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Comparison of nutrient intakes for vegetarians, non-vegetarians, and dieters: Results from the National Health and Nutrition Examination Survey 1999 – 2004

by

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Thesis

Submitted to the School of Health Sciences

Eastern Michigan University

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

in

Human Nutrition

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Abstract

Studies showing lower body mass index for vegetarians than non-vegetarians suggest that a vegetarian diet may be an approach for weight management. The purpose of this study was to compare nutrient intakes of vegetarians, non-vegetarians, and dieters to show that a vegetarian diet does not compromise nutrient intake. National Health and Nutrition Examination Survey (1999-2004) data were analyzed for persons 19 years of age and older. Vegetarians were those who did not report eating meat, poultry, or fish. Dieters were those who consumed 500 kilocalories less than estimated energy requirements. Adjusted means for fiber, vitamins E, A, and C, thiamin, riboflavin, folate, calcium, magnesium, iron, and potassium were higher for vegetarians than for non-vegetarians. Niacin, vitamin B_{12}, and zinc were lower for the vegetarians; however, only zinc was below the Recommended Dietary Allowance. These findings suggest that a vegetarian diet can be recommended for weight management without compromising nutrient intake.

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Chapter 1: Introduction

Interest in vegetarian diets has increased in recent years, and one reason for this growing interest is thought to be related to weight control. Indeed, in two studies of college students (1, 2) weight loss was cited as a reason to adopt a vegetarian diet by one quarter of the subjects. A vegetarian diet as an approach for weight management has been suggested by several studies which have reported that vegetarians tend to be leaner than non-vegetarians (3-7). Body mass index (BMI) can differ as much as 1.9 kg/m^2 for vegetarian men and 2.1 kg/m^2 for vegetarian women compared to non-vegetarians, and the difference can be even greater between non-vegetarians and vegans (Table 1). Body mass index is commonly used as a definition of the degree of adiposity, accounting for differences in body composition by calculating the relationship of weight to height. According to the National Institutes of Health (NIH), a BMI of more than 25 kg/m^2 is in the overweight category, and more than 30 kg/m^2 is considered obese.

Table 1. Selected studies reporting body mass index (BMI) of vegetarians and non-vegetarians

Reference	Subjects	Data source	BMI (kg/m^2) by diet group	men	women
Kennedy and colleagues (3)	10,014 men and women aged ≥19	CSFII[a] 1994-1996	non-vegetarians	26.4	25.7
			vegetarians	25.2	24.6
Newby and colleagues (5)	55,459 women aged 39-73	Swedish Mammography study	meat eaters		24.7
			semi-vegetarians		23.6
			lacto-vegetarians		23.4
			vegans		23.3
Fraser (6)	34,192 men and women aged ≥25	Seventh Day Adventist cohort study 1976-1988	non-vegetarians	26.24	25.88
			semi-vegetarians	25.18	24.83
			vegetarians	24.26	23.73
Spencer and colleagues (7)	37,875 men and women aged 20-97	EPIC-Oxford[b] studies	fish eaters	23.29	22.60
			vegetarians	23.28	22.51
			vegans	22.34	21.75

[a] Continuing Survey of Food Intakes by Individuals

[b] Oxford component of the European Prospective Investigation into Cancer and Nutrition

Numerous weight loss methods have been promoted in books and by the diet industry; however, questions and controversy exist concerning the effectiveness and nutritional adequacy of the various regimens, particularly in the long-term. Dietary patterns of participants in the National Weight Control Registry who have maintained at least a 30-pound weight loss for more than five years include low intakes of energy and fat with moderate carbohydrate intakes (8, 9). This is a pattern recommended by the National Institutes of Health (10), and the Dietary Guidelines (11), which further recommend limiting refined carbohydrates. Low energy and fat intakes along with high fruit, vegetables, and whole grain carbohydrate consumption are also characteristic of vegetarian dietary patterns, particularly vegan diets, suggesting that such diets should be considered an approach for weight management. However, there exists a perception that vegetarian diets are deficient in important nutrients, including protein, calcium, iron, and vitamin B_{12} (12).

There is a need to determine if there is a risk for inadequate nutrient intake when vegetarian diets are used for weight loss, and, if so, what strategies may be used by nutrition professionals to help vegetarian dieters meet recommended nutrient intakes. In addition, this information could help the food industry identify fortification strategies for foods that would help vegetarian dieters meet their goals while maintaining adequate nutrient intakes. Although there is little information describing the effect of vegetarian weight loss diets on nutrient intakes, some research suggests that there are fewer nutrients of concern for vegetarian diets compared to other intervention diets such as the National Cholesterol Education Program STEP II diet (13). Furthermore, subjects following vegetarian diets improved intakes of some nutrients such as fiber, vitamin A, vitamin C,

magnesium, and potassium, all of which are nutrients of concern for the United States population (14).

The purpose of this study is to describe dietary intake quality of non-vegetarians, vegetarians, and dieters using survey data from the National Health and Nutrition Examination Survey (NHANES) and to show that a vegetarian dietary pattern is a version of low-calorie dieting that does not compromise dietary intake quality. This thesis is organized into two sections, using the same NHANES survey data in separate analyses. The first section is a descriptive comparison of nutrient intakes and BMIs of vegetarians and non-vegetarians. Subsets of these two groups were defined by caloric intake, representing dieters and non-dieters, to observe the effect of low-calorie dieting on diet quality. In the second section, an orthogonal analysis was used to answer the specific research questions: Does dietary intake quality differ for (1) non-dieting non-vegetarians and individuals who consume lower calorie diets, (2) dieting non-vegetarians and all vegetarians, and (3) non-dieting vegetarians and dieting vegetarians?

Chapter 2: Literature Review, Part 1

A Vegetarian Diet as a Nutrient-dense Approach for Weight Management

Rationale.

Energy intake of a vegetarian dietary pattern has been shown to be as much as 464 kcal less than that of a non-vegetarian diet (Table 2), suggesting that a vegetarian diet is a version of a low calorie diet that could be used for weight control. Additionally, observations from the Swedish Mammography study (5), the Seventh Day Adventist cohort (6), and the Oxford component of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford) (7), show that vegetarians have lower BMIs than non-vegetarians (Table 1). Although Spencer and colleagues (7) observed a wide range of BMIs within the EPIC-Oxford study groups, the differences between vegetarians and non-vegetarians remained significant after adjusting for lifestyle and dietary factors. In addition, analysis of variance showed that lower protein and higher fiber intakes, characteristic of vegetarian diets, were the most important determinants of BMI. Likewise, Newby and colleagues (5) adjusted for energy and total fat intakes and still observed a lower risk of overweight for vegetarians in the Swedish Mammography study. Work by Kennedy and colleagues (3) and Haddad and Tanzman (4) has also supported the observation that BMIs of vegetarians tend to be lower than those of non-vegetarians. Haddad and Tanzman (4) reported that self-defined vegetarians who ate meat had higher BMIs than those who did not, and both groups had significantly lower BMIs than the non-vegetarians.

Table 2. Selected studies reporting caloric intake of vegetarians and non-vegetarians

Reference	Subjects	Data source	Caloric intake by diet group	kcal
Kennedy and colleagues (3)	10,014 men and women aged ≥19	CSFII[a] 1994-1996	non-vegetarians vegetarians	2073 1609
Newby and colleagues (5)	55,459 women aged 39-73	Swedish Mammography study	meat eaters semi-vegetarians lacto-vegetarians vegans	1378 1238 1211 1143
Davey and colleagues (20)	65,429 men and women aged 20-97	EPIC-Oxford[b]	meat-eaters fish-eaters vegetarians vegans	1916 1852 1816 1665

[a] Continuing Survey of Food Intakes by Individuals

[b] Oxford component of the European Prospective Investigation into Cancer and Nutrition

Nutritional adequacy.

While weight loss and controlling body weight can help reduce the risk of chronic disease, the method used to achieve and maintain a healthy body weight must be nutritionally adequate in order to maintain overall health. Weight management requires long-term adherence to a dietary change, whether it is a low calorie non-vegetarian diet or a vegetarian diet; therefore, it is important to understand the effects of those dietary patterns on nutrient intakes. Observational studies have documented nutrient intakes for individuals who follow vegetarian dietary patterns, showing that these subjects consume diets that are consistent with current dietary guidelines (11), particularly regarding lower intakes of fat, saturated fat, and cholesterol, and higher vitamin C, fiber, magnesium, and beta-carotene (15–20). Despite these advantages, vegetarians are often cautioned that they are at increased risk for inadequate intakes of iron, vitamin B_{12}, calcium, vitamin D, and zinc. Furthermore, there exists the perception that it is difficult to meet protein

requirements without animal products. Barr and Chapman (12) interviewed 35 former vegetarians who described nutritional concerns as a reason for discontinuing the vegetarian diet. Many of these participants indicated inadequate protein intake as a concern, and calcium, iron, and vitamin B_{12} were also mentioned.

Nutrient intake data from population-based studies.

Data from recent population-based studies that have reported nutrient intake patterns for vegetarians have supported only a few of these concerns. One of the largest studies of vegetarian nutrient intake was done in the United Kingdom for the EPIC-Oxford study (20), in which 33,883 adults were categorized as meat-eaters, fish eaters, vegetarians, and vegans. Mean nutrient intakes were reported from data collected from food frequency questionnaires and seven-day food diaries. Results were reported for male and female participants separately and were not adjusted for calories. Vegetarians had lower mean intakes of niacin, vitamins B_6, B_{12}, and D, and zinc than non-vegetarians; however, only vitamin D and zinc were below recommended levels. Iron intake was below the recommended amount for premenopausal women, but was the same for vegetarians and non-vegetarians. Calcium intake was higher for vegetarians than non-vegetarians, as were thiamin, folate, vitamins C and E, and magnesium.

Similar results were observed in an analysis of dietary intakes for the United States population. Haddad and Tanzman (4) classified vegetarians and non-vegetarians aged six years and older (n = 13,313) based on their response to the question "Do you consider yourself to be vegetarian?" Dietary data collected from two nonconsecutive 24-hour recalls showed that some vegetarians ate meat on the data collection days and some non-vegetarians did not, so the groups were further categorized according to a cut-off

level of 10 g of meat consumption per day, where less than that amount was considered "no meat." Mean nutrient intakes based on 2000 calories showed that the vegetarians who did not eat meat consumed less niacin, vitamin B_{12}, and zinc than non-vegetarians who ate meat. When the nutrient intake means were compared to the highest Recommended Dietary Allowances (RDAs) for adults, excluding pregnant and lactating women, only zinc was below the recommended intake. Non-vegetarians who ate no meat had lower niacin, vitamin B_{12}, and zinc intakes than those who ate meat; however, those means were higher than for the vegetarians who ate no meat. In addition, the non-vegetarians who ate no meat had the highest riboflavin and iron intakes among the four groups. Calcium intake for vegetarians who ate no meat (964 $\pm$ 16 mg) was similar to that of non-vegetarians who ate no meat (960 $\pm$ 28 mg), as was total milk consumption for the two groups, reported in calcium equivalents (274 $\pm$ 27 and 304 $\pm$ 15 respectively). The vegetarians may have obtained more calcium from non-dairy sources, and the study reported that they were consuming tofu, which can be made with calcium sulfate, and soy milk, which may be fortified with calcium. In addition, the vegetarians had the highest intake of dark green vegetables, which are also an alternative source of calcium. The vegetarians who ate no meat also had the highest intakes of deep yellow vegetables, tomatoes, lettuce, "other vegetables," total fruit, citrus fruit, dried fruit, and apples, and therefore higher vitamin A and carotenes, vitamins E and C, thiamin, folate, magnesium, and fiber.

In a representative sample of British Colombia adults (19), participants were asked if they considered themselves to be vegetarian, and those who responded "yes" were asked to further characterize any animal product intake. The majority of these self-

defined vegetarians consumed meat, poultry, or fish at least occasionally; however, unlike the analysis by Haddad and Tanzman (4), the group of self-defined vegetarians was not further separated on the basis of meat consumption. Although the data reported for the vegetarians may reflect some nutrient intake from meat, the results were similar to previous studies. Unadjusted for calories, reported niacin, vitamin B_{12}, and zinc intakes were lower for the vegetarians than for the non-vegetarians. All were above recommended amounts; however, this data also includes nutritional supplement use. In this study, prevalence of inadequate intakes of some nutrients was determined, based on intakes from both food and supplements. There were no differences between vegetarians and non-vegetarians for vitamin B_{12} and zinc, and prevalence of inadequate intakes of magnesium, vitamin C, vitamin B_6, and folate were higher for non-vegetarians.

Nutrients of concern.

Iron intakes are often reported to be higher for vegetarians compared to non-vegetarians, and a study of Australian women (n = 74) showed that vegetarians were not more likely to be iron deficient than non-vegetarians (21). However, in several studies, means reported for both vegetarian and non-vegetarian women did not meet recommended amounts for premenopausal women (4, 19, 20). Furthermore, the Institute of Medicine (IOM) has recommended that vegetarians consume 80% more than the RDA for iron due to the lower bioavailability of the non-heme iron in vegetarian diets (22). Phytates are the main inhibitors of iron absorption and are found in whole grains, legumes, and nuts, which are foods that are often the basis of a vegetarian diet. Bioavailability of iron can be improved by combining iron-containing plant foods with vitamin C (23), which is typically found in higher amounts in vegetarian diets. Haddad

and Tanzman (4) reported that self-defined vegetarians who ate no meat reported the highest total fruit and citrus fruit intake, a major source of vitamin C, compared to all non-vegetarians and vegetarians who ate meat.

Reported calcium intakes for vegetarians who consume dairy foods generally meet recommended amounts and are often higher than amounts reported for non-vegetarians (20). Other sources of calcium common in vegetarian diets are leafy greens, almonds, and tofu made with calcium sulfate. While leafy greens contain oxalates which decrease bioavailability of the calcium, the oxalate content of kale, broccoli, and bok choy are low and bioavailability for these vegetables ranges from 49% to 61%, compared to 32% for milk, cheese, and yogurt (24). However, when estimated absorbable calcium per serving was calculated for these absorption rates, it was determined that about two and one-half servings of broccoli or three and one-half cups of kale are necessary to equal the calcium obtained in 240 ml of milk. Dairy foods also contribute vitamin B_{12} to vegetarian diets, and lacto-ovo vegetarians also obtain vitamin B_{12} from eggs. As a result, mean vitamin B_{12} intakes below recommended amounts have not been reported for lacto- and lacto-ovo vegetarians.

Protein intake is typically reported to be lower for vegetarians than for non-vegetarians (4, 5, 19, 20), although not below recommended amounts. It has been suggested that protein requirements are higher for vegetarians due to the lower digestibility of plant proteins; however, according to the Food and Nutrition Board of the IOM this is not supported by available evidence (25).

