HHS Public Access
Author manuscript
Nutr Cancer. Author manuscript; available in PMC 2016 August 01.

Published in final edited form as:
Nutr Cancer. 2015 ; 67(6): 933–940. doi:10.1080/01635581.2015.1055369.

Nutrient composition and anti-inflammatory potential of a prescribed macrobiotic diet

Brook E. Harmon[1], **Mollie Carter**[2], **Thomas G. Hurley**[2,3], **Nitin Shivappa**[2,3], **Jane Teas**[4], and **James R. Hébert**[2,3]

[1]Division of Social and Behavioral Sciences, School of Public Health, University of Memphis, 200 Robison Hall, Memphis, TN, 38152

[2]Cancer Prevention and Control Program, University of South Carolina, 915 Green Street, Suite 200 Columbia, SC 29208

[3]Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, 915 Green Street, Columbia, SC 29208

[4]Thomas Cooper Library, University of South Carolina, 1322 Greene Street, Columbia, SC 29208

Abstract

Despite nutrient adequacy concerns, macrobiotic diets are practiced by many individuals with cancer and other life-threatening illnesses. This study compared the nutrient composition and inflammatory potential of a macrobiotic diet plan with national dietary recommendations and intakes from a nationally representative sample. Nutrient comparisons were made using the: 1) macrobiotic diet plan outlined in the Kushi Institute's Way to Health; 2) Recommended Dietary Allowances (RDA); and 3) National Health and Nutrition Examination Survey (NHANES) 2009–2010 data. Comparisons included application of the recently developed dietary inflammatory index (DII). Analyses focused on total calories, macronutrients, 28 micronutrients, and DII scores. Compared to NHANES data, the macrobiotic diet plan had a lower percentage of energy from fat, higher total dietary fiber, and higher amounts of most micronutrients. Nutrients often met or exceeded RDA recommendations, except for vitamin D, vitamin B12, and calcium. Based on DII scores, the macrobiotic diet was more anti-inflammatory compared to NHANES data (average scores of −1.88 and 1.00, respectively). Findings from this analysis of a macrobiotic diet plan indicate the potential for disease prevention and suggest the need for studies of real-world consumption as well as designing, implementing and testing interventions based on the macrobiotic approach.

INTRODUCTION

Complementary and alternative medical treatments continue to be used with increasing frequency in the U.S. (1–5), and especially by people with cancer and other life-threatening illnesses (6–11). Macrobiotics is one popular alternative or complementary lifestyle approach. Its centerpiece is a predominantly vegetarian, whole-foods diet that has gained popularity because of reports, which attribute recovery from cancers with poor prognoses to macrobiotics (11–14). The macrobiotic diet (MBD) has been shown to reduce total body fat and overall body mass and to produce favorable changes in certain metabolic/biochemical indicators such as serum glucose and lipids (15) as well as immunologic parameters (16). Additionally, there is accumulating evidence that many of the dietary factors recommended by macrobiotics are associated with decreased inflammation (17), which may reduce cancer risk and recurrence (11, 18–20).

Despite its relative popularity, there have been only 129 references in the National Library of Medicine database from 1948 to the time of our review (2 October 2014) in which "Diet, Macrobiotic" appeared as a Medical Subject Heading (MeSH) or "macrobiotic diet" or "macrobiotic" or "macrobiotics" appeared as text words. Of these, 18 specifically mentioned nutrient sufficiency or deficiency with most questioning the safety of the MBD, either on the growth requirements of young children or as part of extreme cleansing regimens (e.g., Zen Macrobiotic) (21–25). Concerns have centered primarily on the nutrient content of the diet, especially energy density, fat, protein, vitamin B12, and iron (26–29).

Analyses of actual dietary intake are hindered by variations in the prescriptions made by macrobiotic diet leaders, geographic location and seasonal variations, and the varying prognoses of practitioners (14, 30–34). This variability is compounded by variations in real-world practice, which can depart considerably from recommendations based on individual interpretation, commitment, and availability of ingredients (35). Although a particular diagnosis might require a specific kind of food restriction, there has evolved a standard MBD for disease prevention and promotion of health (14). Because of the strict requirements of this prescribed diet (12, 35), there is concern that beneficial reports in the literature represent departures from these guidelines and mask potential nutrient deficiencies.

The purpose of this study was to examine the nutrient content of a MBD plan intended for disease prevention, compare the plan's nutrient content to the nutrient content in the average American diet, compare both nutrient profiles to national nutrient recommendations, and use a novel index to assess the anti-inflammatory potential of the macrobiotic and average American diets.

