Meeting recommended dietary intakes in meal plans with \( \geq 4 \) servings of grain-based foods daily

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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 \( \geq 4 \) 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 \( \geq 4 \) 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 \( \geq 19 \) years (17 mg). In the plans for 14–18 year and \( \geq 19 \) 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 \( \geq 4 \) servings of grain-based foods daily can meet nutrient reference values for lacto-ovo vegetarian and rice-based cuisines.

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 \textit{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 \( (P < 0.001) \). At this level of consumption there was a trend for increased risk of disease compared with those who consumed 0–5 servings daily \( (P < 0.001) \). On the other hand, Liu \textit{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 rice; 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 \textit{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\(^{(11)}\).
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, 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. 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. 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.

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; 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.

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 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 whole-grain 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 with the aim of achieving as many of the RDI and AI values as possible 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 and the AGHE 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/m², light physical activity (physical activity level = 1.6–1.7, as defined by FoodWorks) and the mid-point in years of each age group. BMI levels were determined using the average height and weight data for Australian males and females and the 50th centile for age for children. 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 and Food for Health: A Guide to Healthy Eating. 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\(^\text{20}\) followed by the US Department of Agriculture’s Nutrient Database for Standard Reference\(^\text{21}\) 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)\(^\text{7}\) and AGHE\(^\text{10}\) 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 (1200kJ). 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 300ml 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 \(~12350\)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>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breakfast</strong></td>
<td></td>
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</tr>
<tr>
<td>58 g cereal</td>
<td>75 g cereal</td>
<td>58 g cereal</td>
<td>2 cereal biscuits</td>
<td>0·5 C untoasted muesli</td>
<td>75 g cereal</td>
<td>2 slices grain toast</td>
</tr>
<tr>
<td>250 ml skimmed (0·15 %) milk</td>
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<td>250 ml skimmed (0·15 %) milk</td>
<td>250 ml skimmed (0·15 %) milk</td>
<td>250 ml skimmed (0·15 %) milk</td>
<td>250 ml skimmed (0·15 %) milk</td>
<td>2 tsp margarine</td>
</tr>
<tr>
<td>100 g reduced-fat fruit yoghurt</td>
<td>100 g reduced-fat fruit yoghurt</td>
<td>100 g reduced-fat fruit yoghurt</td>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
<td>1 poached egg, tomato, mushrooms</td>
</tr>
<tr>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
<td>2 tsp margarine</td>
<td>2 tsp margarine</td>
<td>2 tsp margarine</td>
<td>3 wholemeal (whole-wheat) pancakes, berries, reduced-fat ricotta, 1 tbsp honey</td>
</tr>
<tr>
<td>2 tsp margarine</td>
<td>2 tsp margarine</td>
<td>2 tsp margarine</td>
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</tr>
<tr>
<td>1 mug white coffee with sweetener</td>
<td>1 mug white coffee with sweetener</td>
<td>1 mug white coffee with sweetener</td>
<td>1 mug white coffee with sweetener</td>
<td>200 ml vegetable juice</td>
<td>1 mug white coffee with sweetener</td>
<td>200 ml fruit juice</td>
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<td>OR</td>
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<td>OR</td>
<td>OR</td>
<td>OR</td>
<td>OR</td>
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</tr>
<tr>
<td>58 g cereal</td>
<td>73 g cereal</td>
<td>58 g cereal</td>
<td>2 cereal biscuits</td>
<td>1·5 C cereal</td>
<td>73 g cereal</td>
<td>3 wholemeal (whole-wheat) pancakes</td>
</tr>
<tr>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
<td>2 slices grain toast</td>
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<tr>
<td>OR</td>
<td>OR</td>
<td>OR</td>
<td>OR</td>
<td>OR</td>
<td>OR</td>
<td>3·5 plain pancakes</td>
</tr>
<tr>
<td>1·7 C cereal</td>
<td>73 g cereal</td>
<td>1·7 C cereal</td>
<td>28 g cereal</td>
<td>1·7 C cereal</td>
<td>73 g cereal</td>
<td>3·5 plain pancakes</td>
</tr>
<tr>
<td>2 thin slices white toast</td>
<td>2 thin slices white toast</td>
<td>2 thin slices white toast</td>
<td>2 thin slices white toast</td>
<td>2 thin slices white toast</td>
<td>2 thin slices white toast</td>
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<tr>
<td><strong>Morning tea</strong></td>
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<tr>
<td>1 fruit</td>
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<tr>
<td>4 brown rice cakes</td>
<td>4 brown rice cakes</td>
<td>200 g diet fruit yoghurt</td>
<td>1 wholemeal (whole-wheat) fruit muffin</td>
<td>200 g diet fruit yoghurt</td>
<td>4 brown rice cakes</td>
<td>200 g diet fruit yoghurt</td>
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<tr>
<td>2 tbsp peanut butter</td>
<td>2 tbsp peanut butter</td>
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<td></td>
<td></td>
<td></td>
<td>2 oatmeal cookies</td>
</tr>
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<td>1 mug white coffee with sweetener</td>
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<td>1 mug white coffee with sweetener</td>
<td>1 mug white coffee with sweetener</td>
<td>1 mug white coffee with sweetener</td>
<td>1 mug white coffee with sweetener</td>
<td>1 mug white coffee with sweetener</td>
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<td><strong>Lunch</strong></td>
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<tr>
<td>Salad with cheese</td>
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<tr>
<td>2 slices wholemeal (whole-wheat) toast and baked beans</td>
<td>Cheese salad wholemeal (whole-wheat) lavash</td>
<td>Salad and egg grain roll</td>
<td>Wholemeal (whole-wheat) pita bread with feta, pumpkin and rocket</td>
<td>Egg salad sandwich on 2 slices pumpernickel</td>
<td>Vegetarian mini pizza on grain English</td>
<td></td>
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<tr>
<td>300 ml skimmed (0·15 %) milk fruit smoothie</td>
<td>300 ml skimmed (0·15 %) milk fruit smoothie</td>
<td>600 ml water</td>
<td>300 ml skimmed (0·15 %) milk fruit smoothie</td>
<td>600 ml water</td>
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### Table 1 *Continued*

