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Food groups and fatty acids associated with self-reported depression: an analysis from the Australian National Nutrition and Health Surveys

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Abstract
Objective The aim of this study was to explore the associations between incidence of depression and dietary intakes of foods and fatty acids in adult Australians. Methods Data from the 1995 Australian National Nutrition Survey (NNS), the 1995 Australian National Health Survey (NHS) and an updated fatty acid database were merged and the 24-h fatty acid intakes were calculated for the 10 986 adult participants ages 18 to 79 y in the 1995 NNS. The merged data set was used to run a logistic regression with depression as the response variable and the food groups and calculated fatty acid values, age, and sex as predictors. Results The regression model indicated that increased intakes per kilojoule of meat, poultry, and game; vegetables; and eicosapentaenoic acid (EPA) are associated with lower odds of having depression, whereas increased intakes of non-alcoholic beverages, milk products and dishes, and docosapentaenoic acid (DPA) are associated with an increase in the odds of having depression. The results confirm a collective effect of diet on mood. Although other studies have shown that fish consumption is associated with lower odds of depression, this study showed lower odds of depression with high meat consumption, possibly reflecting the fact that Australians consume six times more meat than fish. Conclusion Significant associations between food and mood identified in this study warrant further research to determine causality.

Keywords
food, health, groups, surveys, reported, self, depression, associated, analysis, australian, acids, national, nutrition, fatty

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Medicine and Health Sciences | Social and Behavioral Sciences

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Food groups and fatty acids associated with self reported depression: An analysis from the Australian National Nutrition and Health Surveys

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Abstract:

Objective: To explore the associations between incidence of depression and dietary intakes of foods and fatty acids in adult Australians.

Methods: Data from the 1995 Australian National Nutrition Survey (NNS), the 1995 Australian National Health Survey (NHS) and an updated fatty acid database were merged and the 24-hour fatty acid intakes were calculated for the 10,986 adult participants aged 18-79 years in the 1995 NNS. The merged dataset was used to run a logistic regression with depression as the response variable and the food groups and calculated fatty acid values, age and sex as predictors.

Results: The regression model indicated that increased intakes per kilojoule of meat, poultry and game, vegetables, and eicosapentaenoic acid (EPA) are associated with lower odds of having depression, whilst increased intakes of non-alcoholic beverages, milk products and dishes and docosapentaenoic acid (DPA) are associated with increased odds of having depression. The results confirm a collective impact of diet on mood. While other studies have shown that fish consumption is associated with lower odds of depression, this study showed lower odds of depression with high meat consumption, possibly reflecting the fact that Australians consume six times more meat than fish.

Conclusion: Significant associations between food and mood identified in this study warrant further research to determine causality.

Introduction:

The prevalence of depression in the USA has more than doubled over ten years, and it is a major cause of morbidity and disability in the western world [1]. Depression is among the ten leading conditions causing disability in Australia [2]. Gender differences are well documented with a higher prevalence of depression in women [3-5].

The effect of food on mood is a complex area [6]. Some studies have shown beneficial effects of the Mediterranean diet (specifically fruit and nut consumption, monounsaturated to saturated fat ratio and legumes) [7] whilst others have shown benefits of meat and vegetable consumption on depression [3] or fruit and vegetables being associated with reduced depressive symptoms [8,9] whilst energy dense foods being associated with increased depression [8]. These poorer food choices can become a vicious cycle in that foods consumed affects mood but also mood affects food choices [10].

It was noted that fish consumption correlated negatively with the prevalence of major depression in a large cross national study [11]. There are many more studies that have shown beneficial effects of fish consumption on depression [4,5,12-17]. Fish is a rich source of long chain omega-3 polyunsaturated fatty acids (LC n-3 PUFA) [17]. Recent research reflects an increasing awareness of the importance of n-3 and n-6 PUFA in the pathogenesis and management of depression and other mood disorders [18,19]. Some studies show the direct protective effect of LC n-3 PUFA on depression [5], whilst other studies show that a low n-6 to n-3 PUFA ratio is important [20]. More recently a prospective study shows no protective effect of LC n-3 PUFA on depression, but a high ratio of alpha-linolenic acid to linoleic acid is associated with a reduced risk of depression [21].