In a report from the United States Department of Agriculture (USDA), Agricultural Research Service, usual intake data from NHANES 2001-2002 was

compared to the Dietary Reference Intakes (DRI), identifying nutrients with increased risk for inadequate intake (14). According to that analysis, the nutrients of concern for the general population are fiber, potassium, vitamins A, C, and E, calcium, and magnesium. With few exceptions, vegetarians have higher intakes of these nutrients than non-vegetarians (4, 19, 20).

Study purpose.

Although these data suggest that a vegetarian diet could be recommended for weight management without increasing the risk for inadequate nutrient intake, more recent information about vegetarian nutrient intake for the United States population is needed. In addition, an analysis of nutrient intakes for low calorie dieters would provide further information about the effect of low calorie intake on diet quality and would provide a basis for a comparison to a vegetarian diet as an approach for weight management. The purpose of this study was to describe dietary intake quality of non-vegetarians, vegetarians, and dieters using survey data from NHANES 1999-2004 to show that a vegetarian diet could promote weight management without compromising nutrient intake.

Chapter 3: Methods, Part 1

Subjects

Subjects in this study were participants in the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2004. Adults aged 19 years and older with reliable dietary records were eligible for inclusion (n=14,196). From this eligible sample, pregnant and lactating women were excluded, for a final sample size of 13,292. The sample was classified by vegetarian status and dieting status as shown in Figure 1. Vegetarians were defined as those who did not report eating meat, poultry, or fish on the day of the survey, a definition that was previously used by Kennedy and colleagues (3). While all of these subjects may not be vegetarian, their dietary intakes on the day of the survey reflected the nutrient content of a lacto-ovo vegetarian dietary pattern, and this definition also excluded self-defined vegetarians who may actually be semi-vegetarian. Previous studies have found that up to two thirds of self-defined vegetarians reported consuming meat, poultry, or fish on dietary recalls (4, 19, 26). Dieters were defined as those who had caloric intakes that were at least 500 kcal less than their estimated energy requirements (EER) on the day of the survey, a definition that is supported by recommendations from the National Heart, Lung, and Blood Institute for calculating the reduction in energy intake for weight loss of one to two pounds per week (10). The EER for a sedentary activity level was used and was calculated as described by IOM (25) using the physical activity coefficient (PA) 1.0 (see Appendix A).

Approval for this study was obtained from the Human Subjects Review committee at Eastern Michigan University (Appendix B).

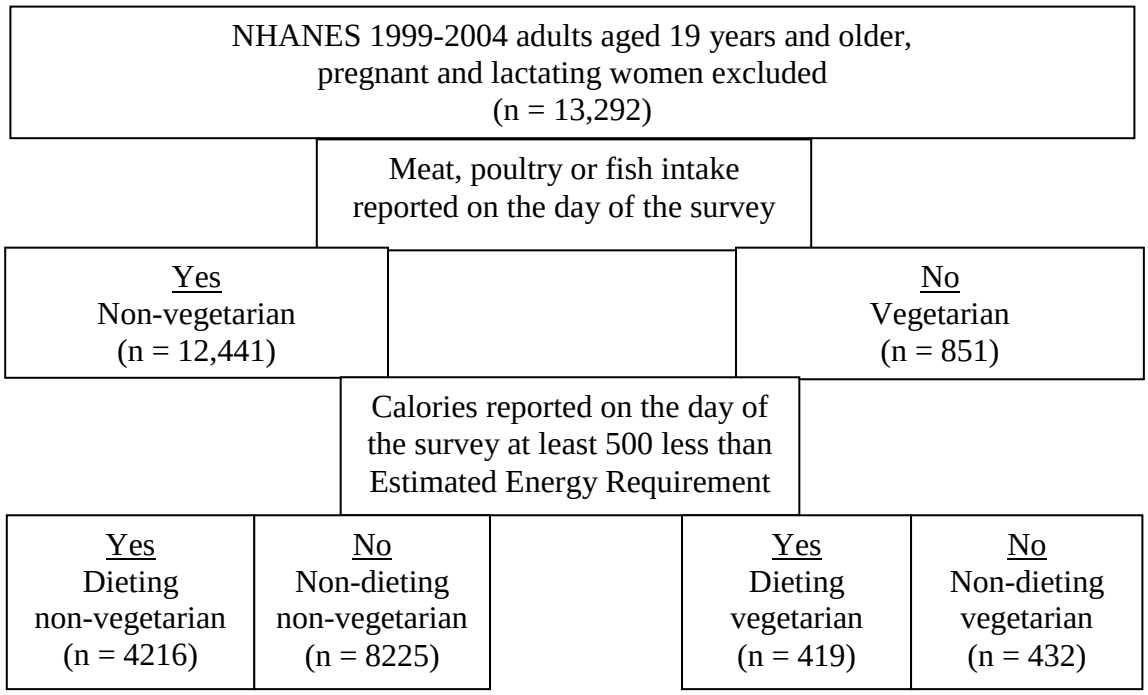

Figure 1. Schematic diagram used for classifying participants of the National Health and Nutrition Examination Survey 1999-2004, ages 19 years and older, by vegetarian and dieting status.

Research Design

The present study is a cross-sectional analysis of dietary recall records and anthropometric data from NHANES 1999-2004. NHANES is a continuous annual survey conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention to obtain nationally representative information on the health and nutritional status of the United States population. The NHANES design is a stratified, multi-stage probability sample and includes oversampling of Mexican Americans, non-Hispanic blacks, and children and adolescents.

Dietary information for NHANES was obtained via a 5-step multiple pass 24-hour recall method conducted by trained interviewers who have bachelor of science degrees in food and nutrition or home economics. In the first step of the interview, a list of foods and beverages consumed the previous day was collected, and in the second step the interviewer probed for foods forgotten from this list. Time and eating occasions for each food were recorded in the third step, followed by detailed descriptions, amounts, and additions collected in the fourth step. The fifth step was a final probe for anything else consumed. Dietary recalls were considered reliable if at least the first four steps were completed and all of the relevant variables associated with the recall contained a value. Only dietary interviews that were considered reliable as coded by NCHS were included in this study.

Anthropometric measurements were made by trained NHANES health technicians in mobile examination centers. Body weight and standing height were determined electronically and were used to calculate body mass index by dividing body weight in kilograms by height in meters squared.

Prior to NHANES 2001-2002, vitamin A was expressed as micrograms of retinol equivalents (mcg RE) and vitamin E was expressed as milligrams of alpha tocopherol equivalents (mg ATE), whereas currently these nutrients are expressed as micrograms of retinol activity equivalents (mcg RAE) for vitamin A and milligrams of alpha-tocopherol (mg AT) for vitamin E. To permit data from the 1999-2000 survey to be combined with 2001-2002 and 2003-2004 data, a special database was released by the USDA that allows the 1999-2000 intake estimates for vitamin A and vitamin E to be calculated in the

current units (27). This database was merged with the NHANES dietary intake data used in the present study.

The MyPyramid Servings Database for USDA Food Codes Version 1 was used to convert NHANES 1999-2002 food intake data into guidance-based amounts defined by the MyPyramid Food Guidance System (28). Data obtained from NHANES 2003-2004 were hand-matched to similar food in the MyPyramid database.

Statistical Analysis

Data preparation was performed using SAS software (version 9.0 for Windows, SAS Institute Inc., Cary, NC). Regression analyses were conducted to compare BMIs and one-day nutrient intakes and MyPyramid equivalents for vegetarians, non-vegetarians, and dieters. Because three two-year cycles of continuous NHANES data were combined, a six-year weight variable was created as described in the Analytic and Reporting Guidelines (29). All analyses were weighted using the NHANES examination sample weights and adjusted for the complex sample design of NHANES with the statistical package SUDAAN version 9.0 (Research Triangle Institute, Research Triangle Park, NC). Means and standard errors were reported, and standard errors were estimated using the Taylor linearization technique of SUDAAN. Statistical significance was set at $p<0.01$. Energy intake was adjusted for gender and ethnicity. Nutrients, MyPyramid equivalents, and BMIs were adjusted for gender, ethnicity, and energy intake. Mean nutrient intakes were calculated as a percentage of the highest RDA or AI from among the amounts for adults, excluding the values for pregnant or lactating women (see Appendix C for amounts used).

Chapter 4: Results, Part 1

Subjects

Within the eligible sample of 13,292 adults aged 19 years and older, there were 6,747 male and 6,545 female participants, and the sample was predominantly non-Hispanic white (51%). The participants were classified by diet group as shown in Figure 1 (see page 12). The 851 participants who did not report eating meat, poultry, or fish on the day of the survey were classified as vegetarian. The remaining 12,441 were classified as non-vegetarian, representing 94% of the sample. Of the 851 vegetarians, 419 were classified as dieters, and of the 12,441 non-vegetarians, 4,216 were dieters. Sample characteristics are shown in Table 3. The mean body mass index was lower for all vegetarians (26.76 $\pm$ 0.25 kg/m^2) than all non-vegetarians (28.14 $\pm$ 0.10 kg/m^2), dieting vegetarians (29.80 $\pm$ 0.39 kg/m^2) than dieting non-vegetarians, (31.43 $\pm$ 0.23 kg/m^2), and non-dieting vegetarians (25.22 $\pm$ 0.31 kg/m^2) than non-dieting non-vegetarians (26.71 $\pm$ 0.09 kg/m^2).

Table 3. Sample characteristics for participants of NHANES[a] 1999 - 2004 ages 19 years and older (N = 13,292) by vegetarian and dieting status.

Characteristic	Vegetarian	Non-vegetarian	Dieting vegetarian	Dieting non-vegetarian	Non-dieting vegetarian	Non-dieting non-vegetarian
	n (%)		*n (%)*		*n (%)*	
	851 (6)	12441 (94)	419 (9)	4216 (91)	432 (5)	8225 (95)
Gender						
Male	362 (43)	6385 (51)	201 (48)	2282 (54)	161 (37)	4103 (50)
Female	489 (57)	6056 (49)	218 (52)	1934 (46)	271 (63)	4122 (50)
Ethnicity						
Non-hispanic white	443 (52)	6170 (50)	188 (45)	1890 (45)	255 (59)	4280 (52)
Non-hispanic black	102 (12)	2600 (21)	72 (17)	1110 (26)	30 (7)	1490 (18)
Mexican American	222 (26)	2803 (22)	116 (28)	926 (22)	106 (25)	1877 (23)
Other race	34 (4)	323 (3)	12 (3)	110 (3)	22 (5)	213 (3)
Other Hispanic	50 (6)	545 (4)	31 (7)	180 (4)	19 (4)	365 (4)
BMI[b] kg/m^2, adjusted for energy, gender, ethnicity*	26.76 ± 0.25	28.14 ± 0.10	29.8 ± 0.39	31.43 ± 0.23	25.22 ± 0.31	26.71 ± 0.09

[a] National Health and Nutrition Examination Survey

[b] Body mass index

* Significantly different within comparisons, $p < 0.01$

Mean Dietary Intakes

Vegetarians vs non-vegetarians.

Table 4 shows mean nutrient intakes for vegetarians and non-vegetarians. Fiber intake was higher for vegetarians than for non-vegetarians, as was calcium, magnesium, iron, vitamins A, C, and E, thiamin, riboflavin, and folate. Niacin, vitamin B_{12}, and zinc were lower for vegetarians. Protein was lower for the vegetarians, as was total fat, saturated fat, monounsaturated, polyunsaturated, and cholesterol. Sodium was lower for the vegetarians (3,027.5 $\pm$ 35.8 mg) than for the non-vegetarians (3,493.6 $\pm$ 16.3 mg); however, both groups were over the 2,300 mg limit for sodium recommended by the Dietary Guidelines for Americans and the DRI tolerable upper intake level.

Table 4. Adjusted mean nutrient intakes for vegetarians and non-vegetarians, ages 19 years and older (N = 13,292) (NHANES[a] 1999-2004)

	Vegetarians *(n=851)*				Non-Vegetarians *(n=12,441)*			
Nutrient[b]	Mean	SE[c]	%DRI[d]		Mean	SE[c]	%DRI[d]	
Energy (kcal)	1,877	± 41.9		*	2,241	± 10.8		
Protein (g)	63.4	± 0.7		*	83.6	± 0.4		
Carbohydrate (g)	312	± 2.7		*	270	± 1.0		
Dietary Fiber (g)	20.3	± 0.6	54%	*	15.4	± 0.2	40%	
Total fat (g)	75.5	± 1.0		*	83.6	± 0.4		
Saturated fat (g)	24.9	± 0.4		*	27.4	± 0.2		
Cholesterol (mg)	208	± 7.4		*	294	± 2.7		
Vitamin E (mg AT[e])	8.3	± 0.3	55%	*	7.0	± 0.1	47%	
Vitamin A (mcg RAE[f])	718	± 28.0	80%	*	603	± 9.6	67%	
Thiamin (mg)	1.7	± 0.0	143%	*	1.6	± 0.0	136%	
Riboflavin (mg)	2.3	± 0.0	174%	*	2.1	± 0.0	165%	
Niacin (mg)	19.2	± 0.4	120%	*	23.9	± 0.2	149%	
Vitamin B6 (mg)	1.8	± 0.1	105%		1.9	± 0.0	110%	
Total folate (mcg DFE[g])	663	± 17.9	166%	*	536	± 6.4	134%	
Vitamin B12 (mcg)	3.8	± 0.2	160%	*	5.3	± 0.1	221%	
Vitamin C (mg)	112	± 6.5	124%	*	91	± 1.6	101%	
Calcium (mg)	1,020	± 22.1	85%	*	845	± 7.1	70%	
Magnesium (mg)	322	± 5.1	77%	*	280	± 2.3	67%	
Iron (mg)	16.9	± 0.4	94%	*	15.5	± 0.1	86%	
Zinc (mg)	10.1	± 0.2	92%	*	12.1	± 0.1	110%	
Sodium (mg)	3,027	± 35.8	132%	*	3,493	± 16.3	152%	
Potassium (mg)	2,770	± 41.7	59%		2,745	± 17.8	58%	

[a] National Health and Nutrition Examination Survey, one day food intake

[b] Energy intake adjusted for gender and ethnicity, all other nutrients adjusted for energy, gender, and ethnicity

[c] Standard error

[d] Based on the highest RDA or AI amount from among the values for adults, excluding the amounts for pregnant and lactating women

[e] α-tocopherol

[f] retinol activity equivalents

[g] dietary folate equivalents

[*] $p < 0.01$

Food group intakes for vegetarians and non-vegetarians are shown in Table 5, reported as MyPyramid equivalents. Vegetarians consumed more total grain, fruit, soy, total dairy and milk, and less discretionary fat than non-vegetarians. In addition, they consumed twice as much whole grain and legumes as non-vegetarians. There was no difference in total vegetable intake between the vegetarians and non-vegetarians;

however, there was a difference in distribution of vegetable type between the groups. The vegetarians ate more dark green vegetables, while the non-vegetarians ate more potatoes.