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

C, cup; tbsp, tablespoon; tsp, teaspoon.
Grain-based meal plans 807

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)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>9–13 years</th>
<th>14–18 years</th>
<th>≥19 years</th>
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<tr>
<td></td>
<td>100 % WG</td>
<td>50/50</td>
<td>100 % RG</td>
</tr>
<tr>
<td>Energy (kJ)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>7996</td>
<td>9212</td>
<td>7996</td>
</tr>
<tr>
<td>M</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>78</td>
<td>91</td>
<td>77</td>
</tr>
<tr>
<td>Total fat (g)</td>
<td>42</td>
<td>52</td>
<td>41</td>
</tr>
<tr>
<td>SFA (g)</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>MUFA (g)</td>
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<td>12</td>
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<tr>
<td>CHO (g)</td>
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<tr>
<td>Protein (%E)</td>
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<td>Fat (%E)</td>
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<td>SFA (%E)</td>
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<td>PUFA (%E)</td>
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<tr>
<td>MUFA (%E)</td>
<td>42</td>
<td>43</td>
<td>42</td>
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<td>Alcohol (g)</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Alcohol (%E)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>1.7</td>
<td>1.8</td>
<td>1.9</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>388</td>
<td>400</td>
<td>425</td>
</tr>
<tr>
<td>Niacin equiv. (mg)</td>
<td>43</td>
<td>43</td>
<td>42</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>281</td>
<td>281</td>
<td>281</td>
</tr>
<tr>
<td>Total folate (µg)*</td>
<td>388</td>
<td>419</td>
<td>378</td>
</tr>
<tr>
<td>Total retinol equiv. (µg)</td>
<td>2207</td>
<td>2258</td>
<td>2288</td>
</tr>
<tr>
<td>Na (mg)*</td>
<td>545</td>
<td>507</td>
<td>545</td>
</tr>
<tr>
<td>K (mg)</td>
<td>2454</td>
<td>2543</td>
<td>2496</td>
</tr>
<tr>
<td>P (mg)</td>
<td>4827</td>
<td>5106</td>
<td>4695</td>
</tr>
<tr>
<td>%RDI</td>
<td>396</td>
<td>421</td>
<td>403</td>
</tr>
<tr>
<td>%RDI</td>
<td>193</td>
<td>170</td>
<td>198</td>
</tr>
</tbody>
</table>
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 $1 \frac{1}{8}$ 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 mg (16 % RDI) of folate; in comparison with the male fruit choices of plums, kiwifruit and lychees which provided $\frac{20}{3}$ % 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 $\geq 19$ 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.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breakfast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wholegrain nasi lemak, egg, peanut, cucumber, dried fish sambal</td>
<td>2 slices grain toast, kaya paste</td>
<td>Kao tom</td>
<td>Beef pho</td>
<td>Grain roll, fried egg and soya sauce</td>
<td>Wholegrain congee, poached egg, soya sauce</td>
<td>Wholegrain ensaymada</td>
</tr>
<tr>
<td>200 ml tea</td>
<td>200 ml tea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR Wholegrain nasi lemak</td>
<td>2 slices grain toast</td>
<td>1 C brown rice</td>
<td>250 g soba noodles</td>
<td>200 ml tea</td>
<td>200 ml tea</td>