In order to elucidate the role of these fatty acids in people with depression, several randomised controlled trials of PUFA supplementation have been done in patients with depression. Some of these have shown significant improvements in the condition of the patients [22-24] while others are equivocal [25-27]. Such inconsistency in results may have been due to a difference in the PUFA type and dose used in different studies, relatively small sample sizes, and use of non-pharmacological interventions such as counselling in both the control and intervention groups [26].

An updated meta-analysis of the effects of LC n-3 PUFA on people diagnosed with depression concluded that there is evidence for the effect of LC n-3 PUFA on mood, but recognising that there is great heterogeneity amongst the studies [28]. Furthermore, most trials have used a combination of EPA and DHA and it is unclear which is more important or if a combination is important,

although a recent meta-analysis suggests that EPA may be more efficacious than DHA in treating depression but more research is warranted [29].

Given that some studies have shown the benefits of certain foods in relation to risk of depression, while other studies have focussed on specific fatty acids in relation to risk of depression, no studies have assessed foods and fatty acids together. Therefore the aim of this study was to determine if there was an association between food groups as well as dietary PUFA intakes and depression in an Australian population using the 1995 Australian National Nutrition and Health Surveys together with an updated fatty acid database.

Experimental methods

Data

Data for the present study were obtained from three sources: the Australian National Health Survey (NHS) of 1995, the Australian National Nutrition Survey (NNS) of 1995 [30] and a fatty acid database [31].

The 1995 NHS collected data about the health status, use of health services and health-related lifestyle of 57,633 people from 21,787 households across Australia [32]. The NNS was conducted on a subset of the respondents to the NHS, and included data from 10,986 adult individuals. Trained personnel administered the NNS and collected data regarding the 24-hour food intake of the participants, frequency of consumption of various foods, and data regarding health status [33]. The NNS and the NHS data were available in the form of a confidentialised unit record file (CURF) released by the Australian Bureau of Statistics for research purposes. No ethics approval was required or sought because the Australian Bureau of Statistics collected the data as part of their statutory obligation to collect data that does not require ethics. The data was made available to universities with conditions of use as outlined in their technical paper [34]. The fatty acid database (FA database) was the updated [35] fatty acid extension of the Australian Nutrient (AUSNUT) database from the Food Standards Australia and New Zealand (FSANZ). It contained updated quantities of fatty acids for different types of foods, coded with the same food codes as in the NNS 1995.

The participants were asked of any recent illness (defined as ‘medical conditions during the two weeks prior to the interview’) or long-term illness (defined as ‘conditions that lasted at least six months or which the respondent expects to last for six months’) that they had suffered. The responses of both recent and long-term illnesses were coded as conditions suffered according to a classification based on the ICD-10 classification of diseases [32]. Depression was one of these medical conditions. The data therefore included those with depression at the time of the survey or within six months prior to it.

Merging and Calculation

Merging files from the three sources, calculation and statistical analyses were conducted using Statistical Analysis Software version 9.1 [SAS; SAS Institute Inc., Cary, NC, USA].

The NNS and NHS data were merged as described in the NNS CURF technical paper [30]. Food codes were used to merge the fatty acid data from the FA database to this merged NNS-NHS dataset. Subsequently, the total intake of each of the fatty acids per day for each person was calculated.

Study participants

The present study included all those participants for whom both the 1995 NNS and the 1995 NHS data were available: 10,986 adult Australians aged 18 and above were included [32].

Statistical analysis

The sex, age, certain food groups, EPA and DPA were included as predictor variables and self reported depression was included as the response variable and logistic regression was performed using SAS 9.1 [SAS Institute Inc., Cary, NC, USA] and the odds ratios and 95% confidence intervals were estimated. A p-value of less than 0.05 was considered as significant in this study.

Modified variables: The data covered a wide interval of ages and therefore it was presumed that modeling age as a linear predictor would be inadequate. Among various alternative approaches, including both age and its square root as linear predictors proved effective in modeling the non-linear influence of age on depression.

Stepwise elimination of non-significant variables led to a preferred model with nine predictors: sex, age, square root of age, and intake measures for four different food groups, EPA and DPA. The four different food groups were: non-alcoholic beverages, meat poultry and game, milk product and dishes, and vegetable products and dishes.

Results

The population characteristics of the participants have been described elsewhere [35]. Table 1 shows the number of participants with and without depression grouped by sex and age categories, with similar representation of both sexes (48% males and 52% females). A majority of the participants (57%) belonged to the middle age group of 25 to 64 years.