Table 5. Adjusted mean intakes of MyPyramid food serving equivalents for vegetarians and non-vegetarians, ages 19 years and older (N = 13,292) (NHANES[a]1999-2004)

		Vegetarians *n=851*				Non-vegetarians *(n=12,441)*	
Food Group	Equivalent	Mean		SE[b]		Mean	SE[b]
Total grain	ounce	7.84	±	0.14	*	6.72	± 0.05
Grain - nonwhole	ounce	6.64	±	0.14	*	6.11	± 0.05
Grain - whole	ounce	1.2	±	0.07	*	0.61	± 0.02
Fruit	cup	1.32	±	0.08	*	0.99	± 0.03
Vegetable	cup	1.58	±	0.08		1.62	± 0.02
Dark Green Vegetables	cup	0.15	±	0.02	*	0.11	± 0.01
Orange Vegetables	cup	0.08	±	0.01		0.08	± 0
Potato	cup	0.25	±	0.02	*	0.41	± 0.01
Meat, poultry, fish	ounce	0.82	±	0.08	*	5.12	± 0.05
Egg	ounce	0.5	±	0.04		0.47	± 0.01
Legumes	cup	0.22	±	0.03	*	0.11	± 0
Soy	ounce	0.33	±	0.06	*	0.05	± 0
Nuts	ounce	0.89	±	0.09	*	0.54	± 0.02
Total dairy	cup	1.98	±	0.07	*	1.52	± 0.02
Milk	cup	1.15	±	0.07	*	0.87	± 0.02
Cheese	cup	0.79	±	0.04	*	0.62	± 0.01
Added sugar	teaspoon	24.11	±	0.82		22.1	± 0.38
Discretionary fat	gram	44.88	±	0.91	*	48.12	± 0.34
Discretionary oil	gram	18.77	±	0.74		17.93	± 0.25

[a] National Health and Nutrition Examination Survey, one day intake, adjusted for gender, ethnicity, and energy

[b] Standard error

* $p < 0.01$

Dieting vegetarians vs dieting non-vegetarians.

Fiber intake was higher for dieting vegetarians than for dieting non-vegetarians, as was calcium (Table 6). Vitamins A, C, and E, folate, magnesium, and iron were also higher for dieting vegetarians, but the differences for these nutrients were not significant. Potassium was lower for the dieting vegetarians than for the dieting non-vegetarians; however, neither group met the 4,700 mg adequate intake level for adults. Cholesterol

and total fat were lower for the dieting vegetarians, and although saturated fat was also lower, the difference was not significant. Mean sodium intake was lower for the dieting vegetarians (2,957.5 ± 56.3 mg) than for the dieting non-vegetarians (3,432.3 ± 32.9 mg); however, both groups were over the 2,300 mg limit for sodium recommended by the Dietary Guidelines for Americans and the DRI tolerable upper intake level.

Table 6. Adjusted mean nutrient intakes for vegetarian and non-vegetarian dieters, ages 19 years and older (N=4,635) (NHANES[a] 1999-2004)

	Dieting vegetarians *(n=419)*				Dieting non-vegetarians *(n-=4,216)*		
Nutrient[b]	Mean	SE[c]	%DRI[d]		Mean	SE[c]	%DRI[d]
Energy (kcal)	1,179	± 29.2		*	1,396	± 10.2	
Protein (g)	64.4	± 0.9		*	83.1	± 0.7	
Carbohydrate (g)	293	± 3.2		*	266	± 2.0	
Fiber (g)	16.0	± 0.6	42%	*	14.3	± 0.3	38%
Total fat (g)	78.4	± 1.1		*	82.7	± 0.9	
Saturated fat (g)	26.4	± 0.6			27.6	± 0.3	
Cholesterol (mg)	200	± 7.1		*	291	± 5.1	
Vitamin E (mg AT[e])	7.5	± 0.5	50%		6.6	± 0.2	44%
Vitamin A (mcg RAE[f])	600	± 43.6	67%		570	± 19.0	63%
Thiamin (mg)	1.6	± 0.1	132%		1.6	± 0.0	131%
Riboflavin (mg)	2.1	± 0.1	159%		2.1	± 0.0	160%
Niacin (mg)	19.6	± 0.6	122%	*	23.4	± 0.3	146%
Vitamin B6 (mg)	1.7	± 0.1	98%		1.8	± 0.0	105%
Folate (mcg DFE[g])	571	± 27.4	143%		519	± 10.2	130%
Vitamin B12 (mcg)	3.9	± 0.2	163%	*	5.2	± 0.2	218%
Vitamin C (mg)	91	± 6.2	101%		81	± 2.6	90%
Calcium (mg)	931	± 40.5	78%	*	837	± 13.8	70%
Magnesium (mg)	283	± 7.3	67%		268	± 3.3	64%
Iron (mg)	15.4	± 0.6	85%		14.8	± 0.2	82%
Zinc (mg)	9.9	± 0.3	90%	*	11.8	± 0.2	107%
Sodium (mg)	2,957	± 56.3	129%	*	3,432	± 32.9	149%
Potassium (mg)	2,445	± 62.5	52%	*	2,591	± 28.2	55%

[a] National Health and Nutrition Examination Survey, one day food intake

[b] Energy intake adjusted for gender and ethnicity, all other nutrients adjusted for energy, gender, and ethnicity

[c] Standard error

[d] Based on the highest RDA or AI amount from among the values for adults, excluding the amounts for pregnant and lactating women

[e] α-tocopherol

[f] retinol activity equivalents

[g] dietary folate equivalents

[*] $p < 0.01$

Food group intakes for dieters are shown in Table 7. The dieting vegetarians consumed more total grain, whole grain, legumes, nuts, cheese, and added sugar. Soy intake was numerically higher for the dieting vegetarians (0.29 ± 0.1 ounce equivalents) than for the dieting non-vegetarians (0.04 ± 0.01 ounce equivalents); however, the difference was not statistically significant. There were no differences between the two groups for intakes of fruit, vegetables, egg, total dairy, milk, and discretionary fats and oils.

Table 7. Adjusted mean intakes of MyPyramid food serving equivalents for vegetarian and non-vegetarian dieters, ages 19 years and older (N=4,635) (NHANES[a] 1999-2004)

		Dieting vegetarians *(n=419)*		Dieting non-vegetarians *(n=4,216)*
Food Group	Equivalent	Mean SE[b]		Mean SE[b]
Total grain	ounce	7.17 ± 0.2	*	6.52 ± 0.09
Grain - nonwhole	ounce	6.35 ± 0.2		6.01 ± 0.08
Grain - whole	ounce	0.82 ± 0.1	*	0.51 ± 0.03
Fruit	cup	0.9 ± 0.1		0.84 ± 0.04
Vegetable	cup	1.41 ± 0.1		1.52 ± 0.03
Dark Green Vegetable	cup	0.11 ± 0		0.1 ± 0.02
Orange Vegetable	cup	0.05 ± 0		0.06 ± 0
Potato	cup	0.3 ± 0		0.39 ± 0.01
Meat, poultry, fish	ounce	1.83 ± 0.1	*	5.14 ± 0.08
Egg	ounce	0.41 ± 0.1		0.45 ± 0.02
Legumes	cup	0.17 ± 0	*	0.11 ± 0.01
Soy	ounce	0.29 ± 0.1		0.04 ± 0.01
Nuts	ounce	0.74 ± 0.1	*	0.54 ± 0.06
Total dairy	cup	1.82 ± 0.1		1.57 ± 0.04
Milk	cup	0.93 ± 0.1		0.83 ± 0.03
Cheese	cup	0.86 ± 0.1	*	0.71 ± 0.03
Added sugar	teaspoon	26.1 ± 1	*	23.13 ± 0.58
Discretionary fat	gram	47.73 ± 1.1		48.37 ± 0.57
Discretionary oil	gram	18.62 ± 0.8		17.37 ± 0.51

[a] National Health and Nutrition Examination Survey, one day intake, adjusted for gender, ethnicity, and energy

[b] Standard error

* $p < 0.01$

Non-dieting vegetarians vs non-dieting non-vegetarians.

Non-dieting vegetarians had higher intakes of fiber, vitamins A, C, and E, thiamin, riboflavin, folate, calcium, magnesium, iron, and potassium than non-dieting non-vegetarians (Table 8). Intakes of protein, total fat, saturated fat, cholesterol, niacin, vitamin B_{12}, and zinc were higher for the non-dieting non-vegetarians. Sodium was higher for the non-dieting non-vegetarians, and both groups were above the recommended 2,300 mg per day.

Total vegetable intake was the same for non-dieting vegetarians and non-dieting non-vegetarians; however, the non-dieting vegetarians ate significantly more dark green vegetables (0.18 $\pm$ 0.11 cup) than the non-dieting non-vegetarians (0.11 $\pm$ 0.01 cup) and significantly less potato (0.2 $\pm$ 0.02 vs 0.42 $\pm$ 0.01 cup) (Table 9). Non-dieting vegetarians ate more grains, legumes, soy, nuts, total dairy, and milk than non-dieting non-vegetarians. Egg and cheese intakes were also higher for the non-dieting vegetarians; however, the differences were not significant.

Table 8. Adjusted mean nutrient intakes for vegetarian and non-vegetarian non-dieters, ages 19 years and older (N=8,657) (NHANES[a] 1999-2004)

	Non-dieting vegetarians *(n = 432)*				Non-dieting non-vegetarians *(n = 8,225)*		
Nutrients[b]	Mean	SE[c]	%DRI[d]		Mean	SE[c]	%DRI[d]
Energy (kcal)	2,440	± 35.7		*	2,623	± 11.4	
Protein (g)	62.5	± 1.3		*	83.9	± 0.6	
Carbohydrate (g)	326	± 4.5		*	271	± 1.3	
Fiber (g)	23.4	± 0.8	62%	*	15.8	± 0.2	48%
Total fat (g)	73.2	± 1.6		*	83.9	± 0.5	
Saturated fat (g)	23.8	± 0.6		*	27.3	± 0.2	
Cholesterol (mg)	213	± 12.2		*	296	± 3.8	
Vitamin E (mg AT[e])	8.8	± 0.3	59%	*	7.2	± 0.1	48%
Vitamin A (mcg RAE[f])	800	± 32.8	89%	*	618	± 10.8	69%
Thiamin (mg)	1.8	± 0.1	151%	*	1.7	± 0.0	142%
Riboflavin (mg)	2.4	± 0.1	184%	*	2.2	± 0.0	169%
Niacin (mg)	18.8	± 0.6	117%	*	24.1	± 0.2	151%
Vitamin B6 (mg)	1.9	± 0.1	112%		1.9	± 0.0	112%
Folate (mcg DFE[g])	730	± 27.5	183%	*	544	± 7.1	136%
Vitamin B12 (mcg)	3.8	± 0.3	158%	*	5.3	± 0.1	221%
Vitamin C (mg)	127	± 7.9	141%	*	95	± 1.8	106%
Calcium (mg)	1,086	± 34.8	91%	*	849	± 8.2	71%
Magnesium (mg)	349	± 6.4	83%	*	286	± 2.5	68%
Iron (mg)	17.9	± 0.5	99%	*	15.9	± 0.1	88%
Zinc (mg)	10.2	± 0.3	93%	*	12.3	± 0.1	112%
Sodium (mg)	3,067	± 56.0	133%	*	3,522	± 20.1	153%
Potassium (mg)	2,983	± 56.5	63%	*	2,817	± 22.3	60%

[a] National Health and Nutrition Examination Survey, one day food intake

[b] Energy intake adjusted for gender and ethnicity, all other nutrients adjusted for energy, gender, and ethnicity

[c] Standard error

[d] Based on the highest RDA or AI amount from among the values for adults, excluding the amounts for pregnant and lactating women

[e] α-tocopherol

[f] retinol activity equivalents

[g] dietary folate equivalents

* $p < 0.01$

Table 9. Adjusted mean intakes of MyPyramid food serving equivalents for vegetarian and non-vegetarian non-dieters, ages 19 years and older (N=8,657) (NHANES[a] 1999-2004)

		Non-dieting vegetarians *(n=432)*				Non-dieting non-vegetarians *(n=8,225)*		
Food Group	Equivalent	Mean		SE[b]		Mean		SE[b]
Total grain	ounce	8.3	±	0.18	*	6.82	±	0.05
Grain - nonwhole	ounce	6.84	±	0.18	*	6.16	±	0.05
Grain - whole	ounce	1.46	±	0.09	*	0.66	±	0.02
Fruit	cup	1.61	±	0.1	*	1.06	±	0.03
Vegetable	cup	1.68	±	0.08		1.67	±	0.02
Dark Green Vegetable	cup	0.18	±	0.11	*	0.11	±	0.01
Orange Vegetable	cup	0.1	±	0.02		0.09	±	0
Potato	cup	0.2	±	0.02	*	0.42	±	0.01
Meat, poultry, fish	ounce	0.06	±	0.09	*	5.11	±	0.07
Egg	ounce	0.57	±	0.05		0.47	±	0.01
Legumes	cup	0.27	±	0.04	*	0.11	±	0.01
Soy	ounce	0.36	±	0.07	*	0.05	±	0.01
Nuts	ounce	1.01	±	0.14	*	0.54	±	0.03
Total dairy	cup	2.12	±	0.12	*	1.5	±	0.03
Milk	cup	1.32	±	0.1	*	0.88	±	0.02
Cheese	cup	0.75	±	0.06		0.58	±	0.01
Added sugar	teaspoon	22.82	±	1.27		21.62	±	0.41
Discretionary fat	gram	42.77	±	1.3	*	48.01	±	0.34
Discretionary oil	gram	18.76	±	1.24		18.19	±	0.29

[a] National Health and Nutrition Examination Survey, one day intake, adjusted for gender, ethnicity, and energy

[b] Standard error

[*] $p < 0.01$

Chapter 5: Discussion, Part 1

It is often difficult to characterize the nutrient content of vegetarian diets due to some ambiguity in the definition of "vegetarian." Dietary patterns of self-defined vegetarians may range from those who eat reduced amounts of red meat, to those who only eat chicken or fish, to those who exclude all animal foods. In an analysis of British Columbia adults (19), 57.6% of the self-defined vegetarians consumed poultry and 22.4% ate red meat at least occasionally. It is unclear from that study whether any of the reported nutrient intakes reflect meat consumption; however, the results are consistent with those of the present study. Haddad and Tanzman (4) found that two thirds of self-defined vegetarian participants in the Continuing Survey of Food Intakes by Individuals (CSFII) 1994-1996 ate meat. When they were further categorized according to a cut-off level of 10 g of meat consumption per day, where less than that amount was considered "no meat," those who ate no meat had the highest intakes of vitamin A and carotene, vitamin E, vitamin C, thiamin, folate, calcium, magnesium, and fiber, and this is supported by the findings in the present study. In this study, vegetarians were defined by the absence of meat, poultry, or fish intake reported on the day of the survey, and the data reflect the nutrient intake of a lacto-ovo vegetarian dietary pattern.

