Mandatory Folate Fortification:
Eat Your Bread

A major project submitted in partial fulfilment for the award of the degree Masters of Nutrition and Dietetics, University of Wollongong

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***Introduction*:** Despite public-health campaigns recommending peri-conceptional daily supplementation of folic acid (400µg/day), many women are failing to reach these recommendations. As a result, Food Standards Australia and New Zealand (FSANZ) have proposed mandatory folic acid fortification in bread-making flour in an effort to reduce the incidence of Neural Tube Defects (NTDs). The purpose of this study was to determine patterns of eating behaviour in women of childbearing age (18-45years), and to evaluate the appropriateness of bread-making flour as the selected medium for folic acid fortification.

Methods: A sample of 178 women aged between 18 and 45 years were recruited to complete a food frequency questionnaire (FFQ).

Results: Women of child-bearing age were found to consume sufficient amounts of fruit, vegetables and meat products, whereas bread and cereal intakes were significantly lower than recommended dietary guidelines of 4 serves per day (P= 0.000). Mean daily intake of bread was 3.6 slices (95% CI, 3.2–4.0 slices/day), indicating that with fortification dietary folate would increase to 112µg/day. This would meet FSANZ's prediction of an increase to 100µg of folic acid with fortification. However, it was revealed 50% of women of child-bearing age consuming less then 3 slices of bread per day will not benefit from fortification.

Discussion: Convincing evidence supports that increased folic acid intake among women of child-bearing age reduces the risk of NTDs. Although bread-making flour is an effective food vehicle for mandatory fortification, educational strategies are essential in promoting increased folate intakes in those women who currently would not benefit from fortification due to dietary choices.

Introduction

Despite many public-health campaigns, a substantial proportion of women of child-bearing age remain unaware of the need to take folic acid supplements during the peri-conceptional period, and an even higher proportion are not implementing these recommendations despite sufficient knowledge [(1)].

Folic acid is the most common synthetic form of folate, and is found to reduce the risks of serious foetal malformations and Neural Tube Defects (NTDs) [(2)]. The process of the neural tube closing is completed by day 22 to 28 after ovulation [(2)]. Incomplete closure of the neural tube may lead to one of the following three NTDs; Spina Bifida, Anencephaly or Encephalocele. In Australia, 300-350 pregnancies are affected each year by NTDs [(2)], of which 70% will result in a late-stage termination [(3)]. It is recommended that there is an increase of maternal folate consumption in at least the first month before and three months following conception, to reduce the risks of NTDs. A minimum consumption of 400µg of folic acid per day during this time is recommended [(2)]. This can be achieved through supplementation alone, or a combination of natural sources as well as supplementation. Foods containing a substantial amount of folate include leafy green vegetables, legumes, nuts, orange juice and some fruits [(3)].

Following international success and experience in fortification programs, Food Standards Australia and New Zealand (FSANZ) have proposed mandatory folic acid fortification of bread-making flour in an effort to reduce the incidence of NTDs [(2)]. The proposed level of mandatory fortification is 230-280µg of folic acid per 100g of bread-making flour, to achieve an average residual level of approximately 200µg folic acid in the flour component of the final food [(2)]. Fortification of bread-making flour will deliver a mean increase of 100µg of folic acid to women of child-bearing age, resulting in an estimated reduction of 14 - 49 out of 300 - 350 pregnancies affected by an NTD each year [(3)].

According to FSANZ, from a practical perspective bread-making flour is a suitable food vehicle for fortification. This is because products that contain bread-making flour are found to be stable and relatively low cost foods, and are regularly consumed

by the majority of the target population [4]. However, fortification may not reach all parts of the population, such as those groups who do not consume bread components in their diets [5]. Studies have shown that the average woman only eats 11 slices of bread per week, therefore at the proposed fortification level this would only provide one day's requirement of folic acid every 7 days [3, 19]. Further studies have also shown that 50% of women do not like to eat bread due to apparent weight gain, and only 5% of women will meet their folic acid requirements with the introduction of mandatory fortification from bread [3].