<td>200 ml tea</td>
</tr>
<tr>
<td>OR Malay nasi lemak</td>
<td>OR 2 slices white toast</td>
<td>OR 1 C brown rice</td>
<td>200 ml tea</td>
<td>OR 25 g Vietnamese bread stick</td>
<td>OR 200 ml tea</td>
<td>OR 200 ml tea</td>
</tr>
<tr>
<td>Morning tea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 g reduced-fat plain yoghurt</td>
<td>250 ml fortified soya beverage</td>
<td>200 g reduced-fat plain yoghurt</td>
<td>200 g reduced-fat plain yoghurt</td>
<td>250 ml fortified soya beverage</td>
<td>200 g reduced-fat plain yoghurt</td>
<td>250 ml fortified soya beverage</td>
</tr>
<tr>
<td>0-5 C sliced fruit</td>
<td>1 C sliced fruit</td>
<td>0-5 C sliced fruit</td>
<td>0-5 C sliced fruit</td>
<td>0-5 C sliced fruit</td>
<td>0-5 C sliced fruit</td>
<td>0-5 C sliced fruit</td>
</tr>
<tr>
<td>0-25 C mixed nuts, fruit and seeds</td>
<td>200 ml water</td>
<td>125 ml fruit juice</td>
<td>200 ml water</td>
<td>125 ml fruit juice</td>
<td>200 ml water</td>
<td>200 ml water</td>
</tr>
<tr>
<td>Lunch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 pieces brown rice sushi, soya sauce</td>
<td>Vietnamese rice paper rolls</td>
<td>2 wholegrain jaioz</td>
<td>2 wholemeal (whole-wheat) fish cakes</td>
<td>Asian vegetable soup</td>
<td>2 slices grain toast</td>
<td>1 C wholegrain lugaw</td>
</tr>
<tr>
<td>Steamed vegetables and tuna</td>
<td>2 C salad vegetables, soya sauce</td>
<td>2 fish balls, chilli sauce</td>
<td>1-5 C steamed vegetables, chilli sauce</td>
<td>250 g soba noodles</td>
<td>0-75 C soya beans</td>
<td>1-5 C steamed Asian greens</td>
</tr>
<tr>
<td>Seafood soup with seaweed</td>
<td>3 rice cakes with rye</td>
<td>Poached egg</td>
<td>1 C brown rice</td>
<td>1 chicken kebab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Afternoon tea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-25C Asian noodle, peanut and soya mix</td>
<td>1 C mixed fruit</td>
<td>14 brown rice crackers with fish spread and miso soup</td>
<td>200 g reduced-fat fruit yoghurt</td>
<td>1 C mixed fruit</td>
<td>200 g reduced fat fruit yoghurt</td>
<td>0-25 C peanuts</td>
</tr>
<tr>
<td>250 ml fortified soya beverage</td>
<td>200 ml water</td>
<td>250 ml fortified soya beverage</td>
<td>200 ml water</td>
<td>200 ml water</td>
<td>250 ml fortified soya beverage</td>
<td>200 ml water</td>
</tr>
<tr>
<td>Dinner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-75 C beef in black bean sauce</td>
<td>1 C miso with tofu, seaweed</td>
<td>1 fish fillet steamed</td>
<td>Miso-glazed salmon</td>
<td>Ginger chicken with Asian greens</td>
<td>Char kway teow</td>
<td>Dol sot bibimbap</td>
</tr>
<tr>
<td>1-5 C steamed vegetables</td>
<td>1-5 C Asian steamed greens</td>
<td>150 g kimchi, soya sauce</td>
<td>2 C steamed vegetables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 C green salad with dressing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 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 ocean sauce, soy sauce, preserved fish and seaweed. 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 food 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 and rice-based food meal plans was the 100 % RG plans having an average of 30 % less fibre than the 100 % WG plans. The difference in Na 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 3.5 g/100 g). Hence, overall the fibre content was 20 ml tea

