AGHE[10] and *Food for Health: A Guide to Healthy Eating*[7]. Refined-grain foods were substituted in the 50/50 and 100 % RG meal plans; this substitution often required larger serving sizes to allow for energy equivalence between the plans.

Food selection information for the two cuisines and recipes for each of the meal plans were obtained from literature searches, cuisine-based recipe books, consultation with experts for the cuisines and online recipe websites from magazines. For the rice-based meal plans where a food contained in a recipe was not available in the AUSNUT or AusFoods database, the online NUTTAB 2006 database[20] followed by the US Department of Agriculture's Nutrient Database for Standard Reference[21] were used to obtain the nutrient information.

The reference values and nutrients for determining nutritional adequacy were as follows.

1. RDI: protein, thiamin, riboflavin, niacin equivalents, folate, retinol equivalents, vitamin C, Ca, P, Zn, Fe and Mg.
2. AI: dietary fibre, Na and K.
3. AMDR: total and saturated fat, carbohydrate and protein.

All meal plans were checked against the *Food for Health* (Dietary Guidelines)[7] and AGHE[10] food group recommendations. The food groups considered were breads/cereals, vegetables, fruit, dairy, legumes, eggs, nuts (including peanut butter) and extra foods. For the rice-based plans, meat was also considered in line with the legumes. Nutrient data were checked against upper limits for a given nutrient where available.

The average number of servings of grain-based foods daily was calculated over a 1 week (7 d) period (e.g. number of servings daily = total number of servings divided by seven). Information on wholegrain food sources was obtained from the Food Standards Australia New Zealand website. The aim of the meal plans was to achieve the RDI and AI values through the inclusion of a variety of different foods and at least four grain-based servings. The ability to prepare the meals and the appropriateness in a food service setting were not considered when creating the meal plans.

Results

All lacto-ovo vegetarian meal plans were able to achieve the AI for fibre regardless of gender and age group. An example is shown in Table 1 demonstrating how the different levels of grain-based foods were equated within the breakfast meal. The nutrient values for the vegetarian plans are shown in Table 2. These nutrient values are an aggregate of all foods included in the meal plan multiplied by the frequency at which they were included.

Including four servings of grain-based foods for children aged 9–13 years limited total diet values for essential nutrients. For females, an average of 3·6 servings were included and for males 4·0 servings were achieved for most plans except 100 % WG, where the average over 1 week was 3·9 servings/d. In these plans, increasing the grain-based food servings to four would have required reductions in other food groups with subsequent reductions in values for essential nutrients, particularly Fe. The lower energy requirements for young females equated to a stronger need for nutrient-dense food choices, as this age group of females needed to meet the same RDI for energy as the males (1200 kJ). These differences were adjusted for in the mid-meal snacks which served as key providers of essential nutrients, while the plans for males had more energy-dense foods such as low-fat ice cream and crackers with peanut butter to meet energy requirements.

Without the inclusion of meat in the meal plans, the greatest contributors to Zn were the dairy products – cheese, milk and yoghurt. Incorporating 300 ml of age-appropriate flavoured milk for children each day was an important contributor to the Zn levels in these meal plans.

All requirements for food groups were achieved. There were more than adequate servings of fruit and dairy food in the meal plans for the younger age group, although high levels of 'extra' foods, particularly for the males. The larger serving of low-fat ice cream was a major contributor. The energy value was not as high as other typical 'extra' foods, but the Ca level was not high enough to be considered as a serving of dairy food. Realistic children's food choices and preferences were considered; for example, an occasional (once weekly) serving of potato chips.

The male adolescents aged 14–18 years had the highest energy requirement of ~12 350 kJ. To meet this requirement, the snacks between meals were again considered important for delivering additional nutrients. Extra grain-based food servings were added in the form of muffins and crackers available in wholegrain and refined-grain varieties. Cashew nuts were also included as a relatively good source of Fe in a vegetarian diet and a convenient snack.

The higher energy requirement for adults aged ≥19 years, compared with younger children, meant meeting nutrient and food group requirements was not as challenging. Again, including grain-based foods within the snacks and additional servings as side dishes to main meals meant meeting the four servings of grain-based foods was feasible. In particular, for males, it was possible to boost the grain-based foods to an average of 5·7 servings/d with the inclusion of garlic bread, chapatti with curry and more grain-based snacks. With the lower energy requirements of females it was possible to meet, but not exceed four servings. Adult-appropriate drink choices were incorporated, in particular coffee and a glass of red wine twice weekly. Again, cashews and dried apricots were integral to providing adequate Fe in this vegetarian meal plan, with foods higher in complementary vitamin C added to increase bioavailability.

All rice-based meal plans were able to achieve the AI for fibre regardless of gender and age group. All plans also exceeded the AI for Na due to the inclusion of ingredients commonly used in Asian cooking. The meal plans and nutrient values of the rice-based diets are shown in Tables 3 and 4, respectively.