The purpose if this study was to determine patterns of eating behaviour in women of child-bearing age and to evaluate the appropriateness of bread-making flour as the selected vehicle for folic acid fortification. It was also the intention of this research to observe the relationship between body mass index (BMI) and bread intake, women's adherence to the Dietary Guidelines for Australian Adults (DGAA), the distribution of consumed bread and cereal products, and the comparison of mean serves of fortified and non-fortified bread and cereals.

Methods

Subjects:

This cohort study design was aimed to recruit as many women as possible between the ages of 18 - 45 years. All women were provided with an information sheet (Appendix 1) and were asked to complete a FFQ (Appendix 2). Participation was voluntary and women were sourced from 4 groups; The Royal Prince Alfred Allergy Unit who were either patients or mothers of children attending the clinic, University Nutrition students, women from Antenatal wards from Royal Prince Alfred Hospital and participants from the General Public.

The potential subjects received a package inviting them to participate in the study including:

1. A patient information sheet outlining the aims and procedures of the study (Appendix 1).
2. A food frequency questionnaire booklet (FFQ): Women's health, allergies, dietary preferences and supplement intake (Appendix 2).
3. A reply paid envelope for return of the questionnaire if they decided to participate.

Inclusion and Exclusion Criteria:

The inclusion criteria consisted of women within childbearing ages of 18 - 45 years. An exclusion criterion applied to those women who were not within childbearing age of 18 - 45years, and those who returned incomplete FFQ.

Ethics and Funding:

Ethics approval for researching women's health using FFQs was submitted to the Central Sydney Area Health Service (CSAHS) Ethics Committee in 2004 and was approved shortly thereafter. Amendments where put through for alterations to the questionnaires in 2006. Results from questionnaires were handled in confidence, and coded to ensure anonymity when entered into the password secured database at RPAH Allergy Clinic. Funding was provided by the Royal Prince Alfred Hospital Allergy Unit.

Study Design:

The FFQ is an extensive questionnaire booklet (Version: 1, Adult 06/04) which was developed by the RPAH Allergy Unit in 2003 with the intention to collect data about women's health, allergies, dietary preferences and supplement intake (Appendix 2). It gathers specific information about the participant and consists of five separate sections. The questionnaires were distributed to the selected sub-groups and a Reply Paid envelope was provided. Each questionnaire had an introduction section which was comprised of the following segments; *'About You'*, '*About You and Known Allergies or Intolerance', 'About your Environment'*, '*About your Children'* and the final section gathered information about *'Your Eating Habits'*. The questionnaires were returned for analysis to the RPAH Allergy Clinic via postal service or returned to the Allergy Unit.

Materials and Procedures:

Food Frequency Questionnaire:

'Women's health, allergies, dietary preferences and supplement intake'

The first section *'About You'* asks for information regarding height, weight, age, current work, travelling time, levels of activity, illnesses and medication. There is a general health checklist for symptoms of allergy or intolerance and asks the participant to indicate how much of each of the 32 statements has applied to them in the previous six months.

The second section *'About you and Known Allergies or Intolerances'* asks about children and pregnancy and/ or breastfeeding status of the participant. If the woman answers 'yes' to either pregnant or breastfeeding it then asks whether they are modifying their diet in any way to reduce the risk of their child developing allergies. This section also contains questions regarding known allergies and intolerance reactions for both the woman and the father of the child to answer (if applicable).

The third section *'About your Environment'* gathers information about home and visited environments to determine possible causes of symptoms within these environments.

The fourth section *'About your Children'* collects information about children (if applicable) and causative factors in the child's general environment. Future studies will cross-reference these responses against previous answers regarding the parent's allergy or intolerance status.

The fifth and final section is a FFQ titled *'Your Eating Habits'* and gathers a detailed record of eating habits over the last three months.