The best logistic regression model (Table 2) showed that, in addition to age ($p=0.031$) and gender ($p<0.0001$), intakes of the following four food groups and two fatty acids were significant predictors of depression: meat, poultry and game products ($p=0.002$); milk products and dishes ($p=0.009$); non-alcoholic beverages ($p=0.01$); vegetable products and dishes ($p=0.015$); EPA (0.027); and DPA ($p=0.0291$). The n-6:n-3 ratio was not significant and did not contribute to the regression model. The intakes of the four food groups and fatty acids are shown in Tables 3 and 4. Men with depression had 25% significantly lower intakes of meat ($p<0.05$) and arachidonic acid ($p<0.05$) compared to men without depression (Table 3). Women with depression had 20% significantly increased intakes of non-alcoholic beverages ($p<0.05$) and milk products and dishes ($p<0.05$) compared with women without depression (Table 4). There was also a 12% lower intake of vegetable products and dishes in women with depression compared to women without depression but this did not reach significance ($p=0.062$). Alcohol and/or fish consumption did not contribute to the prediction of depression in males, females or the whole adult population.

The data set covered a wide interval of ages and hence it was presumed that modeling age as a ‘linear’ predictor would be inadequate. Among various alternative approaches, including both age and its square root as ‘linear’ predictors proved effective in modeling the ‘non-linear’ influence of age on depression. The probability of having depression was estimated using the regression equation from the best fitting model (Table 2). Figure 1 is based on arbitrarily setting each food group and fatty acid intake to its median level and plotting the effect of change in age and sex. It shows that depression increases with age until it peaks around 52 years of age and then reduces with further increase in age. Figure 1 also shows that the probability of having depression is almost twice as much in females as in males.

Discussion

This cross-sectional study showed that people with high intakes of meat, poultry and game products and dishes, vegetables and EPA have lower odds of depression and people with high intake of non-alcoholic beverages, milk and milk products and dishes and DPA have higher odds of depression. The effect of age and sex on self reported depression (figure 1) is highly consistent with other literature where depression was not self reported and these effects were comparable to that observed in the Australian National Survey of Mental Health and Well Being of 1997 [36]. This study is based on Australian National data, but it is conceivable that other countries with similar demographics and diet to Australia (e.g. the USA), these results may be applicable to those countries, but not to countries where fish and seafood consumption is much greater than Australia (e.g. Japan), as fish and seafood has been linked to reduced odds of depression [4,5,12].

A randomised trial that compared behavioural counseling with nutritional counseling to increase fruit and vegetable consumption in people with a low-income neighborhood showed that consumption of these foods improved their physical health status and self-rated health [37]. Another study showed that men and women classed as “healthy cluster” (higher fruit, vegetable and fish consumption) had lower errors in the Mini Mental State Examination [38] and the women in the “healthy cluster” had borderline lower depressive symptoms [38]. A study from the UK reported higher fruit and vegetable consumption was associated with better physical functional health [38]. These studies support the current finding that increased vegetable consumption is associated with reduced odds of depression.

Fish consumption has also been linked to depression [11]. A low frequency of fish consumption was associated with depression in women (but not men) in a Finnish birth cohort study [4]. Infrequent fish consumption (less than once per week) is associated with increased odds ratio of depression of 31% in Finland, which when re-analysed per sex category, women (but not men) were affected [12]. Given that approximately twice as many women suffer from depression than men (as is the case in this study), there is more statistical power to see an effect of food in women than men. Furthermore, some studies showed that higher dietary intake of fish is inversely associated with depressive symptoms [4,5,12] yet this observation was not observed in this study. One potential explanation is that the number of people who regularly consume fish is quite low (as shown in Tables 3 and 4, where the 75^{th} percentile of fish intake is zero) and it is difficult to show associations with limited data.

Fish is the richest sources of LC n-3 PUFA [17] and depletion of LC n-3 PUFA in erythrocyte membranes has been reported in people suffering from depression [39,40]. Some intervention studies of LC n-3 PUFA supplementation have shown improvements in scores of depression as reviewed by Sinclair *et al.* [41]. Furthermore, the American Psychiatry Association endorses the

American Heart Association's dietary guidelines of 1g/day of EPA plus DHA in the treatment of psychiatric disorders, especially given the negligible risks associated with increased consumption of LC n-3 PUFA [42].