METHODS

The average daily nutrients consumed while following a MBD prescribed for disease prevention were estimated using recommendations from the Kushi Institute's Way to Health menu planning guidelines (36). These guidelines are provided to participants of the Kushi Institute's Healing Retreats and are a recognized standard for individuals following a macrobiotic diet. In the guidelines, a week of sample menus is provided for each season of the year. To account for the seasonal variation that occurs in the MBD, each season's menu was entered and analyzed separately to provide seasonal nutrient profiles and the seasonal nutrient profiles were combined to provide an overall nutrient profile. Each menu gave suggested foods for breakfast, lunch, dinner, and an afternoon snack. Way to Health (36) also provided recipes, but serving sizes and guidelines for scaling to meet the higher caloric needs of men compared to women were not specified. Serving sizes per meal were estimated based on the combining of standard portion sizes used in the macrobiotic community and portion sizes recommended in other cancer-focused diets *(based on personal communication* *from Alex Jack and Julia Ferre to Jane Teas)* including Nature's Cancer Fighting Foods (p222) (37). Therefore, each meal item used the following portion sizes: 1 cup of a cooked whole grain, 1–2 cups of vegetables, ¼ cup of salad or pickles, 1 sheet of seaweed, ½ cup of fruit, 1 cup of sweet vegetable drink or tea, 2 tablespoons of fat (i.e., oil, dressing), and ½ cup of beans or bean product (i.e., tofu, tempeh).

The Nutrition Data System for Research (NDSR Version 2009)), licensed from the Nutrition Coordinating Center (NCC) at the University of Minnesota, was used for the analysis of the MBD (38). Recipes and suggested foods derived from the Way to Health menus were entered directly into NDSR as seven days of intake for four seasons. When a suggested food or recipe ingredient was not available, a request to NCC was put in for the food to be added. When NCC could not add a food due to a lack of information, a food of nutrient equivalence was substituted. Substitutions required research into the food's nutrient content and consensus within the study team. A total of 18 substitutions were made (8 in spring, 3 in summer, 5 in fall, and 2 in winter). During analysis, the seven days of data for each season were averaged to provide an estimate of the diet's daily nutrient composition within season. The seasonal averages were then combined to create an overall daily nutrient estimate. Data analysis consisted of descriptive statistics for 28 nutrients plus total calories and percentage of calories from fat, protein, and carbohydrate. Means and standard deviations were computed of each of these nutritional parameters. The same profile of over 28 nutrients was also created using dietary data from the 2009–2010 National Health and Nutrition Examination Survey (NHANES) What We Eat in America to represent the average American diet. For the NHANES nutrient profiles, data from the age groups 30–39 and 40–49 were averaged (39).

The MBD seasonal and overall profiles were compared to NHANES daily nutrient values for men and women. These NHANES profiles and the MBD overall nutrient profile also were compared with Recommended Dietary Allowance (RDA) data for adults 31–50 year olds (40). Of the over 28 nutrients in the profiles, 17 had an RDA that could be compared across the profiles. A dietary inflammatory index (DII) score also was calculated for the seasonal and overall MBD nutrient profiles as well as for the NHANES profiles for men and women.

Development and validation of the DII has occurred over the past five years by researchers at the University of South Carolina. The DII is a tool that can categorize individuals' diets on a continuum from maximally anti-inflammatory to maximally pro-inflammatory (41–43). A higher, positive DII score indicates a more pro-inflammatory diet and a lower, negative score indicates a more anti-inflammatory diet. Nearly 2,000 articles on the effect of 45 food parameters (including whole foods, nutrients, and bioactive compounds) on six inflammatory markers (i.e., C-reactive protein, interleukin (IL)-1β, IL-4, IL-6, IL-10, and tumor necrosis factor-α) were read and scored to determine the inflammatory effect score (42). The DII was standardized to its current range using dietary intake provided by 11 datasets from around the world (42). A complete description of its development is available elsewhere (42, 43). Briefly, the 11 datasets were compiled into a "global database" from which a mean and standard deviation were calculated for each of the 45 food parameters identified from the literature (42). The diets of individuals were expressed relative to the global mean as a ‘z’ score, calculated by subtracting the global mean from the person’s intake and dividing by the standard deviation. To minimize the effect of “right skewing,” ‘z’ scores were converted to a percentile score. To obtain a DII score for an individual, the centered percentile score for each food constituent consumed is multiplied by its respective inflammatory effect score and the food constituent-specific DII scores summed. Construct validity of the DII was established using high-sensitivity C-reactive protein (hs-CRP) samples from the Seasonal Variation of Blood Cholesterol Study (41). A 1-point increase in DII score was associated with an increased odds of elevated hs-CRP when both 24-hour recall data (OR=1.08; 95% CI 1.01, 1.16) and 7-day dietary records (OR=1.10; 95% CI 1.02, 1.19) were used to calculate DII scores. Tests for trends across DII tertiles found significant increasing trends for hs-CRP with both dietary data sources ($P<0.0001$) (41). Thus far, the DII has been found to be associated with inflammatory cytokines including C-reactive protein and IL-6 (41, 44, 45), the glucose intolerance component of metabolic syndrome (44), increased odds of asthma and reduced forced expiratory volume (FEV_1) (45), shiftwork (44), and colorectal cancer among women (46).