Table 1 Meal plan for an entire day for a male adult consuming a lacto-ovo vegetarian diet, showing all wholegrain (line 1), 50 % wholegrain–50 % refined grain (line 2) and all refined grain (line 3) for breakfast only. Remainder of meals show 100 % wholegrain choices

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Breakfast						
58 g cereal	75 g cereal	58 g cereal	2 cereal biscuits	0·5 C untoasted muesli	75 g cereal	2 slices grain toast
250 ml skimmed (0·15 %) milk	250 ml skimmed (0·15 %) milk	250 ml skimmed (0·15 %) milk	250 ml skimmed (0·15 %) milk	250 ml skimmed (0·15 %) milk	250 ml skimmed (0·15 %) milk	2 tsp margarine
100 g reduced-fat fruit yoghurt		100 g reduced-fat fruit yoghurt	100 g reduced-fat fruit yoghurt	100 g reduced-fat fruit yoghurt		1 poached egg, tomato, mushrooms
2 slices grain toast	2 slices grain toast	2 slices grain toast	2 slices grain toast	2 slices grain toast	2 slices grain toast	OR
2 tsp margarine	2 tsp margarine	2 tsp margarine	2 tsp margarine	2 tsp margarine	2 tsp margarine	3 wholemeal (whole-wheat) pancakes, berries, reduced-fat ricotta, 1 tbsp honey
1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	200 ml vegetable juice	200 ml fruit juice
					1 mug white coffee with sweetener	1 mug white coffee with sweetener
OR	OR	OR	OR	OR	OR	OR
58 g cereal	73 g cereal	58 g cereal	2 cereal biscuits	1·5 C cereal	73 g cereal	3 wholemeal (whole-wheat) pancakes
2 slices grain toast	2 slices grain toast	2 slices grain toast	2 slices grain toast	2 slices grain toast	2 slices grain toast	2 slices grain toast
OR	OR	OR	OR	OR	OR	OR
1.7 C cereal	73 g cereal	1.7 C cereal	28 g cereal	1·5 C cereal	73 g cereal	3·5 plain pancakes
2 thin slices white toast	2 thin slices white toast	2 thin slices white toast	2 thin slices white toast	2 thin slices white toast	2 thin slices white toast	2 thin slices white toast
Morning tea						
1 fruit	1 fruit	1 fruit	1 fruit	1 fruit	1 fruit	1 fruit
4 brown rice cakes	200 g diet fruit yoghurt	4 brown rice cakes	200 g diet fruit yoghurt		200 g diet fruit yoghurt	200 g diet fruit yoghurt
2 tbsp peanut butter		2 tbsp peanut butter	1 wholemeal (whole-wheat) fruit muffin		4 brown rice cakes	2 oatmeal cookies
					2 tbsp peanut butter	
1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener
Lunch						
Salad with cheese	2 slices wholemeal (whole-wheat) toast and baked beans	Cheese salad wholemeal (whole-wheat) lavash	Salad and egg grain roll	Wholemeal (whole-wheat) pita bread with feta, pumpkin and rocket	Egg salad sandwich on 2 slices pumpernickel	Vegetarian mini pizza on grain English muffin
300 ml skimmed (0·15%) milk fruit smoothie	600 ml water	300 ml skimmed (0·15 %) milk fruit smoothie	600 ml water	300 ml skimmed (0·15 %) milk fruit smoothie	600 ml water	600 ml water

Table 1 *Continued*

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Afternoon tea						
0·25 C nuts	0·25 C nuts	0·25 C nuts	0·25 C nuts	0·25 C nuts	0·25 C nuts	0·25 C nuts
8 pieces dried fruit	2 wholemeal (whole-wheat) English muffins	8 pieces dried fruit	8 pieces dried fruit	4 grain crisp bread with reduced-fat ricotta and tomato		8 pieces dried fruit
	2 tsp diet jam 2 tsp margarine		1 fruit		1 fruit	1 fruit
1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener	1 mug white coffee with sweetener
Dinner						
0·5 C wholemeal (whole-wheat) pasta	0·75 C vegetable curry	290 g wholemeal (whole-wheat) vegetable lasagne	1·5 C satay tofu and vegetables	1 C wholemeal (whole-wheat) pasta with pesto	1 C vegetable and grain risotto	300 g Moroccan spiced vegetable and grain salad
0·75 C tomato-based pasta sauce	1 C wild rice	1 grain roll with garlic butter	1 C brown rice	300 g mixed vegetables		
30 g cheese	2 slices wholemeal (whole-wheat) bread	30 g reduced-fat cheese				
300 g mixed vegetables	50 g yoghurt dip	300 g mixed vegetables				
200 ml soft drink	200 ml soft drink	200 ml soft drink	200 ml soft drink	200 ml soft drink	1 glass wine	1 glass wine
600 ml water	600 ml water	600 ml water	600 ml water	600 ml water	600 ml water	600 ml water
Supper						
2 C popcorn	1 fruit	2 C fruit salad	1 fruit	200 g low-fat ice cream	200 g low-fat ice cream	12 wholegrain rice crackers
	0·5 C reduced-fat custard 125 ml vegetable juice	1 C reduced-fat custard 125 ml vegetable juice	0·5 C reduced-fat custard 125 ml vegetable juice	200 g fruit crumble 125 ml vegetable juice	200 g fruit crumble 125 ml vegetable juice	2 tbsp salsa 125 ml vegetable juice

C, cup; tbsp, tablespoon; tsp, teaspoon.
Grain breads, rolls and toasts contain intact grains, while wholemeal (whole-wheat) breads, rolls and toasts contain partially ground grains.
Each food group was represented by individual foods providing total for 7 d options.