Whilst fish may be the richest source of LC n-3 PUFA, meat, poultry and game also contain LC n-3 PUFA [35]. Australia is a nation of low fish/seafood consumption with the average intakes being only 26g per day, whilst consumption of meat, poultry and game is six times higher at 158g per day [43]. In this study consumption of meat, poultry and game is associated with reduced odds of depression. Moreover, EPA was also associated with reduced odds of depression and, in Australians, meat contributes approximately half of the LC n-3 PUFA intakes [35,44]. Therefore this six-fold difference in fish/seafood and meat consumption could explain the associations seen with depression observed in this current study. Meat not only contains EPA, but also DPA, another LC n-3 PUFA [44]. In this study, increased consumption of DPA is associated with increased odds of depression. This is contrary to the effects of EPA and meat on depression and it is unclear why this is the case.

While the exact role of the various PUFA in the pathogenesis of depression is unclear, it is suggested that the metabolism of fatty acids in people diagnosed with depression is abnormal, as indicated by the changes in the phospholipid concentrations of long chain PUFA [45]. Maes *et al.* [45] showed that major depression was associated with reduced eicosapentaenoic acid (EPA; 20:5n-3) and docosapentaenoic acid (DPA; 22:5n-3) fractions in phospholipids, reduced alpha-linolenic acid (ALA; 18:3n-3), EPA and total n-3 in cholesteryl esters and increased arachidonic acid (AA; 20:4n-6) to EPA ratio in both phospholipids and in cholesteryl esters. It has also been shown that depression is directly associated with increases in the ratios of n-6 PUFA to n-3 PUFA and of AA to EPA concentrations in plasma and erythrocytes [20,45,46].

Foods that are linked to increased odds of depression are non-alcoholic beverages and milk, which taken together suggests the consumption of tea and coffee as these beverages are often drunk with milk. This is contrary to the reported negative correlation between consumption of tea and depression in a Finnish population, where daily tea consumption was associated with a 53% reduction in the odds of depression [47]. However, the authors acknowledge that Finland is a coffee drinking nation with 86% of Finnish people drinking coffee daily and only 27% of Finnish people drink tea daily. The authors suggest that perhaps this minority tea drinking group could be more health conscious and that the lower depression rates are associated with factors other than tea [47].

Coffee and tea contains caffeine and it is certainly well known that caffeine is associated with increased alertness and an increase in the capacity to process information [48]. It is conceivable that people with depression are consuming these non-alcoholic beverages to provide these effects and that could explain why they are associated with depression. Non-alcoholic beverages such as

soft drinks (sweet drinks or soda) consumption has also been shown to be positively associated with depression [49].

Limitations of this study include 1) the lack of severity of depression and the self –reported data on depression; 2) old National Nutrition and Health Survey Data from 1995 and 1996 and may not be representative sample in 2012; and 3) using 24 hour food intake recall data. However, firstly, the age and gender effect (figure 1) is highly consistent with other literature where depression was not self reported. Secondly, the National Nutrition and Health Survey Data was collected in 1995 and 1996, but there is a new Australian National Health Risk Survey currently being conducted and new National Data should be available in 2013 which can be similarly analysed. Thirdly, whilst 24 hour food intake recall data may miss foods not eaten regularly, like fish/seafood, food frequency data was also collected at the same time and there were no differences between 24 hour recall data and the food frequency data The strengths of this study are the sample size and that it is representative of the Australian population.

In conclusion, in Australian adults increased intakes of vegetables, meat, poultry, game and EPA were associated with reduced odds of depression, whilst increased intakes of non-alcoholic beverages, milk and DPA were associated with increased odds of depression. These findings warrant further investigation into causality.

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BJM, NK, DAG, BG, PRCH, IK initiated the study, interpreted the results and contributed to writing the manuscript; BG and NK conducted the data analysis; BJM wrote the manuscript with input from all co-authors.

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Figure 1: Effect of age on the estimated probability of having depression (at survey or within six months prior to survey) calculated using logistic regression equation for men and women ($p<0.001$)
P = Probability