Data analysis:

On return of the FFQs, information provided in sections one to four was entered into the RPAH patient database (RPAH Allergy Unit Patient Database 2006). Data provided in section five was entered into Microsoft Excel 2002 (Microsoft Corp, USA), and was used for data calculations and figures. Subjects were separated into 4 subgroups which included; 19 - 29 years, 30 - 39 years, 40 - 45 years and a combined group of 19 - 45 years to enable observations of certain trends.

The following was explored:

(1) Adherence to nutritional guidelines for Australian Adults in women aged 19 - 45years
(2) Distribution of bread and cereal products consumed in women aged 19 - 45years
(3) Relationship between BMI and bread intake
(4) Comparison of average serves per day for fortified and non fortified breads and cereals

Statistics were generated using the Statistical Package for the Social Sciences (SPSS version 13.0 for Windows, Chicago IL, USA), and Microsoft Excel. Group data was compared with the reference group using SPSS One Sample *t*-tests, and for statistical tests a P-value of < 0.05 indicated a significant difference between groups.

Results

For the analysis, SPSS and Microsoft Excel was used to determine comparisons of eating patterns in women aged between 19 - 45years (n= 178).

Response:

Since 2003, 1,300 questionnaires have been distributed; of those 252 have been returned giving a response rate of 20%. From the returned questionnaires 178 were used for analysis in this study.

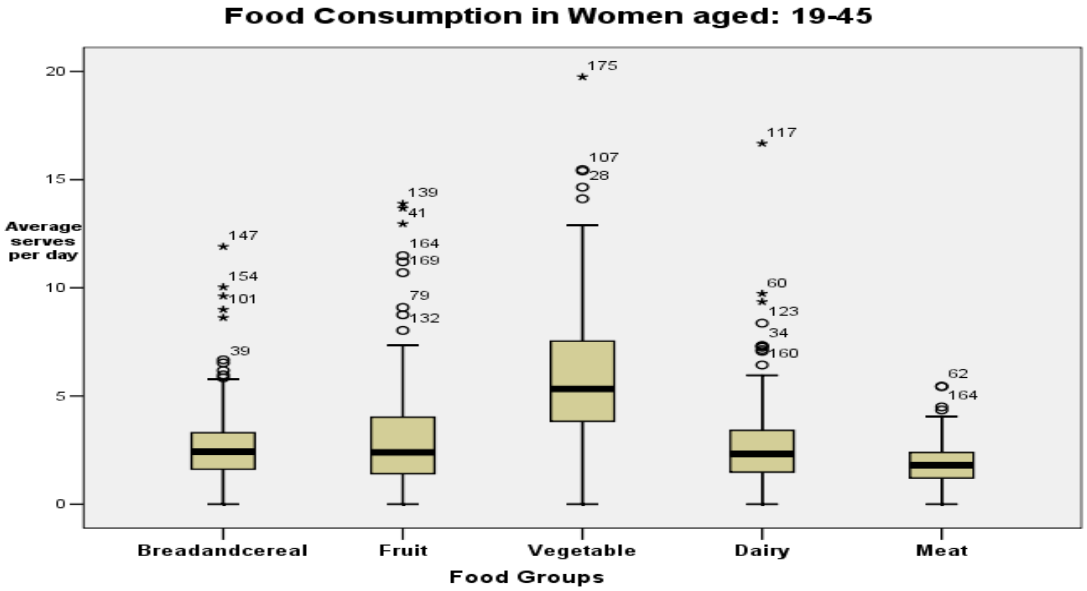
The mean age of participants was 35 years with the youngest at 19 and oldest 73 years. The mean BMI of participants was 23.8kg/m^2; the lowest being 16.3kg/m^2 and the highest 57.6 kg/m^2.

Participants were divided into the following subgroups:

Subgroups (years)	Total number of volunteers
19-45	N= 178
19-29	N= 58
30-39	N= 98
40-45	N= 22

Adherence to Dietary Guidelines:

Figure 1



Women of child-bearing age are consuming sufficient amounts of fruit, vegetables and meat products. Dairy consumption was found to be marginally meeting dietary requirements (P = 0.14), whereas bread and cereal intakes were significantly lower when compared to the DGAA (P = 0.000).