Table 2 Daily nutrient values for lacto-ovo vegetarian meal plans, mean and percentage of the Recommended Dietary Intake (%RDI)

	9–13 years						14–18 years						≥19 years					
	100 % WG		50/50		100 % RG		100 % WG		50/50		100 % RG		100 % WG		50/50		100 % RG	
Nutrient	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Energy (kJ)	7996	9212	7996	9212	7995	9211	9475	12 357	9474	12 356	9473	12 358	8816	12 086	8816	12 086	8817	12 088
CHO (g)	290	327	294	329	299	333	322	389	323	390	327	402	280	372	281	373	285	3085
Protein (g)	78	91	77	89	77	89	88	112	87	111	87	109	81	108	79	106	80	105
Total fat (g)	42	52	41	53	41	52	61	96	63	97	62	94	61	95	63	96	62	93
SFA (g)	14	14	14	15	14	15	17	26	18	27	18	26	15	25	16	26	16	26
PUFA (g)	8	12	8	12	7	12	12	20	11	20	11	18	12	20	12	20	12	19
MUFA (g)	16	20	16	21	15	20	28	43	28	43	28	42	29	43	29	43	29	42
CHO (%E)	63	62	64	62	64	62	59	55	59	55	59	56	56	53	56	53	56	55
Protein (%E)	17	17	17	17	17	17	16	16	16	15	16	15	16	16	16	15	16	15
Fat (%E)	20	21	20	22	19	21	24	29	25	30	25	29	27	30	27	30	27	29
SFA (%E)	6	5	6	6	6	6	6	8	7	8	7	8	6	7	7	8	7	8
PUFA (%E)	4	5	4	5	3	5	5	6	4	6	4	5	5	6	5	6	5	6
MUFA (%E)	7	8	7	8	7	8	11	13	11	13	11	12	12	13	12	13	12	13
SFA (% fat)	37	31	37	32	37	32	30	29	31	30	31	30	27	29	28	30	29	30
PUFA (% fat)	21	26	21	25	21	25	21	22	20	22	20	21	22	23	21	22	21	49
MUFA (% fat)	42	43	42	43	42	43	49	48	49	48	49	49	51	48	51	48	50	49
Alcohol (g)	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4
Alcohol (%E)	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
P:S	0·57	0·86	0·57	0·93	0·50	0·93	0·71	0·77	0·60	0·74	0·60	0·69	0·81	0·81	0·75	0·80	0·75	0·73
Thiamin (mg)																		
Mean	1·7	1·8	1·9	2·0	1·8	2·0	2·3	2·4	2·5	2·5	2·5	2·4	2·4	2·4	2·5	2·5	2·5	2·4
%RDI	243	257	271	286	257	286	256	240	278	250	278	240	267	240	278	250	278	240
Riboflavin (mg)																		
Mean	3·1	3·2	3·4	3·5	3·3	3·5	3·8	3·7	4·1	4·0	4·0	4·0	3·3	3·4	3·6	3·7	3·6	3·7
%RDI	388	400	425	438	413	438	422	336	456	364	444	364	367	309	400	336	400	336
Niacin equiv. (mg)																		
Mean	35	42	35	41	34	39	43	52	42	51	40	48	43	54	41	52	40	50
%RDI	388	467	388	456	378	433	391	433	381	425	363	400	391	450	372	433	363	417
Vitamin C (mg)																		
Mean	281	281	281	281	286	286	225	284	225	284	231	289	203	265	203	265	209	271
%RDI	1004	1004	1004	1004	1021	1021	804	1014	804	1014	821	1032	677	883	677	883	697	900
Total folate (μg)*																		
Mean	388	419	378	399	427	451	364	482	344	462	425	503	361	448	341	428	422	470
%RDI	155	168	151	160	171	180	110	138	104	140	129	152	113	140	107	134	132	147
Total retinol equiv. (μg)																		
Mean	2287†	2258†	2288†	2260†	2474†	2448†	1501	2573	1503	2574	1691	2762	3210†	2059	3211†	2060	3399†	2248
%RDI	545	507	545	508	589	550	309	408	310	409	349	438	642	329	642	330	680	360
Na (mg)*	2454†	2543†	2496†	2751†	2630†	2890†	2602†	3164†	2819†	3368†	2972†	3222†	2511†	3389†	2716†	3597†	2870†	3450†
K (mg)																		
Mean	4827	5106	4695	4943	4571	4820	5254	6231	5090	6066	4960	5877	5097	6329	4939	6164	4809	5975
%RDI	193	170	198	165	183	161	202	173	196	169	191	163	182	167	176	162	172	157
Mg (mg)																		
Mean	515	585	461	511	423	473	654	784	580	710	542	639	643	801	571	726	532	656
%RDI	258	293	231	256	212	237	354	231	193	209	181	188	243	243	215	220	201	199
Ca (mg)																		
Mean	1742	1870	1733	1865	1749	1880	1776	2120	1772	2115	1787	2092	1495	1939	1493	1934	1509	1911
%RDI	218	234	217	233	218	235	169	202	169	201	170	199	178	231	177	230	180	228
P (mg)																		
Mean	1919	2184	1770	1992	1698	1920	2192	2669	2000	2478	1929	2353	1988	2547	1803	2355	1732	2231
%RDI	182	207	168	189	161	182	208	253	190	235	183	223	343	439	311	406	299	385