The data presented in this study for a lacto-ovo vegetarian diet show that this dietary pattern is more nutrient dense than that of the non-vegetarians. Calorie for calorie, the vegetarians had higher intakes of fiber, vitamins A, C, and E, thiamin, riboflavin, folate, calcium, magnesium, iron, and potassium than non-vegetarians. Along with higher fiber intakes, the lower total fat, saturated fat, and cholesterol intakes for vegetarians in this study are consistent with current dietary guidelines, and this was also

seen in two analyses of CSFII 1994-1996 data (3, 4). This nutrient pattern would be expected for a vegetarian diet, with its higher fruit, vegetable, nut, and legume content. Interestingly, in this analysis total vegetable intake was not different between the vegetarians and non-vegetarians; however, the proportion of dark green vegetables to potatoes was higher for vegetarians than non-vegetarians. This agrees with the analysis by Haddad and Tanzman (4), where higher consumption of dark green vegetables and deep yellow vegetables and lower consumption of white potatoes and fried potatoes were observed for vegetarians compared to non-vegetarians.

There were many differences in food and nutrient intake across the groups; however, mean intakes for vegetarians suggest that, overall, they did not have an increased risk for lower nutrient intakes compared to non-vegetarians. Indeed, vegetarians had higher mean intakes of many nutrients than did non-vegetarians. Fiber, vitamins A, C, and E, calcium, magnesium, and potassium have been identified as nutrients of concern for the general population (14), and the vegetarians in the present study had higher mean intakes of all of these nutrients than non-vegetarians. As observed in previous studies (3-5, 15, 17, 19, 20), protein intake was lower for vegetarians, but it was not lower than recommended amounts for adults. Food group intakes for vegetarians included a variety of foods that are high in protein. They ate eggs, dairy, and nuts, and twice the amount of legumes and soy compared to non-vegetarians.

Nutrients of Concern

The higher mean calcium intake of the vegetarians was not surprising since this was a lacto-ovo vegetarian dietary pattern, and the vegetarians had higher total dairy consumption than the non-vegetarians. As such, dairy consumption may have been the

primary source of calcium, but the vegetarians also had higher intakes of alternative sources of calcium, including dark green vegetables, nuts, legumes, and soy. Bioavailability of calcium from some of these sources may be affected by the oxalates and phytates also contained in them, but the calcium in low oxalate vegetables such as kale, broccoli, and bok choy is well absorbed (24).

Other nutrients often thought to be of concern for vegetarian diets are iron, vitamin B_{12}, and zinc. Intake of vitamin B_{12} by lacto-ovo vegetarians is generally not below recommendations, as shown in this analysis as well as previous work (4, 19, 20). Population-based studies (4, 20) have shown higher intakes of iron for vegetarians than non-vegetarians, and similar results are seen in the present analysis. Even so, none of these studies show that premenopausal women meet their recommended iron intake. Furthermore, absorption of iron can be compromised by other constituents of a vegetarian diet, so the IOM has recommended that vegetarians increase iron intake by 80% of the DRI (22). A common practice used by vegetarians to enhance absorption of iron is to consume vitamin C-containing fruits and vegetables, and vegetarians in the present study had mean intakes of more than three cups of fruit and vegetables per day.

Zinc may be more problematic, as vegetarian intakes are typically lower than non-vegetarians (4, 19, 20) and the phytates contained in grains and legumes that are the basis of a vegetarian diet are considered major inhibitors of zinc absorption. Because of this, the IOM estimates that zinc requirements for vegetarians who consume high amounts of grains and legumes may be up to 50% higher than for non-vegetarians (22). It is not clear whether low bioavailability of zinc can be overcome by vitamin C intake; however,

preparation methods such as soaking and sprouting may enhance the bioavailability of zinc from plant sources (30).

Comparisons to Dietary Reference Intakes

Comparing mean intakes for vitamins and minerals to RDAs or Adequate Intakes (AIs) would suggest that both vegetarians and non-vegetarians exceeded recommendations for most nutrients, and risk for inadequate intake is low. However, guidelines for the application of DRIs in dietary assessments from the IOM Subcommittee on Interpretation and Uses of Dietary Reference Intakes (31) specifically discuss the inappropriate use of RDAs and AIs to assess nutrient adequacy for groups. Regression-adjusted mean nutrient intakes may be used to evaluate differences between subgroups of a population, but adequacy must be assessed by comparing usual intakes to Estimated Average Requirements (EARs). The means for only one day of nutrient intakes are reported in this analysis; therefore, these data do not represent usual intake and may not be compared to EARs to assess adequacy for these groups. However, it may be helpful in practice to observe how mean nutrient amounts compare to recommended amounts as a way to further interpret the effect of the vegetarian diet on nutrient intake (see Figures 1 – 10, Appendix D). For example, mean vitamin A intake for vegetarians is 718 RAE, which is closer to the 900 RAE recommended for adult males than is the 603 RAE mean intake for non-vegetarians. Vegetarians are also closer to the 420 mg recommendation for adult males for magnesium at 322 mg than at 280 mg for non-vegetarians. While niacin and vitamin B_{12} intakes are significantly lower for vegetarians than for non-vegetarians, they are above the recommended amounts for adults and this is consistent with previous work (4, 20).

Caloric Reduction

Caloric balance has been indicated as a major determinant of weight loss (32-34), despite ongoing efforts to determine the effects of macronutrient composition on weight loss (35-37). Population-based studies have shown that vegetarians have caloric intakes as much as 464 kcal lower than non-vegetarians (3, 5, 20). This, taken with data showing that, on average, BMIs for vegetarians are 1.4 kg/m^2 lower than non-vegetarians (3,5,6,7), suggests that a vegetarian diet could be considered a version of a low calorie diet for weight management. The present study also supports this assumption, showing that the vegetarians consume 363 fewer calories than do non-vegetarians, and the mean BMI of vegetarians is 1.4 kg/m^2 lower than the mean for non-vegetarians.

Arguably, the 363 kcal difference between the vegetarians and the non-vegetarians in this study is less than the amount recommended by the National Heart Lung and Blood Institute of the National Institutes of Health for weight loss. However, recent work by Swinburn and colleagues (38) suggests that an energy excess of approximately 380 kcal per day may explain the weight gain observed in adults since the early 1970s. Nevertheless, current recommendations for weight loss of one to two pounds per week include decreasing caloric consumption by 500 to 1000 kcal per day (10). To observe the effect of a 500 kcal deficit on diet quality, subjects with caloric intakes of at least 500 kcal less than their estimated energy requirements were separated from the vegetarian and non-vegetarian groups and identified as dieters.

The nutrient intake pattern of the dieting vegetarians compared to the dieting non-vegetarians was similar to the comparison of all vegetarians and all non-vegetarians, although there were fewer significant differences between the two dieting groups. This

suggests that the vegetarian dietary pattern affected dietary quality more than did caloric intake. When "dieting," the vegetarians still had higher intakes of vitamins A, C, and E, folate, magnesium, and iron, although the differences were no longer significant. This could be explained by the observation that there were no differences between the groups for consumption of fruit, total vegetables, dark green vegetables, orange vegetables, or potatoes. Fiber intake remained significantly higher for the dieting vegetarians, as did intake of whole grains, legumes, and nuts as sources of fiber. Calcium also remained significantly higher, although total dairy intake did not. With fewer significant differences for food group intakes, the food choices of the dieting vegetarians resembled a dietary pattern more similar to the dieting non-vegetarians than to the non-dieting vegetarians. This may explain the observation that nutrient intake differences between vegetarians and non-vegetarians were extended when the dieters were separated from the groups.

It is interesting to note that BMIs were higher for subjects identified as dieters than for those who were identified as non-dieters. This could be explained by underreporting of dietary intake by those with higher BMIs, as it is well documented that underreporting occurs in self-reported dietary information on dietary surveys, particularly for overweight individuals (39). However, it may also be indicative of the status of their dieting. It is possible that many individuals in this group have only begun the lower calorie diet and have not yet lost weight, or that the current BMIs represent a decrease from the time that the dieters began the lower calorie diet.

Strengths and Limitations

Strengths of this study include the large sample size, based on recent, nationally representative data of adults in the United States. The credibility of the NHANES survey data is well accepted, and the sample size allows for statistically reliable estimates of dietary intakes.

Analysis of only one day of nutrient intake data was a limitation of this study. The data presented here can illustrate and compare diet quality for vegetarians, non-vegetarians, and dieters but cannot represent usual intakes to be used to assess adequacy of the diets. Further analysis of current data is needed to determine usual intakes, and linking nutrient intake data with biochemical markers of nutrient intake could provide insight into long-term effects of the dietary patterns. This type of analysis could be particularly powerful if the NHANES survey could provide data to indicate vegetarian status and the duration of that dietary pattern. Ad hoc analysis of the present study showed that ferritin, vitamin B_{12}, and serum iron levels were the same for vegetarians and non-vegetarians (Appendix E). This may be indicative of the definition of vegetarians used in this analysis, or the duration of the diet if the subjects were indeed vegetarian. Validation of the definition of vegetarians used in this study – those who did not eat meat, poultry, or fish on the day of the survey – is based on caloric intake and BMI differences that agree with previous analyses comparing vegetarians with non-vegetarians (3-7, 20). In addition, food group intake data showing higher consumption of legumes and soy agree with work by Haddad and Tanzman (4) reporting higher intakes of these foods by self-defined vegetarians who did not eat meat.

Also lacking in this study were data on vitamin D and omega-3 fatty acids, which are considered nutrients of concern for vegetarians 30). Given the current and emerging evidence of the impact of these nutrients on chronic disease, future analyses of vegetarian diet quality should include these nutrients.

Conclusion

Results of this analysis and others (4, 19, 20) indicate that a vegetarian dietary pattern is nutrient dense and is consistent with current dietary guidelines. It may be necessary for vegetarians to be particularly aware of zinc intake, and efforts to increase vitamins E, A, calcium, and magnesium intakes are necessary for both vegetarians and non-vegetarians. A modified food guide pyramid for lacto-vegetarians and vegans (41) and a food guide for North American vegetarians (42) have been developed, with specific recommendations for optimizing intake of vitamin B_{12}, iron, zinc, calcium, and vitamin D. At lower caloric intakes, dietary counseling may be needed to plan a more nutrient-dense diet, and this is the case for both vegetarians and non-vegetarians.

An interesting question is whether the vegetarian diets of recent years have benefited from food fortification and the development of products fortified to the specific needs of vegetarians. In a 1954 study (43) comparing lacto-ovo vegetarians and vegans to non-vegetarians, it was found that the lacto-ovo vegetarians consumed lower, yet adequate, protein, higher calcium, vitamin C, and thiamin, similar iron and riboflavin, and lower niacin than non-vegetarians. Complete food group intake data were not provided; however, it was implied that few commercially prepared foods were consumed by the vegetarians, with the exception of “commercially prepared nut foods” as meat substitutes. These results were similar to the present study; however, the sample was

small and data were not reported for all nutrients. Population-based data obtained before the marketing of fortified foods could be compared to the present study to provide further insight.

It is also likely that education by nutrition professionals about food choices may be the reason that there are few nutrient concerns for vegetarians in this sample. With resources such as the position statement of the American Dietetic Association on vegetarian diets (30) and the American Dietetic Association Vegetarian Nutrition Dietetic Practice Group, registered dietitians are well positioned to provide the most accurate information to the public to ensure adequate nutrient intakes for vegetarian dieters.

Chapter 6: Literature Review, Part 2

A Vegetarian Diet Improves the Nutritional Quality of Weight Loss Dieting

Efficacy of vegetarian weight loss diets.

A vegetarian diet has been suggested as an approach for weight management by several studies which have reported that vegetarians tend to be leaner than non-vegetarians (3-7). In a follow-up to the EPIC-Oxford study, Rosell and colleagues (43) found that individuals (n = 966) who adopted a vegetarian diet within the year before the follow-up survey had the lowest annual weight gain compared to those consuming an omnivorous diet (n = 13,288). Furthermore, it was noted that vegetarians who reverted to a non-vegetarian diet had the highest annual weight gain. However, few studies have compared vegetarian diets to low calorie non-vegetarian diets as a means for weight loss, and results are mixed.

Burke and colleagues (44) compared a lacto-ovo vegetarian (LOV) diet to a diet that included meat, poultry, and fish in a sample of 182 men and women, and both groups were instructed to follow the same calorie and fat restrictions. The two groups were further divided to determine the effect of treatment preference on weight loss and adherence to the diet. At six months, those in the LOV group (n = 84) lost more weight than did the non-vegetarians (n = 98), but the difference was not significant. However, this may have been due to non-adherence to the LOV diet. A sub-group of the LOV diet who were 100% adherent (n = 47) had lower caloric intakes and lost significantly more weight (10.63 ± 5.39 kg vs 4.98 ± 3.95 kg, $p < 0.001$) than those who were not adherent (n = 24). Results reported after 18 months found no significant difference between the LOV and non-vegetarian diets, and there was also no effect for treatment preference (45).

This may have been due to a further decline in compliance to the LOV diet, and these conclusions are consistent with an earlier study by Hakala and Karvetti (46). In that study, 136 men and women were randomized to a 1200 kcal lacto-vegetarian diet, a 1200 kcal omnivorous diet or a control diet with no caloric restriction. After 12 months, weight loss for the lacto-vegetarian dieters who completed the study (n = 31) was 9.2 kg, and the non-vegetarians (n = 37) lost an average of 10.4 kg. However, 23% of the lacto-vegetarian group was non-compliant for at least part of the year, and those who were compliant for the entire year lost an average of 10.5 kg.

Like Burke and colleagues, Phillips and colleagues (47) were interested in the effect of diet preference on weight and body composition. They recruited a small group of men and women (n = 43) who had previously decided to adopt a vegetarian diet, and analyzed anthropometric data to determine the effect of that dietary change on weight, BMI, and measurements of waist, hip, mid-upper arm circumference, and bicep and tricep skin-folds. The findings indicated significant reductions in waist, hip, and skin-fold measurements, suggesting that the subjects became leaner despite the fact that the change in weight was not significant. An important difference in this study compared to the study by Burke and colleagues was that the subjects had already decided to become vegetarian before the study began, and their diets were self-selected with no restrictions made and no advice offered on how to follow the diet except to exclude meat. For the purpose of the study, the vegetarian diet was defined as including dairy, eggs, and fish, but only eight of the 33 subjects participating at the end of the six month study ate fish.