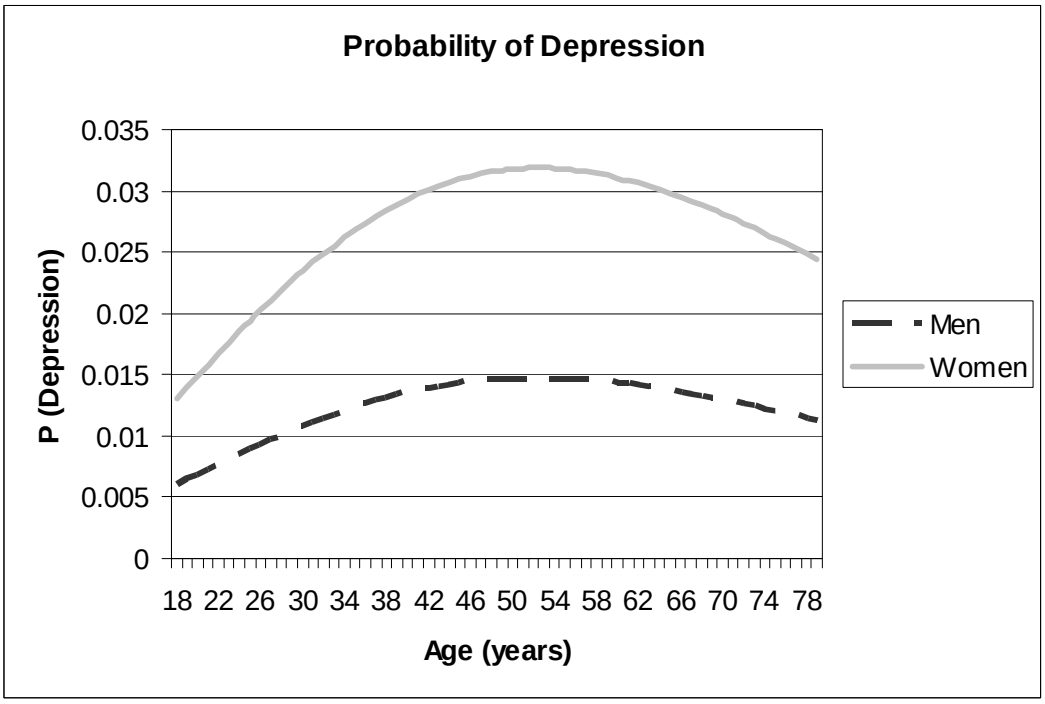

Table 1. The entire adult population (n=10,986) divided into the number of participants per sex and age group.

		N	% of total population	N with Depression	% in age group with depression
Males	18-24 yrs	550	5%	4	0.7%
	25-34 yrs	1084	10%	12	1.1%
	35-44 yrs	1056	10%	14	1.3%
	45-54 yrs	882	8%	15	1.7%
	55-64 yrs	672	6%	8	1.2%
	65-79 yrs	781	7%	12	1.5%
	Over 80 yrs	121	1%	1	0.8%
	Total	5146	47%	66	1.3%
Females	18-24 yrs	645	6%	11	1.7%
	25-34 yrs	1268	12%	30	2.4%
	35-44 yrs	1117	10%	36	3.2%
	45-54 yrs	987	9%	34	3.4%
	55-64 yrs	765	7%	23	3.0%
	65-79 yrs	886	8%	22	2.5%
	Over 80 yrs	172	2%	2	1.2%
	Total	5840	53%	158	2.7%
Total	18-24 yrs	1195	11%	15	1.3%
	25-34 yrs	2352	21%	42	1.8%
	35-44 yrs	2173	20%	50	2.3%
	45-54 yrs	1869	17%	49	2.6%
	55-64 yrs	1437	13%	31	2.2%
	65-79 yrs	1667	15%	34	2.0%
	Over 80 yrs	293	3%	3	1.0%
	Total	10986	100%	224	2.0%

[1] All mentioned percentages have been calculated as percent of 10,986; the sum of all percentages does not add up to the total percentage due to rounding.

Table 2: Summary of logistic regression analysis showing significant variables

Summary of Regression					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	p- value
Intercept	1	-9.51	2.22	18	<0.0001
Age (yrs)	1	-0.10	0.051	4.0	0.046
Square root of age (yrs)	1	1.47	0.679	4.7	0.031
Sex_f	1	0.79	0.152	27.3	<0.0001
Non-alcoholic beverages (ml % per energy)	1	0.21	0.08	6.7	0.010
Meat, poultry and game (mg % per energy)	1	-29.9	9.64	9.6	0.002
Milk products and dishes (mg % per energy)	1	10.1	3.87	6.8	0.009
Vegetables (mg % per energy)	1	-15.7	6.48	5.9	0.015
EPA (mg % per energy)	1	-40.7	18.4	4.9	0.027
DPA (mg % per energy)	1	69.0	25.7	7.2	0.0291

Table 3 The mean, SD, median, 25th and 75th percentile of intakes from major foods groups and fatty acids in adult men (18-79 yrs) with and without depression.