Table 2 *Continued*

	9–13 years						14–18 years						≥19 years					
	100 % WG		50/50		100 % RG		100 % WG		50/50		100 % RG		100 % WG		50/50		100 % RG	
Nutrient	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Fe (mg)																		
Mean	15	16	15	16	15	16	17	21	17	21	17	20	18	22	19	23	18	22
%RDI	250	267	250	267	250	267	213	263	213	263	213	250	225	367	238	383	225	367
Zn (mg)																		
Mean	12	13	11	12	11	12	14	17	13	16	13	15	13	16	13	16	12	15
%RDI	240	260	220	240	220	240	233	155	217	145	217	136	200	133	200	133	185	125
Dietary fibre (g)	38	41	32	35	27	30	43	53	37	47	32	39	46	53	40	47	35	40

WG, wholegrain; 50/50, 50 % wholegrain–50 % refined grain; RG, refined grain; F, female; M, male; CHO, carbohydrate; %E, percentage of energy; P:S, ratio of polyunsaturated fat to saturated fat; equiv., equivalents.
*Some values for the adult data were unavailable.
†Exceeds upper limit.

The meal plans for children aged 9–13 years were not able to incorporate the total four servings of grain-based foods and still meet the RDI for all nutrients within the appropriate energy requirement. Initial meal plans that did include four servings each day were not able to meet the RDI for Fe and folate. The grain servings were mostly within main meals while mid-meal snacks contained nutrient-rich foods to meet the food group targets for growing children, predominantly fruit and dairy.

Meeting dairy requirements was also a challenge in the rice-based (quasi-Asian) diets across all age groups. For children only 1·8 dairy servings/d, not the recommended two servings were achieved, although the plans did reach the lower end of the RDI range for Ca. Meeting dairy requirements was complicated as breakfast cereal and milk are not typical foods, and a very high prevalence of lactose intolerance exists among the Asian population[22]. Fortified soya beverages were used as daily drinks to contribute to ‘dairy’ and Ca.

Increased energy requirements for adolescents aged 14–18 years made it feasible to include four servings of grain foods in 100 % RG and 100 % WG meal plans. This was met with larger serving sizes of grain foods within meals and occasional grain-based snacks such as cookies and pancakes. While many of the RDI values are similar, these needed to be met with less energy for females than for males. More nutrient-dense foods were included to account for these differences. For example, for females, morning tea fruit selections included grapefruit, banana and mango which provided 64 μg (16 % RDI) of folate; in comparison with the male fruit choices of plums, kiwifruit and lychees which provided ~20 % of this amount of folate. Fruit was a major contributor to energy and essential micronutrients in the plans and the inclusion of fresh tropical fruits, juice and dried fruit contributed to an average of four servings daily.

It was again a challenge to meet the four servings of grain-based foods for adults aged ≥19 years because of the lack of grain-based snacks in the Asian cuisine. Again, grain-based foods were confined predominantly to the main meals and the increased serving size of these meals compared with children was the best strategy for increasing the total number of grain-based foods servings daily. Again, fruit contributed many of the snacks in these plans and specifically berries were included to boost the micronutrient content of the female diets.

Discussion

Achievement of the RDI and AI requirements for the lacto-ovo vegetarian and quasi-Asian meal plans required careful consideration of food choices depending on the target age group and gender. Zn, Fe, folate and Na levels provided the most challenge. The first three were often below the nutrient reference value while the latter was generally above the value. Zn, Fe and folate were

Table 3 Meal plan for an entire day for a female adult consuming a rice-based (quasi-Asian) diet, showing all wholegrain (line 1), 50 % wholegrain–50 % refined (line 2) and all refined grain (line 3) for breakfast only. Remainder of meals show 100 % wholegrain choices