Turner-McGrievy and colleagues (48) recruited a group of 64 overweight postmenopausal women to compare a low-fat vegan diet to the National Cholesterol

Education Program Step II diet. Within the group of 59 women who completed the study, those who followed the low fat vegan diet lost significantly more weight ($p = 0.012$) after the 14-week intervention (5.8 kg) than those on the Step II diet (3.8 kg). This effect continued for two years after the 14-week intervention, with loss of 4.9 kg at one year for the vegan group compared to 1.8 kg for the Step II group, and 3.1 kg at two years for the vegan group compared to 0.8 kg for the Step II group (49). Although no energy intake restriction was prescribed for either diet, the vegan diet did not allow the use of added oils, avocados, olives, nuts, nut butters, or seeds, and allowed only 10% of energy intake from fat, whereas the subjects following the Step II diet were allowed 30% of energy intake from fat. Fat intakes reported as percent of total energy intake were 11% $\pm$ 4% for the vegan group and 20% $\pm$ 6% for the Step II group. Despite this, it is interesting to note that caloric intake was not significantly different between the groups at the end of the 14-week intervention, yet the vegan group lost more weight.

Nutritional quality of vegetarian weight loss diets.

While the benefits of a vegetarian diet may include lower risk of overweight and obesity, there exists a perception that vegetarian diets are deficient in important nutrients, including protein, calcium, iron, and vitamin B_{12}. Although there are few data to demonstrate the effect of a vegetarian weight loss diet on nutrient intakes, some studies suggest that there are fewer nutrients of concern for vegetarian diets compared to other therapeutic diets. In a review of popular weight loss diets, Freedman and colleagues (50) constructed a menu based on recommendations for the Ornish diet, which is a very low fat vegetarian diet that has been recommended for weight loss (51). Based on the nutrient

analysis for that menu, only vitamin E and vitamin B_{12} were less than the DRI, at 47% and 42%, respectively.

When the Ornish diet was compared to other weight loss diets in a group of 291 women aged 25 to 50, eight-week nutrient intake data showed that fiber and vitamin C intakes improved from the baseline omnivorous diet (C.D. Gardner, unpublished data, July 2008). Mean intakes of all other vitamins and minerals decreased for the vegetarian group, and vitamins D, E, and A, calcium, iron, and magnesium were below the DRIs. Furthermore, the groups following the non-vegetarian diets in this study also did not meet DRIs for vitamins D, calcium, iron, and magnesium. Contrary to the values previously calculated for the sample menu (50), vitamin B_{12} intake for the group following the Ornish diet remained within the RDA at 4.0 mcg. The sample menu had only one cup of skim milk and no fortified foods as sources of vitamin B_{12}, whereas the study sample following the diet were free-living individuals who may have used more fortified foods, dairy, and eggs to attain this level for vitamin B_{12}.

Turner-McGrievy and colleagues (13) reported that intakes of fiber, total vitamin A, beta-carotene, thiamin, vitamin B_6, folic acid, vitamin C, magnesium, and potassium increased when 29 omnivorous dieters changed to a vegan eating plan for 14 weeks, while their intakes of vitamin D, vitamin B_{12}, calcium, phosphorus, selenium, and zinc decreased. Only vitamin A intake was adequate at both baseline and 14 weeks, whereas thiamin and vitamin C improved to recommended levels at the end of the 14 weeks. Similar changes in nutrient intakes were seen when a group of 49 non-vegetarians followed a low-fat vegan diet for 22 weeks, with increases in fiber, vitamin A and carotene, vitamin C, folate, magnesium, and potassium. Although vitamin B_{12} intake

decreased, it was still within recommended amounts, suggesting that this vegan diet included some fortified foods (52).

Study purpose.

These studies have shown how changing from non-vegetarian to vegetarian or low fat vegan diets affects nutrient intake compared to other low fat or low calorie diets. However, they were small samples, and the diets were defined by macronutrient or food group intakes, or a combination of these. There have been no population-based studies that have used mean nutrient intake contrasts to observe the effect of low calorie dieting and vegetarianism on diet quality. The purpose of this study was to analyze survey data from NHANES 1999-2004 to show that a vegetarian diet is a version of a low calorie diet that does not compromise nutrient intake by answering the specific research questions: Does dietary intake quality differ for (1) non-dieting non-vegetarians and individuals who consume lower calorie diets, (2) dieting non-vegetarians and all vegetarians, and (3) non-dieting vegetarians and dieting vegetarians?

Chapter 7: Methods, Part 2

Subjects

Subjects in this study were participants in the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2004. Adults aged 19 years and older with reliable dietary records were eligible for inclusion (n=14,196). From this eligible sample, pregnant and lactating women were excluded, for a final sample size of 13,292. This sample was further separated on the basis of vegetarianism and low calorie dieting. Vegetarians were defined as those who did not report eating meat, poultry, or fish on the day of the survey (n= 851), a definition that was previously used by Kennedy and colleagues (3). While all of these subjects may not be vegetarian, their dietary intakes on the day of the survey reflected the nutrient content of a lacto-ovo vegetarian dietary pattern, and this definition also excluded self-defined vegetarians who may actually be semi-vegetarian. Previous studies have found that up to two thirds of self-defined vegetarians reported consuming meat, poultry, or fish on dietary recalls (4,19,26) Dieters were defined as those who had caloric intakes that were at least 500 kilocalories less than their estimated energy requirements (EER) on the day of the survey (n= 4635), a definition that is supported by recommendations from the National Heart, Lung, and Blood Institute for calculating the reduction in energy intake for weight loss of one to two pounds per week (10). The EER for a sedentary activity level was used and was calculated as described by IOM (25) using the physical activity coefficient (PA) 1.0 (see Appendix A).

Approval for this study was obtained from the Human Subjects Review committee at Eastern Michigan University (Appendix B).

Research Design

This study is a cross-sectional analysis of dietary recall records and anthropometric data from NHANES 1999-2004. NHANES is a continuous annual survey conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention to obtain nationally representative information on the health and nutritional status of the U.S. population. The NHANES design is a stratified, multi-stage probability sample and includes oversampling of Mexican Americans, non-Hispanic blacks, and children and adolescents.

Dietary information for NHANES was obtained via a 5-step multiple pass 24-hour recall method conducted by trained interviewers who have bachelor of science degrees in food and nutrition or home economics. In the first step of the interview, a list of foods and beverages consumed the previous day was collected, and in the second step the interviewer probed for foods forgotten from this list. Time and eating occasions for each food were recorded in the third step, followed by detailed descriptions, amounts, and additions collected in the fourth step. The fifth step was a final probe for anything else consumed. Dietary recalls were considered reliable if at least the first four steps were completed and all of the relevant variables associated with the recall contained a value. Only dietary interviews that were considered reliable as coded by NCHS were included in this study.

Anthropometric measurements were made by trained NHANES health technicians in mobile examination centers. Body weight and standing height were determined electronically and were used to calculate body mass index (BMI) by dividing body weight in kilograms by height in meters squared.

Prior to NHANES 2001-2002, vitamin A was expressed as micrograms of retinol equivalents (mcg RE) and vitamin E was expressed as milligrams of alpha-tocopherol equivalents (mg ATE), whereas currently these nutrients are expressed as micrograms of retinol activity equivalents (mcg RAE) for vitamin A and milligrams of alpha tocopherol (mg AT) for vitamin E. To permit data from the 1999-2000 survey to be combined with 2001-2002 and 2003-2004 data, a special database was released by the United States Department of Agriculture (USDA) that allows the 1999-2000 intake estimates for vitamin A and vitamin E to be calculated in the current units (27). This database was merged with the NHANES dietary intake data used in the present study.

The MyPyramid Servings Database for USDA Food Codes Version 1 was used to convert NHANES 1999-2002 food intake data into guidance based amounts defined by the MyPyramid Food Guidance System (28). Data obtained from NHANES 2003-2004 were hand-matched to similar food in the MyPyramid database.

Statistical Analysis

Data preparation was performed using SAS software (version 9.0 for Windows, SAS Institute Inc., Cary, NC). Because three two-year cycles of continuous NHANES were combined, a six-year weight variable was created as described in the Analytic and Reporting Guidelines (29). All analyses were weighted using the NHANES examination sample weights and adjusted for the complex sample design of NHANES with the statistical package SUDAAN version 9.0 (Research Triangle Institute, Research Triangle Park, NC).

To answer the specific research questions, orthogonal comparison sets were devised as shown in Table 10. Contrasts and standard errors were reported for each

orthogonal set, and the differences were calculated as a percentage of the highest RDA or AI from among the amounts for adults, excluding the values for pregnant or lactating women (see Appendix C for amounts used). Energy intake was adjusted for gender and ethnicity. Nutrients, MyPyramid servings, and BMIs were adjusted for gender, ethnicity, and energy intake. Standard errors were estimated by the Taylor linearization technique of SUDAAN, and statistical significance was set at $p<0.01$. Because the Food and Drug Administration has defined 10% of the recommendation for intake of a nutrient as a good source of that nutrient, that amount was used in this study to define a significant change in nutrient intake, and the term "biological significance" was used for the purpose of discussion of this concept.

Table 10. Orthogonal comparison sets for vegetarians, non-vegetarians, and dieters.

	Non-dieting non-vegetarians	Dieting non-vegetarians	Non-dieting vegetarians	Dieting vegetarians
NLC vs LC	3	-1	-1	-1
DNV vs V	0	2	-1	-1
NDV vs DV	0	0	1	-1

NLC (non-low calorie) = non-dieting non-vegetarians
LC (low calorie) = dieting non-vegetarian, non-dieting vegetarians, dieting vegetarians
DNV = Dieting non-vegetarians
V = all vegetarians
NDV = non-dieting vegetarians
DV= dieting vegetarians

Chapter 8: Results, Part 2

Subjects

The eligible sample of 13,292 adults aged 19 years and older was classified as either vegetarian or non-vegetarian, and 6% of the sample was vegetarian. These two groups were further subdivided by caloric intake to represent dieters and non-dieters. Because the non-dieting non-vegetarians had the highest caloric intake, they were designated as the non-low calorie group, and the dieters and vegetarians were combined to create the low calorie group for the first comparison set. Sample characteristics for each comparison set are presented in Table 11. The negative value for the contrast BMI for the first comparison set indicated that the mean BMI for the non-low calorie group was 1.8 kg/m^2 lower than the mean of the low calorie group. The mean BMI of the dieting non-vegetarians was 3.9 kg/m^2 higher than that of the vegetarian group, and the mean of the non-dieting vegetarians was 4.6 kg/m^2 lower than that of the dieting vegetarians. The contrasts for all three comparisons were significant at $p<0.01$.

Table 11. Sample characteristics for orthogonal comparisons of non-vegetarians, vegetarians, and dieters, ages 19 years and older (N=13,292) (NHANES[a] 1999-2004)

Characteristic	Non-low calorie	Low Calorie	Dieting non-vegetarians	Vegetarians	Non-dieting vegetarians	Dieting vegetarians
n	8,225	5,067	4,216	851	432	419
Gender						
Male	4,103	2,644	2,282	362	161	201
Female	4,122	2,423	1,934	489	271	218
Contrast BMI[b] (SE[c]) kg/m^2 adjusted for energy, gender, ethnicity	-1.8 (0.23)†		3.9 (0.25)†		-4.6 (0.49)†	

[a] National Health and Nutrition Examination Survey

[b] Body mass index

[c] Standard error

† $p < 0.01$

Contrasts

Orthogonal set 1 – Non-low calorie vs low calorie diets.

Mean differences of nutrient intakes for non-low calorie (non-dieting non-vegetarians) and the low calorie group are shown in Table 12. Positive values for total fat, saturated fat, and cholesterol indicate that non-dieting non-vegetarians had higher intakes than the low calorie group. Sodium intake for the non-dieting non-vegetarians was also higher. The negative value for fiber shows that the mean intake of fiber was 1.89 g lower for the non-dieting non-vegetarians than for the low calorie group. However, this difference represents less than 5% of the RDA for fiber and so was not considered biologically significant. Calcium and magnesium intakes were also lower for the non-dieting non-vegetarians, and while the differences were statistically significant, they were not biologically significant. The mean differences for niacin, vitamin B_{12}, and zinc show that intakes for those nutrients were higher for the non-dieting non-vegetarian representing 24%, 45%, and 16% of the RDAs respectively, and so were considered biologically significant. The mean difference for folate represented higher intake for the low calorie group and was biologically significant at 14% of the RDA.

Negative values for the mean differences for food group intakes (Table 13) show that the non-dieting non-vegetarians ate less total grain and whole grain, legumes, soy, nuts, total dairy, cheese, and added sugar. Total vegetable and potato consumption was higher for the non-dieting non-vegetarians than for the low calorie group, as was discretionary fat.

Table 12. Contrasts of nutrient intake means for non-dieting non-vegetarians and low calorie group[a], NHANES[b] 1999-2004 participants ages 19 years and older (N=13,292)

Nutrient[c]	Contrast mean		SE[d]		Contrast %DRI[e]	
Energy (kcal)	967.44	±	18.24	*		
Protein (g)	14.60	±	0.86	*		
Carbohydrate (g)	-20.43	±	2.39	*		
Fiber (g)	-1.89	±	0.43	*	-5.0	
Total fat (g)	6.63	±	1.10	*		
Sat fat (g)	1.63	±	0.39	*		
Cholesterol (mg)	63.80	±	6.16	*		
Sodium (mg)	401.25	±	36.30	*		
Potassium (mg)	170.81	±	34.44	*	3.6	
Vitamin E (mg AT[f])	-0.40	±	0.24		-2.6	
Vitamin A (mcg RAE[g])	-31.84	±	24.07		-3.5	
Thiamin (mg)	0.03	±	0.03		2.2	
Riboflavin (mg)	0.01	±	0.03		0.8	
Niacin (mg)	3.78	±	0.31	*	23.6	**
Vitamin B_6 (mg)	0.16	±	0.04	*	9.4	
Folate (mcg DFE[h])	-56.54	±	14.26	*	-14.1	**
Vitamin B_{12} (mcg)	1.07	±	0.21	*	44.5	**
Vitamin C (mg)	-3.31	±	4.04		3.7	
Calcium (mg)	-92.25	±	18.13	*	-7.7	
Magnesium (mg)	-10.76	±	3.79	*	-2.6	
Iron (mg)	0.02	±	0.28		0.1	
Zinc (mg)	1.75	±	0.17	*	15.9	**

[a] Dieting non-vegetarians and all vegetarians

[b] National Health and Nutrition Examination Survey

[c] One day food intake, energy intake adjusted for gender and ethnicity, all other nutrients adjusted for energy, gender, and ethnicity

[d] Standard error

[e] Based on the highest RDA or AI amount from among the values for adults, excluding the amounts for pregnant and lactating women

[f] α-tocopherol

[g] retinol activity equivalents

[h] dietary folate equivalents

* Significant , $p<0.01$

** Biologically significant, ≥ 10% DRI

Table 13. Contrasts of MyPyramid food group intake means[a] for non-dieting non-vegetarians and low calorie group[b], NHANES[c] 1999-2004 participants ages 19 years and older (N=13,292)

	MyPyramid equivalent	Contrast mean		SE[d]	
Total grain	ounce	-0.44	±	0.10	*
Non-whole grain	ounce	-0.17	±	0.10	
Whole grain	ounce	-0.26	±	0.05	*
Fruit	cup	-0.04	±	0.05	
Vegetable	cup	0.15	±	0.05	*
Dark green vegetable	cup	-0.02	±	0.01	
Orange vegetable	cup	0.02	±	0.01	
Potato	cup	0.12	±	0.02	*
Meat, poultry, fish	ounce	2.79	±	0.10	*
Egg	ounce	0.01	±	0.03	
Legume	ounce	-0.07	±	0.02	*
Soy	ounce	-0.18	±	0.04	*
Nuts	ounce	-0.21	±	0.07	*
Total dairy	cup	-0.32	±	0.06	*
Milk	cup	-0.13	±	0.05	
Cheese	cup	-0.19	±	0.03	*
Added sugar	teaspoons	-2.16	±	0.66	*
Discretionary fat	grams	2.18	±	0.72	*
Discretionary oil	grams	0.12	±	0.59	

[a] One day intake, adjusted for energy, gender, and ethnicity

[b] Dieting non-vegetarians and all vegetarians

[c] National Health and Nutrition Examination Survey

[d] Standard error

* $p < 0.01$

Orthogonal set 2 – Dieting non-vegetarians vs vegetarians.