Table 1

Two values are provided in the DGAA for various food groups, which allows for special eating patterns (Appendix 3). The minimum of these values was used for graphical representation and statistical analysis.

Food Group	DGAA Recommendation	Mean serve per day	P value One sample *t*-test
Bread & Cereal	4	2.7	P= 0.00 *
Fruit	2	3.1	P= 0.00 **
Vegetable	5	5.9	P= 0.00 **
Dairy	3	2.8	P= 0.14
Meat	1	1.9	P= 0.00 **

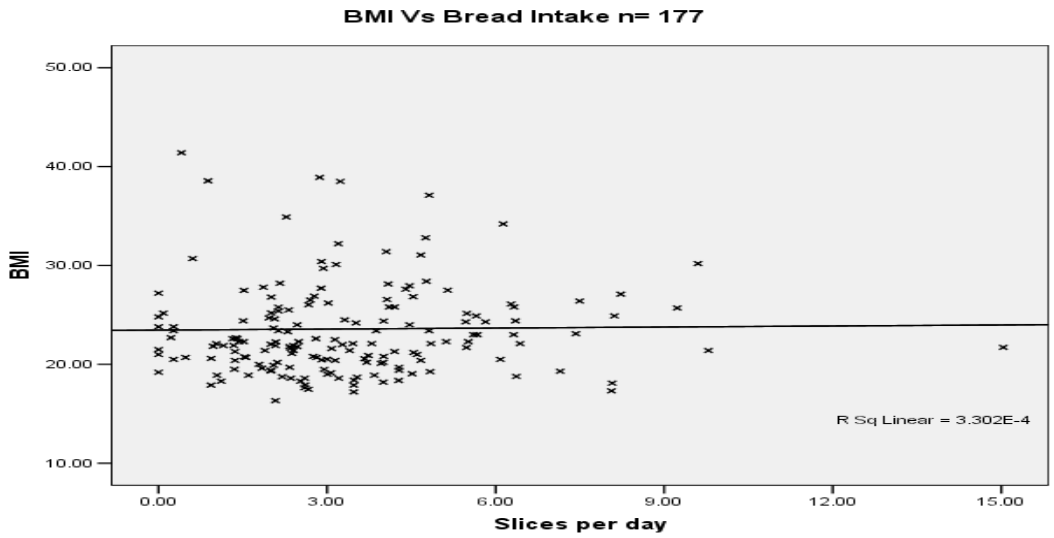
Note: One serve of bread is equivalent to two slices of bread

* Significantly lower than DGAA

** Significantly higher than DGAA

Relationship between Body Mass Index (BMI) and bread intake:

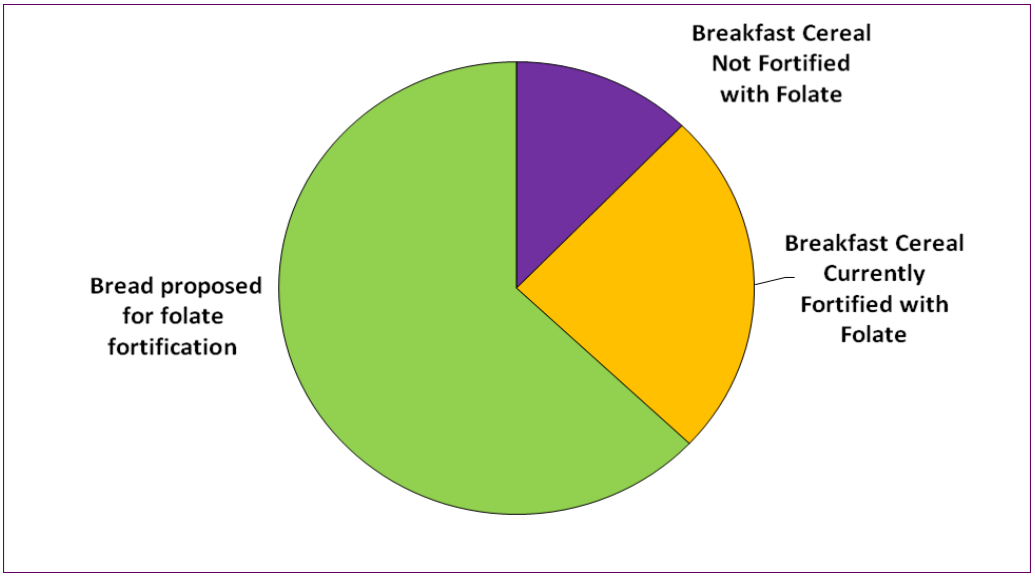
Figure 2



This scatter plot represents bread intakes of women of child-bearing age compared with their individual BMIs. BMI values ranged from a minimum of 16.3 kg/m^2 to a maximum of 57.6 kg/m^2. The mean BMI value for the study population was 23.8kg/m^2. There was found to be no correlation between increased BMI and total number of bread slices per day, (R2= 0.018, P= 0.810).

Distribution of bread and cereal products consumed in women aged 19 - 45y:

Figure 3

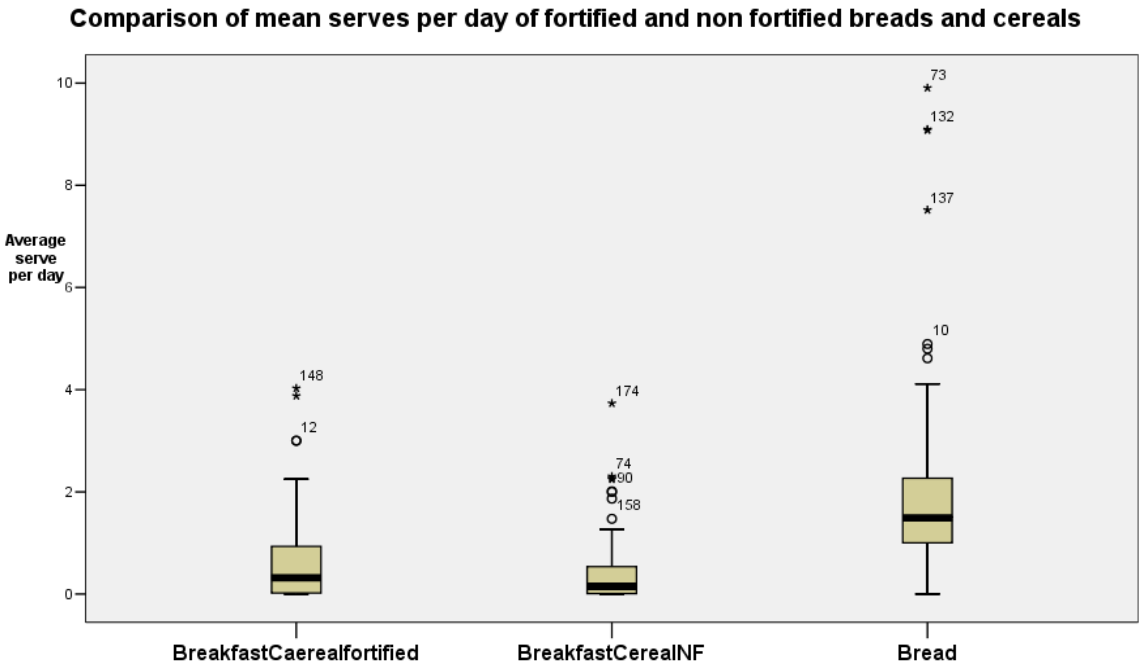


This graph represents an overall view of bread and cereal consumption in women of child-bearing age. Within the study population, one quarter (25%) are consuming

folate fortified breakfast cereals, 12% are consuming non-folate fortified breakfast cereals, and the remaining percentage are consuming bread products which are currently under proposal for folate fortification (63%).