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Breakfast						
Wholegrain nasi lemak, egg, peanut, cucumber, dried fish sambal	2 slices grain toast, kaya paste	Kao tom	Beef pho	Grain roll, fried egg and soya sauce	Wholegrain congee, poached egg, soya sauce	Wholegrain ensaymada
		1 C brown rice	250 g soba noodles			
200 ml tea	200 ml tea	200 ml tea	200 ml tea	200 ml tea	200 ml tea	200 ml tea
OR	OR	OR	OR	OR	OR	OR
Wholegrain nasi lemak	2 slices grain toast	1·16 C white rice	250 g rice noodles	25 g Vietnamese bread stick	White rice congee	White rice ensaymada
OR	OR	OR	OR	OR	OR	OR
Malay nasi lemak	2 thin slices white toast	1·16 C white rice	250 g rice noodles	25 g Vietnamese bread stick	White rice congee	White rice ensaymada
Morning tea						
200 g reduced-fat plain yoghurt	250 ml fortified soya beverage	200 g reduced-fat plain yoghurt	200 g reduced-fat plain yoghurt	250 ml fortified soya beverage	200 g reduced-fat plain yoghurt	250 ml fortified soya beverage
0·5 C sliced fruit	1 fruit	1 C sliced fruit	0·5 C sliced fruit	1 fruit	0·5 C sliced fruit	0·5 C sliced fruit
0·25 C mixed nuts, fruit and seeds			0·25 C mixed nuts, fruit and seeds			
200 ml water	125 ml fruit juice	200 ml water	125 ml fruit juice	200 ml water	125 ml fruit juice	200 ml water
Lunch						
8 pieces brown rice sushi, soya sauce	Vietnamese rice paper rolls	2 wholegrain jaioz	2 wholemeal (whole-wheat) fish cakes	Asian vegetable soup	2 slices grain toast	1 C wholegrain lugaw
Steamed vegetables and tuna	2 C salad vegetables, soya sauce	2 fish balls, chilli sauce	1·5 C steamed vegetables, chilli sauce	250 g soba noodles	0·75 C soya beans	1·5 C steamed Asian greens
Seafood soup with seaweed		Poached egg	1 C brown rice	1 chicken kebab		
3 rice cakes with rye		0·5 C salad vegetables, soya sauce		3 rice cakes with rye		
		0·5 C brown rice				
200 ml tea	200 ml tea	200 ml tea	200 ml tea	200 ml tea	200 ml tea	200 ml tea
Afternoon tea						
0·5C Asian noodle, peanut and soya mix	1 C mixed fruit	14 brown rice crackers with fish spread and miso soup	200 g reduced-fat fruit yoghurt	1 C mixed fruit	200 g reduced fat fruit yoghurt	0·25 C peanuts
250 ml fortified soya beverage	200 ml water	250 ml fortified soya beverage	200 ml water	250 ml fortified soya beverage	250 ml fortified soya beverage	200 ml water
Dinner						
0·75 C beef in black bean sauce	1 C miso with tofu, seaweed	1 fish fillet steamed	Miso-glazed salmon	Ginger chicken with Asian greens	Char kway teow	Dol sot bibimbap
1·5 C steamed vegetables	1·5 C Asian steamed greens	150 g kimchi, soya sauce	2 C steamed vegetables		1·5 C steamed Asian vegetables	
	1 C green salad with dressing					

Table 3 *Continued*

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1 C brown rice 200 ml fruit juice	1 C brown rice 200 ml water	1 C brown rice 200 ml water	250 g soba noodles 200 ml water	250 g soba noodles 200 ml water	250 g soba noodles 200 ml water	1 C brown rice 200 ml fruit juice
Supper						
0·5 C fruit salad	3 wholemeal (whole-wheat) pancakes	12 brown rice crackers	100 g tofu 'ice cream'	0·5 C fruit salad	0·25 C sago pudding	2·5 pieces dried fruit OR 1·5 tbsp sultanas/raisins
200 ml tea	200 ml tea	200 ml tea	200 ml tea	200 ml tea	200 ml tea	200 ml tea

C, cup; tbsp, tablespoon; tsp, teaspoon.
Grain breads, rolls and toasts contain intact grains, while wholemeal (whole-wheat) breads, rolls and toasts contain partially ground grains.
Glossary of meals: ensaymada, egg sponge/flour filled dough pastry ball; lugaw, meat- and tofu-based rice porridge with coconut liquid base (Philippines); nasi lemak, coconut-soaked steamed rice; char kway teow, stir-fried rice cake strips; sambal, chilli and shrimp paste (Malaysia); kaya paste, coconut and egg paste (Singapore); kao tom, meat-based clear breakfast soup (Thailand); kimchi, pickled cabbage; dol sot bibimbap, mixed dish of rice, sliced meat, vegetables and raw egg (Korea); pho, noodle soup (Vietnam), congee, rice broth/porridge; mango pudding, gelatine-based evaporated milk and fruit, jaiozi, steamed meat-filled dumplings (China).
Each food group was represented by individual foods providing total for 7 d options.

achieved in the majority of plans through required food choices seen as rich sources of each nutrient. This was of greater concern in the vegetarian meal plans where the avoidance of meat or fish reduced the range of choices. In these plans the consideration of non-haem Fe and its interactions with vitamin C was also addressed to ensure the bioavailability was maximised.

For the 100 % WG meal plans, these nutrients were not as difficult to achieve due to the inherent nutrient density of the grains. Breakfast maximised the use of fortified cereal products helping to increase target nutrient levels, especially when compared with a bread/toast-based breakfast. The Fe content of the rice-based plans for 100 % WG and 50/50 plans could have further been increased if black rice[23] was used rather than the more readily available brown rice. However, the plans were based on Westernised cuisine and food composition databases. While each of the 100 % WG and some 50/50 plans did include brown rice, the majority of Asian cuisines are based on a number of different varieties of white rice only. While in a meal planning and cooking sense it was possible to substitute white rice for brown, whether this would be an acceptable substitution to the Asian population remains to be seen.