Negative values for fiber, vitamins A, C, and E, thiamin, riboflavin, folate, calcium, magnesium, and iron show that dieting non-vegetarians had lower mean intakes of these nutrients than all vegetarians (Table 14). The mean differences represent more than 10% of the DRIs for these nutrients and so were considered biologically significant. Positive values for niacin, zinc, and vitamin B_{12} show that these nutrients were higher for dieting non-vegetarians, and the mean differences were biologically significant. Sodium was also higher for the dieting non-vegetarians, and the mean difference represents 18% of the tolerable upper intake level of 2,300 mg for adults.

The dieting non-vegetarians had lower total grain, non-whole grain, whole grain, and fruit intakes than the vegetarian group (Table 15). There were no differences in vegetable consumption between the two groups except potato intake, which was higher for the non-vegetarian dieters. As expected, the vegetarians ate more legumes, soy, nuts, and the dieting non-vegetarians ate more meat, poultry, and fish, and discretionary fat. Total dairy and milk intakes were also higher for the vegetarians.

Table 14. Contrasts of nutrient intake means for dieting non-vegetarians (N=4,216) and all vegetarians (N=851), NHANES[a] 1999-2004 participants ages 19 years and older

Nutrients [b]	Contrast mean		SE[c]		Contrast %DRI [d]	
Energy (kcal)	-413.30	±	29.51	*		
Protein (g)	19.60	±	0.86	*		
Carbohydrate (g)	-43.78	±	2.69	*		
Fiber (g)	-5.37	±	0.53	*	-14.1	**
Total fat (g)	6.96	±	0.90	*		
Sat fat (g)	2.51	±	0.41	*		
Cholesterol (mg)	84.50	±	8.09	*		
Sodium (mg)	419.72	±	36.39	*		
Potassium (mg)	-123.41	±	36.06	*	-2.6	
Vitamin E (mg AT[e])	-1.59	±	0.25	*	-10.6	**
Vitamin A (mcg RAE[f])	-130.23	±	27.94	*	-14.5	**
Thiamin (mg)	-0.13	±	0.03	*	-10.4	**
Riboflavin (mg)	-0.15	±	0.04	*	-11.7	**
Niacin (mg)	4.23	±	0.40	*	26.4	**
Vitamin B_6 (mg)	0.04	±	0.05		2.1	
Folate (mcg DFE[g])	-131.79	±	15.27	*	-32.9	**
Vitamin B_{12} (mcg)	1.40	±	0.22	*	58.3	**
Vitamin C (mg)	-27.80	±	5.54	*	-30.9	**
Calcium (mg)	-171.96	±	19.99	*	-14.3	**
Magnesium (mg)	-48.00	±	4.58	*	-11.4	**
Iron (mg)	-1.86	±	0.35	*	-10.3	**
Zinc (mg)	1.72	±	0.24	*	15.6	**

[a] National Health and Nutrition Examination Survey

[b] One day food intake, energy intake adjusted for gender and ethnicity, all other nutrients adjusted for energy, gender, and ethnicity

[c] Standard error

[d] Based on the highest RDA or AI amount from among the values for adults, excluding the amounts for pregnant and lactating women

[e] α-tocopherol

[f] retinol activity equivalents

[g] dietary folate equivalents

*Significant, $p<0.01$

** Biologically significant, ≥10% DRI

Table 15. Contrasts of MyPyramid food group intake means[a] for dieting non-vegetarians (N=4,216) and all vegetarians (N=851), NHANES[b] 1999-2004 participants ages 19 years and older

	MyPyramid equivalent	Contrast mean		SE[c]	
Total grain	ounce	-1.21	±	0.14	*
Non-whole grain	ounce	-0.59	±	0.14	*
Whole grain	ounce	-0.63	±	0.07	*
Fruit	cup	-0.42	±	0.06	*
Vegetable	cup	-0.03	±	0.07	
Dark green vegetable	cup	-0.05	±	0.02	
Orange vegetable	cup	-0.01	±	0.01	
Potato	cup	0.14	±	0.02	*
Meat, poultry, fish	ounce	4.19	±	0.08	*
Egg	ounce	-0.05	±	0.04	
Legume	ounce	-0.11	±	0.02	*
Soy	ounce	-0.28	±	0.06	*
Nuts	ounce	-0.34	±	0.09	*
Total dairy	cup	-0.40	±	0.06	*
Milk	cup	-0.29	±	0.06	*
Cheese	cup	-0.10	±	0.04	
Added sugar	teaspoons	-1.33	±	0.72	
Discretionary fat	grams	3.12	±	0.85	*
Discretionary oil	grams	-1.32	±	0.78	

[a] One day intake, adjusted for energy, gender, and ethnicity

[b] National Health and Nutrition Examination Survey

[c] Standard error

* $p < 0.01$

Orthogonal Set 3 – Non-dieting vegetarians vs dieting vegetarians.

Positive values for fiber, potassium, vitamins A, C, and E, calcium, magnesium, thiamin, riboflavin, vitamin B_6, folate, phosphorus, and iron shown in Table 16 indicate that non-dieting vegetarians have higher mean intakes of these nutrients than dieting vegetarians. With the exception of vitamin E, the mean differences for these nutrients represent more than 10% of recommended intakes, and so were considered biologically significant. Intakes of sodium and cholesterol were also higher for the non-dieting

vegetarians, whereas total fat and saturated fat intakes were higher for the dieting vegetarians.

There were few significant differences for food group intake between the non-dieting and dieting vegetarians (Table 17). The non-dieting vegetarians ate more whole grain, fruit, vegetables, and legumes than the dieting vegetarians, and the dieting vegetarians ate more discretionary fat. It appeared that dieting vegetarians had higher intakes of meat, poultry, and fish than the non-dieting vegetarians; however, this was due to adjustment for kcal, gender, and ethnicity, and unadjusted values confirmed that neither group ate meat, poultry, or fish.

Table 16. Contrasts of nutrient intake means for nondieting vegetarians (N=432) and dieting vegetarians (N=419), NHANES[a] 1999-2004 participants ages 19 years and older

Nutrient [b]	Contrast mean		SE[c]		Contrast %DRI [d]	
Energy (kcal)	1260.70	±	40.18	*		
Protein (g)	-1.85	±	1.77			
Carbohydrate (g)	32.68	±	6.17	*		
Fiber (g)	7.35	±	0.72	*	19.3	**
Total fat (g)	-5.25	±	1.85	*		
Sat fat (g)	-2.69	±	0.75	*		
Cholesterol (mg)	13.58	±	14.55			
Sodium (mg)	110.18	±	86.12			
Potassium (mg)	537.57	±	91.69	*	11.4	**
Vitamin E (mg AT[e])	1.34	±	0.52		8.9	
Vitamin A (mcg RAE[f])	200.22	±	51.54	*	22.2	**
Thiamin (mg)	0.22	±	0.07	*	18.6	**
Riboflavin (mg)	0.33	±	0.09	*	25.0	**
Niacin (mg)	-0.80	±	0.81		5.0	
Vitamin B_6 (mg)	0.19	±	0.09		11.1	**
Folate (mcg DFE[g])	158.99	±	43.23	*	39.7	**
Vitamin B_{12} (mcg)	-0.12	±	0.33		-4.9	
Vitamin C (mg)	35.73	±	6.58	*	39.7	**
Calcium (mg)	154.84	±	60.71		12.9	**
Phosphorus (mg)	137.15	±	42.80	*	19.6	**
Magnesium (mg)	65.63	±	9.82	*	15.6	**
Iron (mg)	2.50	±	0.78	*	13.9	**
Zinc (mg)	0.32	±	0.43		2.9	

[a] National Health and Nutrition Examination Survey

[b] One day food intake, energy adjusted for gender and ethnicity, all other nutrients adjusted for energy, gender, and ethnicity

[c] Standard error

[d] Based on the highest RDA or AI amount from among the values for adults, excluding the amounts for pregnant and lactating women

[e] α-tocopherol

[f] retinol activity equivalents

[g] dietary folate equivalents

* Significant, $p<0.01$

** Biologically significant, ≥ 10% DRI

Table 17: Contrasts of MyPyramid food group intake means[a] for non-dieting vegetarians (N = 432) and dieting vegetarians (N - 419), NHANES[b] 1999-2004 participants ages 19 years and older

	MyPyramid equivalents	Contrast mean		SE[c]	
Total grain	ounce	1.13	±	0.25	*
Non-whole grain	ounce	0.48	±	0.23	
Whole grain	ounce	0.65	±	0.12	*
Fruit	cup	0.71	±	0.10	*
Vegetable	cup	0.27	±	0.10	*
Dark green vegetable	cup	0.07	±	0.03	
Orange vegetable	cup	0.04	±	0.02	
Potato	cup	-0.10	±	0.05	
Meat, poultry, fish	ounce	-1.77	±	0.15	*
Egg	ounce	0.16	±	0.07	
Legume	ounce	0.10	±	0.04	*
Soy	ounce	0.07	±	0.12	
Nuts	ounce	0.27	±	0.15	
Total dairy	cup	0.30	±	0.20	
Milk	cup	0.39	±	0.15	
Cheese	cup	-0.11	±	0.10	
Added sugar	teaspoons	-3.28	±	1.68	
Discretionary fat	grams	-4.97	±	1.63	*
Discretionary oil	grams	0.14	±	1.59	

[a] One day intake, adjusted for energy, gender, and ethnicity

[b] National Health and Nutrition Examination Survey

[c] Standard error

* $p < 0.01$

Chapter 9: Discussion, Part 2

This is the first study to demonstrate the effects of dieting and vegetarianism on dietary intake quality using an orthogonal analysis of NHANES 1999-2004 survey data. This type of analysis provides the ability to contrast mean results for one group with mean results for a combination of groups. Furthermore, covariance between the sets of comparisons is reduced to zero (eliminating confounding or influence of other comparisons), as suggested by the independent, non-redundant, and non-overlapping characteristics of orthogonality. The absence of correlation, or orthogonality, between the comparison sets chosen for this study can be shown by calculating the sum of the coefficients and the sum of the products of the corresponding coefficients (Table 18). These comparison sets were devised to answer three specific questions: Does dietary intake quality differ for (1) non-dieting non-vegetarians and individuals who consume lower calorie diets, (2) non-vegetarian dieters and vegetarians, and (3) non-dieting vegetarians and dieting vegetarians? Contrasting the mean nutrient intakes for each set indicates the degree (and the direction) to which the dietary patterns affect nutrient intake. This analysis enables the observation of patterns of nutrient intakes between diet groups, and these observations suggest the changes that may occur when changing from one dietary pattern to another. Calculating the contrast means as a percentage of DRIs provides a perspective that may be more meaningful to practice by showing how these changes affect the ability of the dieters to meet recommended nutrient intakes.

Table 18. Orthogonal comparison sets and coefficient calculations

	Non-dieting non-vegetarians	Dieting Non-vegetarians	Non-dieting vegetarians	Dieting vegetarians	Sum of coefficients
NLC vs LC	3	-1	-1	-1	0
DNV vs V	0	2	-1	-1	0
NDV vs DV	0	0	1	-1	0

Sum of products for each pair of lines:
1,2: (3)(0) + (-1)(2) + (-1)(-1) + (-1)(-1) = 0
1,3: (3)(0) + (-1)(0) + (-1)(1) + (-1)(-1) = 0
2,3: (0)(0) + (2)(0) + (-1)(1) + (-1)(-1) = 0

Does Dietary Intake Quality Differ for Non-dieting Non-vegetarians and Individuals Who Consume Lower Calorie Diets?

The focus of this question was on the effect of lower calorie intake on dietary intake quality, and so the groups with lower caloric intakes were combined and compared to the group with highest caloric intake, in this case the non-dieting non-vegetarians. Because population-based studies (3, 5, 20) have shown that vegetarians have lower caloric intakes than non-vegetarians, vegetarians were included in the lower calorie diet group along with dieting non-vegetarians.

Differences between the non-dieting non-vegetarians and the low calorie group were significant for all macronutrients, sodium, potassium, niacin, folate, vitamins B_6, B_{12}, and C, calcium, magnesium, and zinc, indicating that dietary quality does differ for non-dieting non-vegetarians and low calorie dieters. The low calorie group had lower intakes of niacin, vitamins B_6 and B_{12}, and zinc, and this may reflect the inclusion of the vegetarians in the low calorie group, as these are known nutrients of concern for vegetarian dietary patterns. Likewise, the higher fiber, calcium, magnesium, and folate

intakes for the low calorie group may also reflect the vegetarian dietary pattern, as previous work has shown that vegetarians typically have higher intakes of these nutrients (4, 19, 20, B. Farmer, unpublished data, 2009).

Dietary patterns that limit or omit meat, poultry, and fish and include more plant protein such as legumes and nuts and more whole grains increase fiber and mineral intake while decreasing saturated fat and cholesterol intake, and this is evident in the comparison of non-dieting non-vegetarians to the low calorie group. The low calorie group had lower intakes of meat, poultry, and fish than the non-dieting non-vegetarians, with corresponding lower intakes of total fat, saturated fat, and cholesterol. The higher whole grain, legume, nuts, soy, and total dairy intake of the low calorie group would be expected to provide the higher fiber, calcium, and magnesium amounts that were observed for this group compared to the non-dieting non-vegetarians.

These findings suggest that low calorie dieting increases the risk for lower intakes of niacin, vitamins B_6 and B_{12}, and zinc. It also appears that low calorie dieters have lower total fat, saturated fat, and cholesterol intakes, and higher fiber, calcium, and magnesium. While this dietary pattern may be characteristic of other weight loss diets, it is also likely that this nutrient profile is influenced by the inclusion of the vegetarians in this group. The inclusion of the vegetarians in the low calorie group also influenced the differences in vegetable intakes. Total vegetable intake was higher for the non-dieting non-vegetarians, and this could be partially due to higher potato intake for that group. Previous work (4, B. Farmer, unpublished data, 2009) has reported higher intake of dark green vegetables and lower potato intakes for vegetarians.