Folate Fortification:

Figure 4



When comparing mean serves of bread per day of fortified and non-fortified breads and cereals, it was established that the mean daily intake of bread was 3.6 slices (95% CI 3.2-4.0 slices/day). Hence, it seems that 50% of women of child-bearing age consuming less then 3 slices of bread per day will not benefit from fortification.

Discussion

The purpose of this project was to determine patterns of eating behaviour in women of child-bearing age and to evaluate the appropriateness of bread-making flour as the selected vehicle for folic acid fortification. Their adherence to the DGAA was also assessed and they were found to consume sufficient amounts of fruit, vegetable and meat products in their diet. However, they were significantly low in bread and cereal consumption (Table 1). The comparison of mean serves of fortified and non-fortified bread and cereal products showed that 50% would not benefit from folic acid fortification due to insufficient bread consumption (Figure 4). There was no correlation between BMI to bread intake, hence bread appears not to be associated with weight gain in this study population.

Women in this study were typical of those from economically developed countries, who have been shown to consume relatively low amounts of calories from cereals, tubers and other starchy foods [(9)]. The low intake of calories from bread and cereals was evident as mean intakes were below minimum values suggested by the DGAA [(Figure 1 and 3) Appendix 3]. This trend may be associated with the incidence of eating trends within today's society, where particularly adolescent women are following strict low carbohydrate diets such as the Atkins, in hope of a putative effect on their waistlines [(5)]. It is speculated that if the daily consumption of these foods is increased, an increase in BMI also increases, leading to weight gain [(5)].

The reported consumption of fruit and vegetables by participants (Figure 1 and Table 1) is an improvement from the results of the 1995 National Nutrition Survey which found women aged 19-64 consumed an average of only 44% and 46%, of the suggested intake of fruit and vegetables per day respectively [(6)]. The high intake of vegetables in women when compared to fruit is possibly due to seasonal variances of foods, as the majority of this data was collected during winter months. The mean intake of dairy foods was found to be adequate in all subgroups of women (Figure 1 and Table 1), even though some women were marginally meeting suggested recommendations (P= 0.136) (Table 1).

Trends showed that all subgroups of women consumed 'extra foods' in excessive quantities, a result that coincides with the increased prevalence of obesity in society today. It has been shown that increasing the intake of energy dense snack foods does not always correspond with increased levels of fullness [7]. The lack of correlation between the consumption of bread and BMI (Figure 2), suggests the calories consumed from 'extra foods' replaced those of other food groups such as cereals, rather than in addition with other food groups. The BMI values ranged from 16.3 to 57.6 kg/m^2 with a mean BMI value of 23.8kg/m^2, falling within the 'healthy range' [8]. Although some outliers were present, the results are consistent with findings typical of dietary surveys showing that underreporting is common among overweight respondents [7, 14].

Due to there being no sufficient evidence of a correlation between bread intake and weight, it can only be concluded that within this population bread consumption is clearly not a marker of weight gain. Trends in energy consumption are difficult to establish because of a variety of measurement issues. This introduces a systemic bias, resulting in the paradoxical observation that obese individuals appear to eat less than lean people [14]. Further analysis of this data may alleviate some of the expressed concerns regarding inadequate reporting of food intake.

The move to reduce the incidence of NTDs in women of child-bearing age through fortification of bread-making flour still remains an issue of concern. The entire population, not just women of child-bearing age could be exposed to potential health risks [3]. Diseases investigated for a potential inverse association with increased folic acid intakes are cardiovascular disease, some cancers, diseases associated with cognitive functions and masking the diagnosis of vitamin B_{12} deficiency [2]. Although there was once thought to be an association between increased folic acid and homocystenie for the development cardiovascular disease, evidence still remains uncertain [11, 18]. There are several studies suggesting the possibility of a detrimental component to the role of folate in carcinogenesis [11, 22]. However, other evidence shows those doses of folic acid much higher than that achieved through fortification, have inconclusive protective effects on cancer and/or cognitive functions [2, 23].