Na levels were above the AI in most meal plans. In the vegetarian plans this was primarily attributed to the high Na content of processed and packaged foods (not usually grain-based), which were included to reflect common Western eating patterns and a need for convenience. While grain-based foods did contribute Na to the meal plans, it was the cumulative effect of foods such as pre-packaged pasta and simmer sauces, deli meats, pre-packaged mixed spices and vegetable stock that resulted in the overall high Na load. The Na content of all of the rice-based plans exceeded the AI, due to the inclusion of processed and packaged foods (not usually grain-based) and Na-rich ingredients such as soya, fish and oyster sauce, stock, miso and seafood ingredients such as shrimp paste, seaweed and preserved fish. Inclusion of these foods was necessary to accurately reflect modern Asian cuisine. Grain-based foods were again not a major contributor to the Na load. Thus, the whole of diet was responsible for the excessive Na load, which is likely to be an accurate reflection of Na intake within the context of traditional Asian cuisine.

It is notable that the composition of all vegetarian and rice-based meal plans was sufficient to meet the AI for fibre. The primary difference between the vegetarian grain-based food meal plans was the 100 % RG plans having an average of 30 % less fibre than the 100 % WG. The difference in fibre content was marginal for the 100 % RG and 100 % WG rice-based meal plans, as a cup of brown rice has only one-third of the fibre (1·5 g/100 g) of wholemeal (whole-wheat) pasta (5·7 g/100 g) and 20 % less fibre than two slices of grain bread (containing intact grains; 4·1 g/100 g) or two Weetbix (whole-wheat cereal; 3·2 g/100 g). Hence, overall the fibre content was

Table 4 Daily nutrient values for rice-based (quasi-Asian) meal plans, mean and percentage of the Recommended Dietary Intake (%RDI)

	9–13 years						14–18 years						≥19 years					
	100 % WG		50/50		100 % RG		100 % WG		50/50		100 % RG		100 % WG		50/50		100 % RG	
Nutrient	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Energy (kJ)	7995	9212	7996	9212	7996	9212	9475	12 354	9475	12 357	9475	12 355	8817	12 084	8817	12 085	8815	12 086
CHO (g)	232	283	237	287	240	290	279	340	282	342	284	345	259	319	261	323	264	327
Protein (g)	101	107	98	104	94	101	116	146	114	147	110	143	111	149	108	145	105	141
Total fat (g)	60	67	59	66	58	65	71	104	70	105	70	104	65	104	64	103	64	102
SFA (g)	15	17	15	17	15	16	17	25	17	26	17	26	16	26	16	25	16	25
PUFA (g)	19	20	18	19	17	19	23	30	23	29	22	28	19	29	19	28	18	28
MUFA (g)	20	23	20	22	19	22	23	38	23	38	23	38	22	39	22	38	22	38
CHO (%E)	48	53	51	51	52	54	50	48	51	48	52	48	51	45	51	46	52	47
Protein (%E)	22	20	21	19	20	19	21	20	20	20	20	20	22	21	21	21	20	20
Fat (%E)	29	27	27	27	27	27	28	32	27	32	27	32	28	32	27	32	27	32
SFA (% fat)	28	28	28	28	28	29	27	27	27	26	27	28	28	25	28	24	29	25
PUFA (% fat)	35	34	34	33	34	33	37	32	36	29	36	31	34	28	34	27	33	28
MUFA (% fat)	37	38	37	38	38	38	37	41	37	38	37	41	38	38	38	37	39	37
SFA (%E)	7	7	7	7	7	6	6	7	6	8	6	8	7	8	7	7	7	7
PUFA (%E)	9	8	8	7	8	7	9	9	9	8	8	8	8	9	8	8	7	8
MUFA (%E)	9	9	9	9	9	9	9	11	9	11	9	11	9	12	9	11	9	11
Alcohol (g)	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0	5
Alcohol (% energy)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
P:S	1·27	1·18	1·20	1·12	1·13	1·19	1·35	1·20	1·35	1·12	1·29	1·08	1·19	1·12	1·19	1·12	1·13	1·12
Thiamin (mg)																		
Mean	1·4	1·5	1·2	1·2	1·0	1·1	1·7	2·0	1·5	1·7	1·3	1·5	1·6	1·9	1·4	1·6	1·2	1·4
%RDI	155	167	133	133	111	122	154	167	136	142	181	125	145	158	127	133	109	117
Riboflavin (mg)																		
Mean	2·0	2·1	1·9	2·1	1·9	2·0	2·4	2·7	2·4	2·9	2·4	2·9	2·2	2·9	2·1	2·9	2·1	2·8
%RDI	222	233	211	233	211	222	218	208	218	230	218	230	200	223	191	223	191	215
Niacin equiv. (mg)																		
Mean	41	45	40	43	34	43	51	62	50	60	49	60	50	61	49	60	47	53
%RDI	342	375	333	358	283	358	365	385	357	375	350	375	357	381	350	375	394	331
Vitamin C (mg)																		
Mean	248	377	248	377	248	383	242	421	242	417	242	417	237	363	237	363	237	362
%RDI	620	943	620	942	620	956	605	1053	605	1043	605	1043	527	807	527	807	527	804
Total folate (μg)*																		
Mean	333	365	311	344	301	343	473	491	458	480	439	469	446	491	428	465	412	453
%RDI	111	122	104	147	100	114	118	123	115	120	110	117	112	123	107	116	103	113
Total retinol equiv. (μg)																		
Mean	982	995	987	999	990	1177	1711	1644	1715	1662	1732	1667	1603	1649	1610	1654	1625	1659
%RDI	163	166	165	167	165	196	244	183	245	185	247	185	229	183	230	184	232	184
Na (mg)*	7451†	7567†	7496†	7611†	7376†	7505†	7891†	10 456†	7891†	10 611†	7784†	10 483†	7625†	10 552†	7607†	10 557†	7517†	10 450†
K (mg)	3346	3880	3240	3774	3169	3763	4124	5031	4051	5003	3942	4924	3884	4945	3782	4830	3699	4751
Mg (mg)																		
Mean	465	513	395	443	361	416	547	671	504	610	435	574	525	670	480	597	413	560
%RDI	194	214	166	185	150	173	152	164	140	149	121	140	169	168	155	149	133	140
Ca (mg)																		
Mean	1103	1156	1102	1155	1089	1157	1406	1331	1405	1472	1402	1458	1193	1439	1189	1439	1191	1425
%RDI	110	116	110	116	109	116	108	102	108	113	107	112	119	144	119	144	119	143
P (mg)																		
Mean	1779	1877	1616	1715	1543	1649	2166	2339	2072	2352	1900	2274	1994	2492	1893	2325	1729	2246
%RDI	142	150	129	137	123	132	173	187	166	188	152	178	199	249	189	233	173	225