Does Dietary Intake Quality Differ for Dieting Non-vegetarians and All Vegetarians?

When the low calorie group was divided to compare the dieting non-vegetarians to vegetarians, the pattern of mean differences for nutrient intakes was similar to differences observed between non-dieting non-vegetarians and the low calorie group; however, more of the differences were significant. Niacin, vitamin B_{12}, zinc, protein, total fat, saturated fat, and cholesterol intakes were all lower for the vegetarians, an observation that is typical of this dietary pattern. Also typical for vegetarian diets are the higher fiber, potassium, vitamins A, C, and E, calcium, and magnesium intakes shown here. These are all nutrients that are characteristic of plant-based diets and are also all nutrients of concern for the general population (14). Similarly, Turner-McGrievy and colleagues (45) reported that when dieters changed from a non-vegetarian diet to a vegan eating plan for 14 weeks, their intakes of protein, fat, saturated fat, cholesterol, vitamin B_{12}, and zinc decreased, while intakes of fiber, total vitamin A, beta-carotene, folic acid, vitamin C, magnesium, and potassium increased.

These findings suggest that, with the exception of niacin, vitamin B_{12}, and zinc, a vegetarian dietary pattern improves the quality of low calorie dieting. It should be noted, however, that while the mean contrasts represent significant decreases for niacin, vitamin B_{12}, and zinc for vegetarians, previous studies (4, 19, 20, B. Farmer, unpublished data 2009) have shown that mean intakes of niacin and vitamin B_{12} for lacto-ovo vegetarians typically meet recommendations. Nonetheless, the decreases for niacin, vitamin B_{12}, and zinc represent 26%, 58%, and 15% of the RDAs, respectively, and demonstrate the need for attention to these nutrients when changing from non-vegetarian to vegetarian dieting.

Does Dietary Intake Quality Differ for Non-dieting Vegetarians and Dieting Vegetarians?

Food and nutrient intake patterns observed in this comparison suggest that vegetarians who decrease caloric intake by 500 kcal or more, possibly with the intention of weight loss, increase their risk for poor nutrient intake. The dieting vegetarians consumed significantly lower amounts of whole grains, fruit, vegetables, and legumes, and more discretionary fat, and this is reflected in significant differences for intakes of fiber, vitamin A, vitamin C, thiamin, riboflavin, folate, calcium, magnesium, and iron, The differences for each of these nutrients represent more than 10% of the DRI, and notably, the differences for folate and vitamin C each represent nearly 39% of the DRI. This finding demonstrates the need for individuals who are considering a lower calorie vegetarian diet for weight loss to consult with a nutrition professional for strategies to ensure that nutrient needs are met on that diet.

Conclusion

Results of this analysis go beyond descriptive comparisons of vegetarians, non-vegetarians, and dieters to show how changes in dietary patterns affect nutrient intakes. Differences shown for the dieting non-vegetarians and the vegetarians indicate that the vegetarian diet improves the quality of low calorie dieting by decreasing fat, saturated fat, and sodium while increasing intakes of vitamins A, C, and E, thiamin, riboflavin, folate, calcium, magnesium, iron, and fiber. Previous studies (13, 49) have shown that intakes of niacin, vitamin B_{12}, and zinc decrease when a non-vegetarian changes to a vegetarian diet for weight loss, and this is supported by the present study. However, descriptive means reported for lacto-ovo vegetarian intakes of these nutrients show that niacin and

vitamin B_{12} means are above recommended amounts, although zinc is not (B. Farmer, unpublished data, 2009). It may be problematic when vegetarians decrease caloric intake by 500 kcal or more, as significant decreases in nutrient intakes were observed when dieting vegetarians were compared to non-dieting vegetarians. Population-based studies have shown that vegetarians have caloric intakes as much as 464 kcal lower than non-vegetarians (3, 5, 20), suggesting that a vegetarian diet can be a low calorie diet for weight loss without further decreases in caloric intake.

Chapter 10: Summary and Conclusions

The purpose of this thesis was to show that a vegetarian diet is a version of a low calorie diet that does not compromise nutrient intake. In order to demonstrate this, the first objective of the research was to describe nutrient intakes and BMIs for non-vegetarians, vegetarians, and dieters using survey data from NHANES 1999-2004. Dietary intake quality was better for vegetarians than for non-vegetarians, as shown by higher energy-adjusted mean intakes of fiber, vitamins A, C, and E, thiamin, riboflavin, folate, calcium, magnesium, and iron, and lower mean intakes of total fat, saturated fat, cholesterol, and sodium. When the groups were divided by caloric intake to represent dieters and non-dieters, the same patterns were observed, except that there were fewer significant differences between the dieting vegetarians and the dieting non-vegetarians. The differences were extended for the non-dieting vegetarians compared to the non-dieting non-vegetarians.

The second objective of this research was to compare the differences in nutrient intakes using an orthogonal analysis. The observations in this analysis demonstrated the degree and direction to which nutrient intakes were affected by dieting and vegetarianism. Low calorie dieting appeared to improve intakes of fiber, potassium, folate, calcium, and magnesium, while lowering total fat, saturated fat, and cholesterol as well as niacin, vitamins B_6 and B_{12}, and zinc. However, this is a pattern suggestive of vegetarian nutrient intakes and these observations may have been influenced by the inclusion of the vegetarians in the low calorie group. When the vegetarians were separated from the low calorie group and compared to the dieting non-vegetarians, the results showed significant increases in iron, magnesium, calcium, vitamins A, C, and E,

folate, riboflavin, thiamin, and fiber for the vegetarians, suggesting that a vegetarian dietary pattern improves the quality of low calorie dieting. However, dietary quality was adversely affected by decreasing the caloric intake of the vegetarian diet.

This research contributes toward a better understanding of dietary intake quality for vegetarians, non-vegetarians, and dieters, and supports previous work (4, 19, 20) which has shown that the quality of a vegetarian diet is consistent with current dietary guidelines. Although the data demonstrate that a vegetarian approach for weight loss would not compromise nutrient intake, there may be a critical point at which decreasing the caloric level of a vegetarian diet would result in inadequate nutrient intakes. Nutrition professionals will need to be aware of the caloric intakes and food choices made by dieting clients to ensure that nutrient needs are met.

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APPENDICES

Appendix A: Estimated energy requirement (EER) calculations

EER for Men Ages 19 Years and Older

$EER = 662 - (9.53 \times \text{age [y]}) + PA \times (15.91 \times \text{weight [kg]} + 539.6 \times \text{height [m]})$

Where PA is the physical activity coefficient:

PA = 1.00 if physical activity level (PAL) is estimated to be $\geq 1.0 < 1.4$ (sedentary)

EER for Women Ages 19 Years and Older

$EER = 354 - (6.91 \times \text{age [y]}) + PA \times (9.36 \times \text{weight [kg]} + 726 \times \text{height [m]})$

Where PA is the physical activity coefficient:

PA = 1.00 if PAL is estimated to be $\geq 1.0 < 1.4$ (sedentary)

Appendix B: Human Subjects Review approval

EASTERN MICHIGAN UNIVERSITY

March 18, 2009

Bonnie Farmer
c/o George Liepa
Eastern Michigan University
School of Health Science
Ypsilanti, Michigan 48197

Dear Bonnie Farmer,

The CHHS Human Subjects Review Committee has reviewed the revisions to your proposal entitled: "Comparison of nutrient intakes for vegetarians, non-vegetarians, and dieters: Results from the National Health and Nutrition Examination" (CHHS 09-033).

The committee reviewed your proposal and its revisions and concluded that the risk to participants is minimal. Your study is approved by the committee.

Appendix C: Highest dietary reference intake amounts from among the values for adults, excluding the amounts for pregnant or lactating women

	RDA[a]	AI[b]	UL[c]
Vitamin E (mg AT[d])	15		
Vitamin A (mcg RAE[e])	900		
Thiamin (mg)	1.2		
Riboflavin (mg)	1.3		
Niacin (mg)	16		
Vitamin B6 (mg)	1.7		
Folate (mcg DFE[f])	400		
Vitamin B12 (mcg)	2.4		
Vitamin C (mg)	90		
Calcium (mg)		1200	
Magnesium (mg)	420		
Iron (mg)	18		
Zinc (mg)	11		
Sodium (mg)			2300
Potassium (mg)		4700	

[a] Recommended dietary allowance

[b] Adequate intake

[c] Tolerable upper intake level

[d] alpha tocopherol

[e] retinol activity equivalent

[f] dietary folate equivalent

Appendix D: Comparison of nutrient intakes to dietary reference intake amounts

Vegetarian Nutrients of Concern

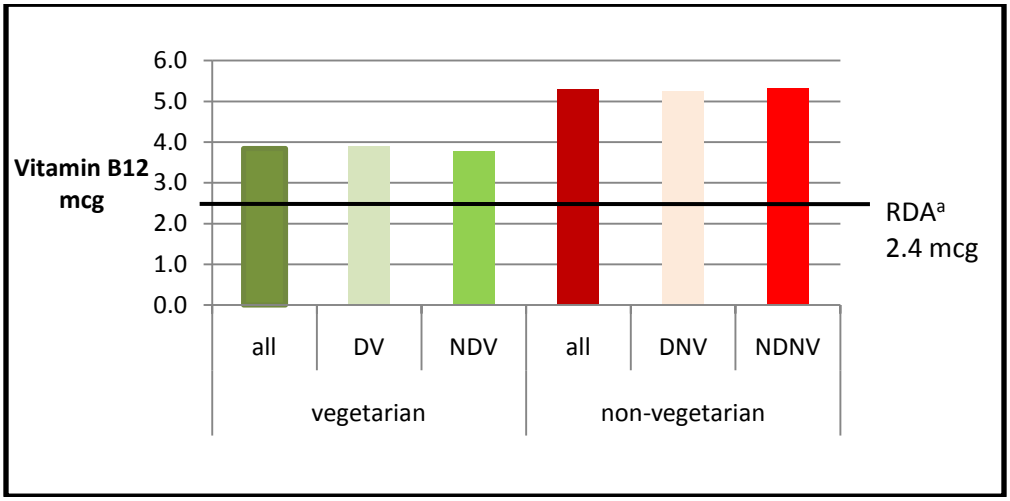

Figure 1. Comparison of mean vitamin B_{12} intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[b] 1999-2004.
[a] Recommended dietary allowance
[b] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity
DV= dieting vegetarian
NDV= non-dieting vegetarian
DNV= dieting non-vegetarian
NDNV= non-dieting non-vegetarian

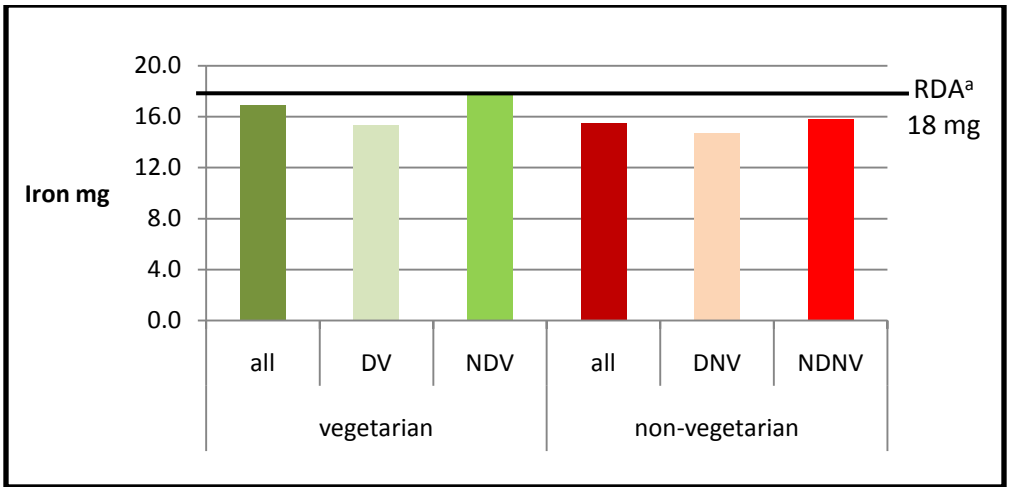

Figure 2. Comparison of mean iron intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[b] 1999-2004.
[a] Recommended dietary allowance
[b] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity
DV= dieting vegetarian
NDV= non-dieting vegetarian
DNV= dieting non-vegetarian
NDNV= non-dieting non-vegetarian

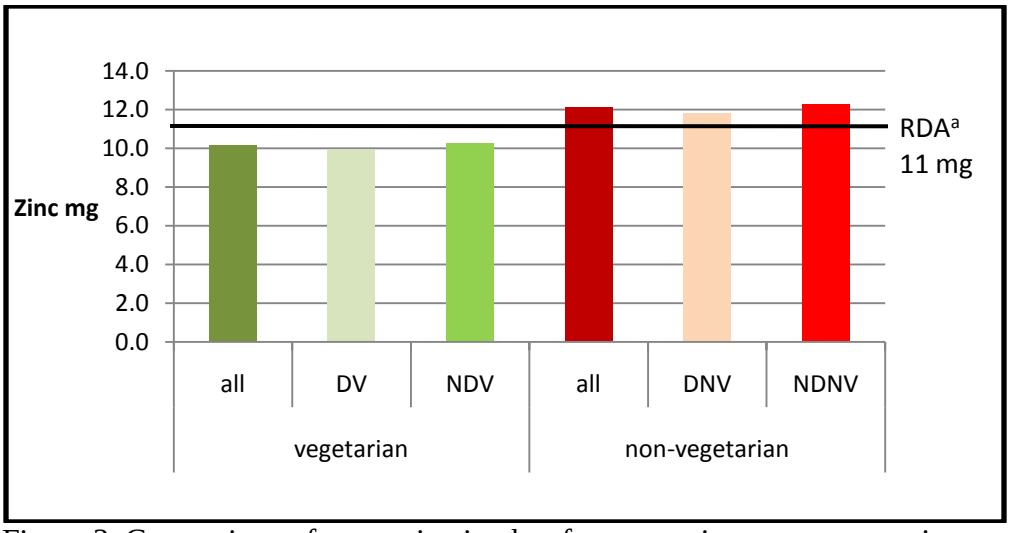

Figure 3. Comparison of mean zinc intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[b] 1999-2004.
[a] Recommended dietary allowance
[b] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity
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DNV= dieting non-vegetarian
NDNV= non-dieting non-vegetarian

Nutrients of concern for the general population

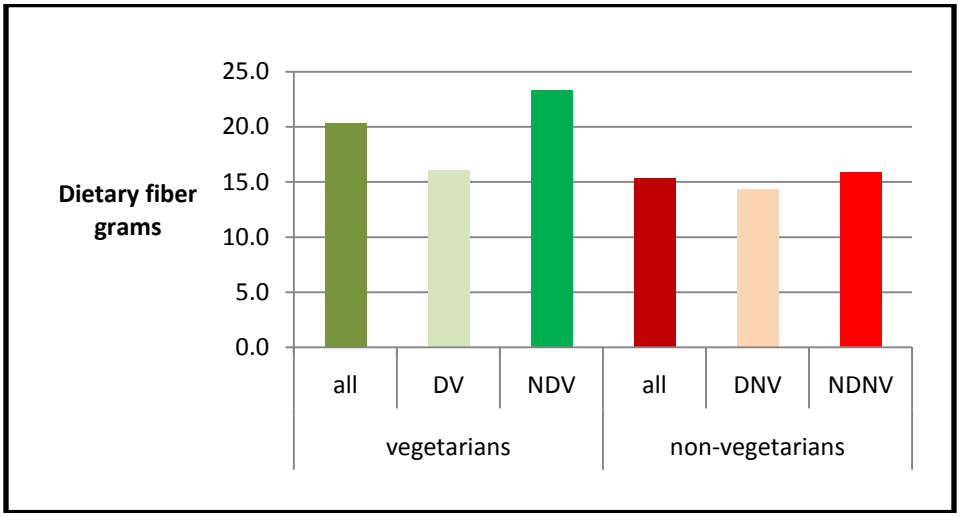

Figure 4. Comparison of mean fiber intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[a] 1999-2004.