There are potential health risks and uncertainties associated with increased folic acid intakes in particular intakes of up to 1,000µg/day, which is the upper limit level [2]. It is important to recognize that the upper limit refers to the amount of synthetic folate (folic acid) being consumed per day from fortified foods and/or supplements. There is no health risk and no upper limit for natural sources of folate found in food [11, 16].
There are concerns that high levels of folic acid could mask vitamin B_{12} deficiency, particularly in the elderly, leading to neurological damage [11]. Among countries that have introduced mandatory fortification with folic acid, there have been no reports of adverse effects on neurological function, especially in people aged 65 years and over with low vitamin B_{12} status [2]. The upper limit for folic acid has been set on the basis of masking the diagnosis of vitamin B_{12} deficiency at high doses. However, in the absence of vitamin B_{12} deficiency, there is little information on adverse effects which may occur at levels above the upper limit [11].

From a practical perspective, bread-making flour is considered a feasible vehicle due to it widely and regularly being consumed by the target population. When comparing mean serves of bread per day of fortified and non-fortified breads and cereals, it was established that mean daily intake of bread was 3.6 slices (1.8 serves/day). This indicates that with fortification, dietary folate intake would increase by 112µg/day (Figure 4). This stipulates FSANZ's prediction of an increase to 100µg/day of folic acid with fortification [2], resulting in an estimated reduction of 14 – 49 pregnancies affected by an NTD each year [3, 14]. Further evidence from the National Nutritional Survey [6] indicates that 83% of Australian women of child-bearing age consume products containing bread-making flour [2, 15], which further emphasises the appropriateness of bread-making flour as a valid fortification vehicle.

However, it was revealed that 50% of women within the study population consumed less than 3 slices of bread per day, indicating they will not benefit from fortification due to dietary choices (Figure 4). According to the Australian Food and Grocery Council, bread-making flour is an incorrect vehicle for fortification due to the average woman only eating 11 slices of bread per week [3, 19]. This indicates that at the proposed fortification level set by FSANZ; only one day's requirement of folic acid would be provided every seven days [3, 19].

Data from previous studies show that only 5% of women will meet their folic acid requirements with mandatory fortification of bread, while the remainder of the population will continue taking supplements and obtaining natural food sources of folate to ensure they are meeting their daily requirements of 400µg [3, 14].

Limitations and Recommendations:

For results to be generalised to the greater population, recruitment of subjects need be less bias toward those attending the Allergy Unit and Nutrition Students. Current alterations to the format of the FFQ will assist in increasing its validity as well as gaining further information about certain focus topics.

Of the various approaches to collecting information regarding dietary intake, FFQs are quicker and easier than diet records, but are also considered to be less accurate [10, 17]. The FFQ used in this project was developed to provide information regarding the types of foods consumed, with particular attention directed on allergenic foods. The 'other' foods that were manually listed in the FFQ by participants were not calculated into spreadsheet totals (Appendix 2 and 4) due to time constraints and it is possible that not all results were reliable estimates of actual quantities consumed. Minor alterations to the format of this FFQ have currently been developed which will in the future reduce misinterpretation, and hence increase its validity (Appendix 6).

Conclusions

This project has shown that women of child-bearing years are consuming sufficient amounts of fruit, vegetables and meat products supplying them with adequate amounts of folate through natural food sources. However, they are marginally meeting their dairy recommendations, and are consuming significantly lower intakes of bread and cereal products compared with dietary guidelines. Convincing evidence supports that increased folic acid intakes among women of child-bearing ages helps to reduce the incidence of neural tube defects prior to conception and during pregnancy. Although bread-making flour is an effective food vehicle for mandatory fortification in women who are consuming bread based products, educational strategies are essential for promoting increased folate intakes in those women who currently would not benefit from fortification due to dietary choices.

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