Table 4 *Continued*

	9–13 years						14–18 years						≥19 years					
	100 % WG		50/50		100 % RG		100 % WG		50/50		100 % RG		100 % WG		50/50		100 % RG	
Nutrient	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Fe (mg)																		
Mean	17()	18()	16	17	16	17	19	26	19	25	19	25	17	24	17	24	17	24
%RDI	213	225	200	213	200	213	127	236	127	227	127	227	94	300	94	300	94	300
Zn (mg)																		
Mean	12	13	11	12	11	12	13	18	13	18	13	18	13 ()	18	13	17	12	17
%RDI	200	217	183	200	183	200	186	138	186	138	186	138	163	129	163	121	150	121
Dietary fibre (g)	26	28	24	26	23	26	31	40	30	36	28	35	30	38	28	36	26	35

WG, wholegrain; 50/50, 50 % wholegrain–50 % refined grain; RG, refined grain; F, female; M, male; CHO, carbohydrate; %E, percentage of energy; P:S, ratio of polyunsaturated fat to saturated fat; equiv., equivalents.
*Some values for the adult data were unavailable.
†Exceeds upper limit.

lower in rice-based meal plans. Differences between 100 % RG and 100 % WG meal plans were minimised, with the major contributors to fibre being fruits and vegetables. To achieve the AI levels in the rice-based meal plans, careful consideration of the types of snack food and meal choices at breakfast, lunch and dinner was needed. The meal plans also consisted of a combination of different modern Westernised Asian foods drawn from many different Asian cultures.

The younger age groups were unable to achieve the four servings of grain-based foods daily while maintaining the recommended number of servings from other food groups, within the energy requirements. All meal plans, however, met or exceeded three servings of grain-based foods daily. One of the difficulties in including the four servings of grain-based foods within rice-based meal plans was the lack of grain-based snacks available. Snacks tended to be based on fruit or soya.

Creation of the meal plans focused on achievement of the nutrient targets as the primary goal secondary to food group targets. They were not created for institutional food service/food preparation purposes and hence some contained similar food choices on subsequent days. The plans were also limited to the foods contained within the available food composition databases at the time of the project. The AUSNUT 1999[16] data did not contain the range of food choices presently available to the general public, nor a range of culturally specific foods. Many Asian food items needed to be added to the database (using food labels) as the AUSNUT database was derived from the previous National Nutrition Survey. This survey was conducted in 1995 during which time modern Asian cuisine was not as popular or available throughout Australia. The later NUTTAB 2006 database was also used to source some missing values. This database did contain a ‘new’ collection of Asian food items; however, many were still missing. The use of food packaging nutrient values was not ideal, but was required for the present study in the absence other suitable values.

The total Na values obtained for the rice-based meal plans did exceed the upper limit for Na (2300 mg for adults); however, limitations to food composition databases as discussed below suggest that these values may not be entirely accurate. The nutrient databases are also limited in their Na values. The 1999 data did not contain complete Na data, which if available would have seen further changes to total Na levels of the meal plans. The rice option in the database also only gave an option for rice cooked with salt. Steamed rice is popular among many Asian cultures, indicating again that the nutrient database was limited in its ability to adequately represent the food choices. The Australian food industry has also worked towards decreasing the Na content of foods over the past decade, also potentially decreasing the total values.

Similarly, the databases did not contain complete values for all food items for total folate, again potentially

increasing this level. Similar limitations were also encountered for the breakdown of the nutrient data for specific fatty acids or for the inclusion of added or free sugars.