[a] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity

DV= dieting vegetarian

NDV= non-dieting vegetarian

DNV= dieting non-vegetarian

NDNV= non-dieting non-vegetarian

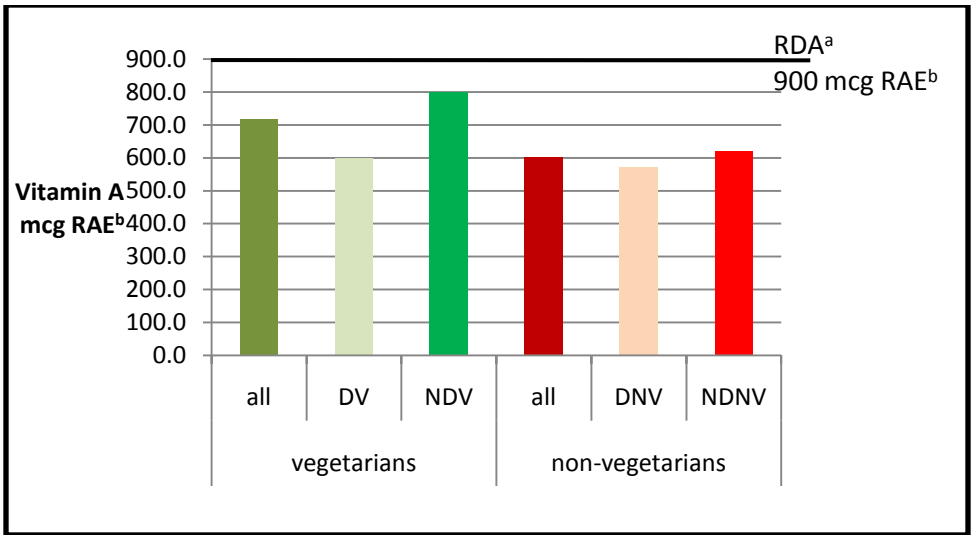

Figure 5. Comparison of mean vitamin A intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[c] 1999-2004.

[a] Recommended dietary allowance

[b] retinol activity equivalents

[c] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity

DV= dieting vegetarian

NDV= non-dieting vegetarian

DNV= dieting non-vegetarian

NDNV= non-dieting non-vegetarian

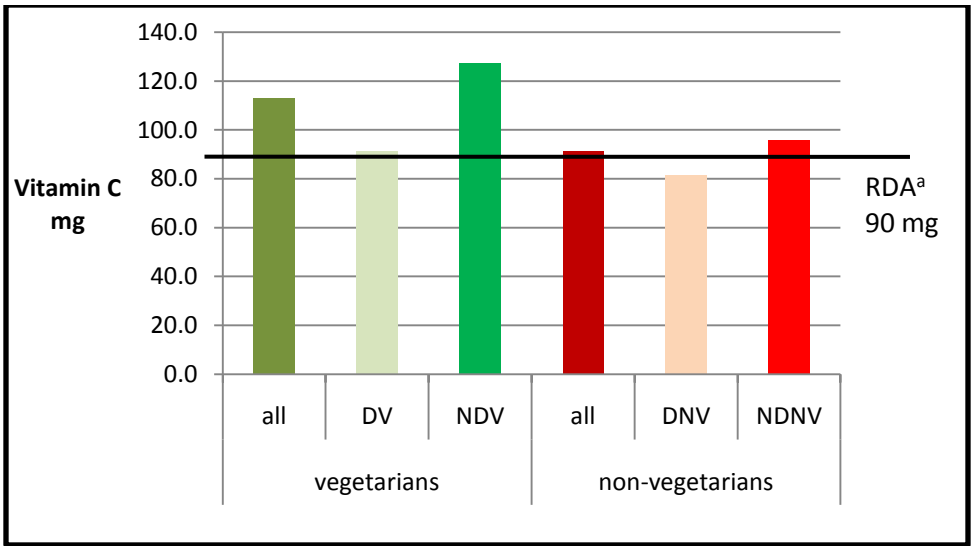

Figure 6. Comparison of mean vitamin C intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[b] 1999-2004.
[a] Recommended dietary allowance
[b] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity
DV= dieting vegetarian
NDV= non-dieting vegetarian
DNV= dieting non-vegetarian
NDNV= non-dieting non-vegetarian

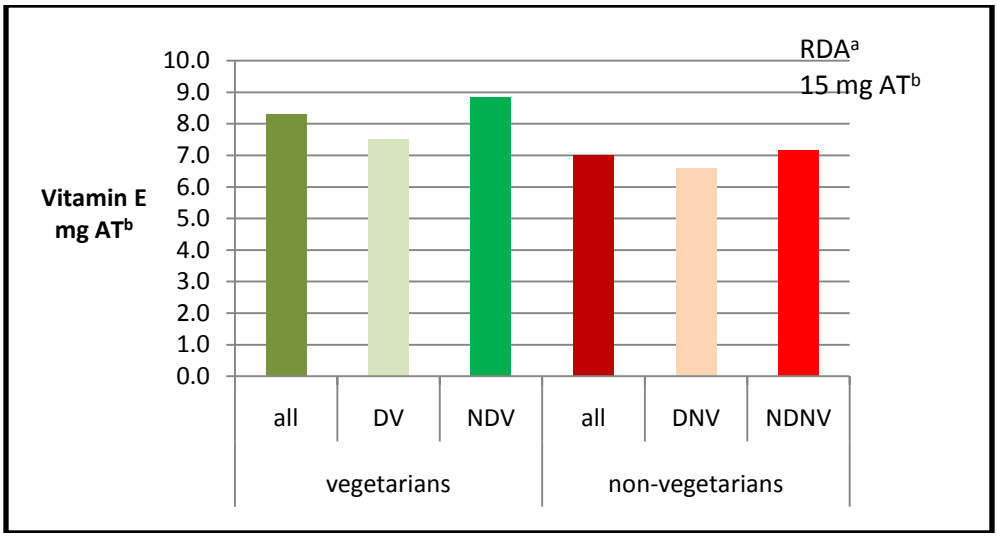

Figure 7. Comparison of mean vitamin E intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[c] 1999-2004.
[a] Recommended dietary allowance
[b] alpha tocopherol
[c] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity
DV= dieting vegetarian
NDV= non-dieting vegetarian
DNV= dieting non-vegetarian
NDNV= non-dieting non-vegetarian

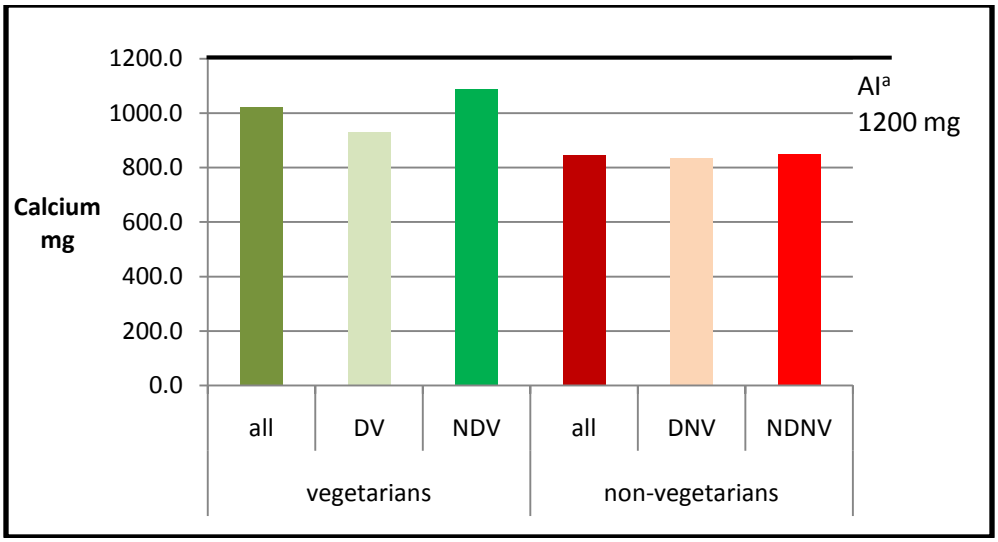

Figure 8. Comparison of mean calcium intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[b] 1999-2004.
[a] Adequate intake
[b] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity
DV= dieting vegetarian
NDV= non-dieting vegetarian
DNV= dieting non-vegetarian
NDNV= non-dieting non-vegetarian

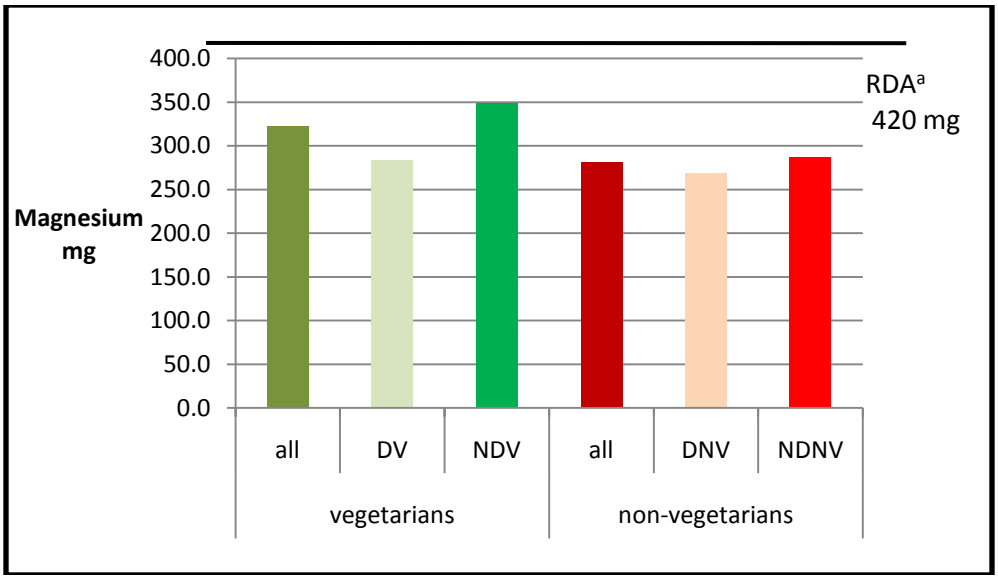

Figure 9. Comparison of mean magnesium intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[b] 1999-2004.
[a] Recommended dietary allowance
[b] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity
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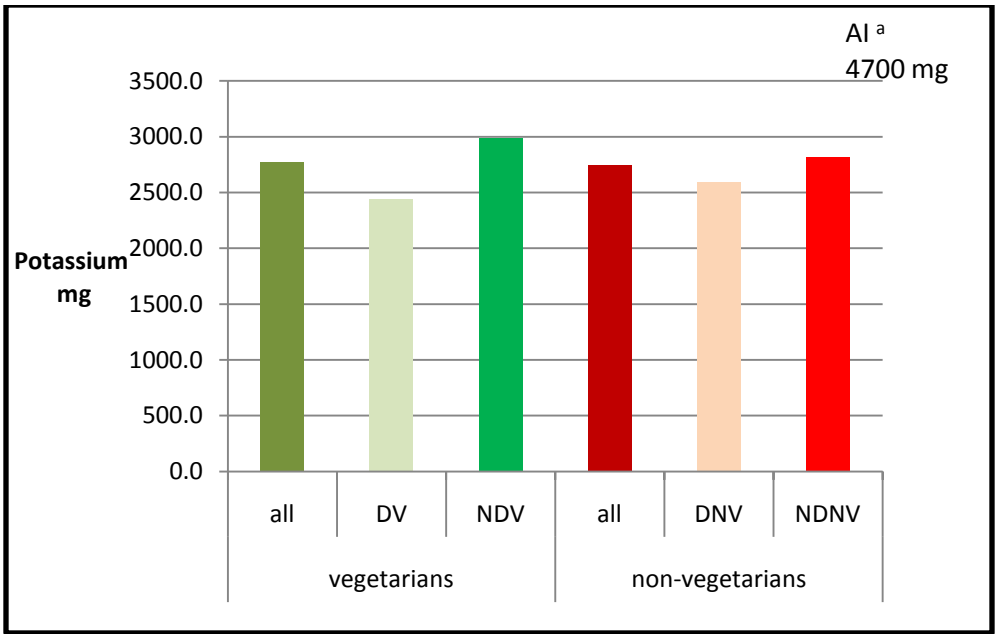

Figure 10. Comparison of mean potassium intakes for vegetarians, non-vegetarians and dieters from participants, ages 19 years and older, of NHANES[b] 1999-2004.

[a] Adequate intake

[b] National Health and Nutrition Examination Survey, one day nutrient intake adjusted for energy, gender, and ethnicity

DV= dieting vegetarian

NDV= non-dieting vegetarian

DNV= dieting non-vegetarian

NDNV= non-dieting non-vegetarian

Appendix E: Vitamin B_{12} and iron status

Vitamin B12 and iron status for participants ages 19 years and older, NHANES[a] 1999-2004 by vegetarian status.

	Vegetarians			Non-vegetarians		
	Mean		SE[b]	Mean		SE[b]
Vitamin B_{12} (pg/mL)	597.93	±	18.62	616.81	±	16.44
Serum iron (ug/dL)	81.89	±	2.06	84.36	±	0.51
Ferritin (ng/mL)	44.7	±	2.17	44.21	±	1.43

[a] National Health and Nutrition Examination Survey

[b] standard error

* $p < 0.01$