	No depression (n=10762)					With Depression (n=224)				
	Mean	SD	Median	P25	P75	Mean	SD	Median	P25	P75
Energy (kJ)	11056	4273	10389	8111	13227	10108	3179	10235	8425	12064
Food group (g/d)										
Non-alcoholic beverages	1298	834	1171	761	1696	1228	894	1062	589	1548
Alcoholic beverages	435	822	0	0	529	376	780	0	0	381
Alcohol	19.4	34.1	0	0	28.6	21.0	47.4	0	0	25.4
Fish and seafood products & dishes	34	103	0	0	0	42	108	0	0	0
Meat, Poultry, Game products & dishes*	298	272	229	112	413	225	203	191	73	337
Milk products & dishes	327	336	252	83	465	318	260	271	124	467
Vegetable products & dishes	288	242	247	96	424	256	216	221	67	356
Fatty Acid (g/d)										
Linoleic acid	11.59	7.64	9.81	6.37	14.89	9.97	6.23	9.18	5.38	13.74
Arachidonic acid*	0.188	0.173	0.148	0.076	0.246	0.140	0.122	0.122	0.047	0.191
Total *n*-6 PUFA	11.94	7.72	10.17	6.67	15.27	10.22	6.29	9.41	5.66	13.93
Alpha-linolenic acid	1.16	0.77	0.99	0.68	1.43	1.12	0.82	0.94	0.55	1.46
EPA	0.089	0.218	0.042	0.018	0.085	0.061	0.097	0.031	0.013	0.070

DPA	0.087	0.103	0.060	0.023	0.118	0.070	0.076	0.054	0.014	0.093
DHA	0.118	0.334	0.035	0.014	0.080	0.100	0.189	0.026	0.010	0.064
Total *n*-3 PUFA	1.46	1.02	1.22	0.84	1.78	1.35	0.92	1.20	0.79	1.53
Total PUFA	13.40	8.26	11.56	7.79	16.94	11.57	6.92	10.69	6.59	15.88

DPA, docosapentaenoic acid

* $P<0.05$ one way ANOVA

Table 4 The mean, SD, median, 25th and 75th percentile of intakes from major foods groups and fatty acids in adult women (18-79 yrs) with and without depression.

	No depression					With Depression				
	Mean	SD	Median	P25	P75	Mean	SD	Median	P25	P75
Energy (kJ)	7505	2949	7103	5494	9127	7697	3177	7489	5437	9254
Food group (g/d)										
Non-alcoholic beverages*	1158	671	1058	761	1509	1416	859	1269	772	1838
Alcoholic beverages	106	321	0	0	4.1	129	349	0	0	64
Alcohol	7.5	19.2	0	0	1.2	8.9	19.5	0	0	10.3
Fish and seafood products & dishes	25	80	0	0	0	23	75	0	0	0
Meat, Poultry, Game products & dishes	178	186	127	48	252	152	175	104	23	211
Milk products & dishes*	259	248	200	72	370	331	295	287	118	446
Vegetable products & dishes	237	195	208	89	346	208	170	185	69	305
Fatty Acid (g/d)										
Linoleic acid	8.05	5.50	6.88	4.32	10.33	8.14	5.33	6.65	4.34	10.84
Arachidonic acid	0.115	0.114	0.087	0.041	0.156	0.110	0.103	0.081	0.034	0.159
Total n-6 PUFA	8.25	5.55	7.08	4.50	10.55	8.34	5.37	6.92	4.59	10.97
Alpha-linolenic acid	0.795	0.551	0.674	0.450	0.985	0.871	0.605	0.721	0.432	1.18
EPA	0.058	0.137	0.024	0.009	0.050	0.046	0.062	0.025	0.007	0.054

DPA	0.051	0.062	0.033	0.010	0.068	0.052	0.061	0.035	0.007	0.079
DHA	0.085	0.228	0.021	0.008	0.050	0.073	0.149	0.018	0.008	0.048
Total n-3 PUFA	0.99	0.70	0.82	0.55	1.22	1.04	0.68	0.88	0.54	1.37
Total PUFA	9.24	5.92	8.07	5.23	11.78	9.38	5.85	8.27	5.23	12.17

DPA, docosapentaenoic acid

* *P* <0.05 one way ANOVA