Conclusion

The results show that with careful food selection, meal plans with ≥4 servings of grain-based foods daily can meet RDI and AI for lacto-ovo vegetarian and rice-based cuisines. Particular strategies to meet the nutrient needs for different ages and genders within each cuisine were required. The most important finding in terms of the difference between wholegrain and refined-grain foods was that a healthy individual's nutrient requirements could be met by including three to four servings of wholegrain or refined-grain foods daily.

Acknowledgements

Source of funding: This study was funded by an industry project supported by Go Grains Health & Nutrition, Australia. *Conflicts of interest:* There are no conflicts of interest to declare. *Authors' contributions:* Y.P. was involved in the conduct of the research and drafting of the manuscript. L.T. provided advice during the research work and editing of the manuscript. *Acknowledgements:* The authors would like to thank Ms Holley Jones and Ms Sayne Dalton for their assistance with the study. The authors would also like to acknowledge Go Grains Health & Nutrition for providing the funding for this project.

References

1. Smith AT, Kuznesof S, Richardson DP *et al.* (2003) Behavioural, attitudinal and dietary responses to the consumption of wholegrain foods. *Proc Nutr Soc* **62**, 455–467.
2. Seal CJ (2006) Whole grains and CVD risk. *Proc Nutr Soc* **65**, 24–34.
3. Dalton SMC, Tapsell L & Probst Y (2012) Potential health benefits of wholegrain wheat components. *Nutr Today* **47**, 163–174.
4. Steffen LM, Jacobs D, Stevens J *et al.* (2003) Associations of whole-grain, refined-grain, and fruit and vegetable consumption with risks of all-cause mortality and incident coronary artery disease and ischemic stroke: the Atherosclerosis Risk in Communities (ARIC) Study. *Am J Clin Nutr* **78**, 383–390.
5. Liu S, Stamfer MJ, Hu FB *et al.* (1999) Whole-grain consumption and risk of coronary heart disease: results from the Nurses' Health Study. *Am J Clin Nutr* **70**, 412–419.
6. Rangan A, Schindeler S, Hector DJ *et al.* (2009) Assessment of typical food portion sizes consumed among Australian adults. *Nutr Diet* **66**, 227–233.
7. Lang R & Jebb SA (2003) Who consumes whole grains, and how much? *Proc Nutr Soc* **62**, 123–127.
8. National Health and Medical Research Council (2003) *Food for Health: Dietary Guidelines for Australian Adults. A Guide to Healthy Eating.* Canberra: Commonwealth of Australia; available at http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/n29.pdf.
9. Marquart L, Salvin JL & Fulcher RG (2002) *Whole-grain Foods in Health and Disease.* St. Paul, MN: American Association of Cereal Chemists, Inc.
10. Smith A, Kellet E & Schmerlaib Y (1998) *The Australian Guide to Healthy Eating. Background Information for Nutrition Educators.* Canberra: Commonwealth of Australia.
11. Messer E (1989) Methods for studying determinants of food intake. In *Research Methods in Nutritional Anthropology*, pp. 1–33 [G Pelto, P Pelto and E Messer, editors]. Tokyo: United Nations University.
12. National Institute of Health and Welfare (2009) Vegetarian diet. http://www.nlm.nih.gov/medlineplus/vegetariandiet.html (accessed January 2009).
13. Australian Government Culture Portal (2008) Australian food and drink. http://www.cultureandrecreation.gov.au/articles/foodanddrink/ (accessed November 2008).
14. Heinemann RJB, Fagundes Pl, Pinto EA *et al.* (2005) Comparative study of nutrient composition of commercial brown, parboiled and milled rice from Brazil. *J Food Compost Anal* **18**, 287–296.
15. Department of Health and Ageing, National Health and Medical Research Council (2006) *Nutrient Reference Values for Australia and New Zealand.* Canberra: Australian Government.
16. Australia New Zealand Food Authority (1999) *AUSNUT – Australian Food and Nutrient Database.* Canberra: ANZFA.
17. National Health and Medical Research Council (2006) *Nutrient Reference Values for Australia and New Zealand: Executive Summary.* Canberra: NHMRC.
18. Australian Bureau of Statistics (1995) *How Australians Measure Up. Catalogue* no. 4359.0. Canberra: ABS.
19. Department of Education and Early Childhood Development, State Government of Victoria (2008) Weight: child health record: growth details. http://www.education.vic.gov.au/ecsmanagement/mch/childhealthrecord/growth/default.htm (accessed November 2008).
20. Food Standards Australia New Zealand (2007) NUTTAB 2006 online version. http://www.foodstandards.gov.au/monitoringandsurveillance/nuttab2006/onlineversionintroduction/onlineversion.cfm (accessed October 2008).
21. US Department of Agriculture, Nutrient Data Laboratory (2008) USDA Nutrient Database for Standard Reference; Release 21. http://www.nal.usda.gov/fnic/foodcomp (accessed October 2008).
22. Vesa T, Marteau P & Korpela R (2000) Lactose intolerance. *J Am Coll Nutr* **19**, 2 Suppl., 165S–175S.
23. Bhat R, Deosthale Y, Roy D *et al.* (2006) Nutritional and toxicological evaluation of black tip rice. *J Sci Food Agric* **33**, 41–47.