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 C brown rice</td>
<td>1 C brown rice</td>
<td>1 C brown rice</td>
<td>250 g soba noodles</td>
<td>250 g soba noodles</td>
<td>250 g soba noodles</td>
<td>1 C brown rice</td>
</tr>
<tr>
<td>200 ml fruit juice</td>
<td>200 ml water</td>
<td>200 ml water</td>
<td>200 ml water</td>
<td>200 ml water</td>
<td>200 ml water</td>
<td>200 ml fruit juice</td>
</tr>
<tr>
<td>Supper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 C fruit salad</td>
<td>3 wholemeal (whole-wheat) pancakes</td>
<td>12 brown rice crackers</td>
<td>100 g tofu 'ice cream'</td>
<td>0.5 C fruit salad</td>
<td>0.25 C sago pudding</td>
<td>2.5 pieces dried fruit OR 1.5 tbsp sultanas/raisins 200 ml tea</td>
</tr>
<tr>
<td>200 ml tea</td>
<td>200 ml tea</td>
<td>200 ml tea</td>
<td>200 ml tea</td>
<td>200 ml tea</td>
<td>200 ml tea</td>
<td>200 ml tea</td>
</tr>
</tbody>
</table>

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/four filled dough pastry; bulgogi, 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; jiaozi, steamed meat-filled dumplings (China).

Each food group was represented by individual foods providing total for 7 d options.

In these plans the consideration of non-ferrous 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. In these plans the consideration of non-ferrous Fe and its interactions with vitamin C was also addressed to ensure the bioavailability was maximised.
Table 4 Daily nutrient values for rice-based (quasi-Asian) meal plans, mean and percentage of the Recommended Dietary Intake (%RDI)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>9–13 years</th>
<th>14–18 years</th>
<th>≥19 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100% WG</td>
<td>50/50</td>
<td>100% RG</td>
</tr>
<tr>
<td>Energy (kJ)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>CHO (g)</td>
<td>232</td>
<td>283</td>
<td>237</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>101</td>
<td>107</td>
<td>98</td>
</tr>
<tr>
<td>Total fat (g)</td>
<td>60</td>
<td>67</td>
<td>59</td>
</tr>
<tr>
<td>SFA (g)</td>
<td>15</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>MUFA (g)</td>
<td>20</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td>CHO (%E)</td>
<td>48</td>
<td>53</td>
<td>51</td>
</tr>
<tr>
<td>Protein (%E)</td>
<td>22</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Fat (%E)</td>
<td>29</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>SFA (%fat)</td>
<td>28</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>PUFA (%fat)</td>
<td>35</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>MUFA (%fat)</td>
<td>37</td>
<td>38</td>
<td>37</td>
</tr>
<tr>
<td>SFA (%E)</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>PUFA (%E)</td>
<td>9</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>MUFA (%E)</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Alcohol (g)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Alcohol (%energy)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Niacin equiv. (mg)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>248</td>
<td>277</td>
<td>248</td>
</tr>
<tr>
<td>Total folate (µg)*</td>
<td>620</td>
<td>943</td>
<td>620</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>465</td>
<td>513</td>
<td>465</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>110</td>
<td>116</td>
<td>110</td>
</tr>
<tr>
<td>Total retinol equiv. (µg)</td>
<td>3346</td>
<td>3880</td>
<td>3240</td>
</tr>
</tbody>
</table>

Mean values are presented, and %RDI is calculated as a percentage of the Recommended Dietary Intake.
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 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 of 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

### Table 4

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>10–12 years</th>
<th>13–14 years</th>
<th>15–18 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe (mg)</td>
<td>Mean 17</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Zn (mg)</td>
<td>Mean 12</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Dietary fibre (g)</td>
<td>26</td>
<td>28</td>
<td>24</td>
</tr>
</tbody>
</table>

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.
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**