RESULTS

Table 1 compared energy-adjusted nutrient profiles and the DII score of the MBD with those from NHANES for men and women. Nutrient intakes for the MBD are shown for each of the four [Julian] seasons of the year as well as for the overall diet. Seasonal variation was seen. Spring had the highest overall calories; however, the nutrient levels in the fall were higher for percent of calories from fat as well as nutrients such as polyunsaturated fatty acids, folate, β-carotene, phosphorus, iron, sodium, and potassium.

When comparing the overall MBD to NHANES, large differences in energy-adjusted nutrient intakes were seen. The MBD was associated with a lower percentage of energy from fat (14% compared to 33% NHANES-men and women) and a higher percentage from carbohydrates (71% compared to 47%NHANES-men, 51% NHANES-women). The amount of saturated fatty acids in the MBD was much lower than in NHANES (2.9g compared to 12g NHANES-men and women). Total sugar in the MBD was half that seen in NHANES (20.6g compared to 52g NHANES-men, 57.6g NHANES-women), while total dietary fiber was 4–5 times higher (34.7g compared to 7.3g NHANES-men, 8.7g NHANES-women).

Equally large differences were seen in many micronutrients. With the exception of lycopene, carotenoid concentrations for the MBD were higher than in NHANES, as much as 9 to 10 times higher for α-carotene (2363mcg compared to 170mcg NHANES-men, 232mcg NHANES-women) and β-carotene (9508mcg compared to 837mcg NHANES-men, 1204mcg NHANES-women). Many of the B vitamins also were found at higher concentrations in the MBD, with the exception of B12 (1mcg compared to 2.5mcg NHANES-men, 2.6mcg NHANES-women) and Vitamin D (1.3mcg compared to 2.1mcg NHANES-men, 2.5mcg NHANES-women). In looking at DII scores across seasons for the MBD, the lowest DII score was seen for fall (−2.59) followed by spring (−2.30), winter (−1.48) and summer (−0.98). The DII scores calculated from NHANES data were lower (more anti-inflammatory) for men compared to women by half (0.64 and 1.36, respectively);

however, the overall MBD was more anti-inflammatory (−1.88) than either NHANES profile.

When non-energy adjusted nutrient values were compared to the RDAs, both the MBD and NHANES generally met or exceeded recommendations for nutrients (Table 2). For some nutrients, such as dietary fiber, the MBD exceeded the RDAs (50g compared to 38g RDA-men, 25g RDA-women), whereas the NHANES data indicated dietary fiber intake in the average American diet was lower than recommended (20g NHANES-men, 16g NHANES-women). With iron, the MBD (18g) and NHANES (19g) exceeded the 8mg/day RDA for men. The MBD met the 18mg/day recommendation for women, while intakes in NHANES for women (14mg) were lower than recommended. For other nutrients, such as phosphorus and sodium, both the MBD and NHANES exceeded recommendations. Intakes of vitamins D and B12, calcium, and potassium, were all lower in the MBD than recommended. NHANES for men and women indicated vitamin D intake was lower than the 15mg RDA at 5.8mcg and 4.5mcg, respectively; while the MBD was even lower, at 1.8mcg. With vitamin B12, NHANES indicated men and women (6.8mcg and 4.7mcg, respectively) both consumed more than the recommended amounts, (2.4mcg), while the MBD was lower than recommended (1.4mcg). Calcium in the MBD was almost half the recommended amount (598mg compared to 1000mg), while NHANES for men (1207mg) was slightly above, and women’s intake (917mg) slightly below recommendations. The MBD and NHANES both showed lower levels of potassium (3056mg macrobiotic, 3356mg NHANES-men, 2406mg NHANES-women) than recommended (4700mg).

DISCUSSION

It is important to examine the nutrient adequacy and potential nutritional mechanisms of complementary and alternative diet recommendations. Concerns have been voiced about possible harmful effects of adhering to a MBD (22, 24–27). Comparisons with NHANES data and current national recommendations indicate the MBD has a more anti-inflammatory nutritional profile than the average American diet; however, key nutrients such as vitamin D, vitamin B12, and calcium tend to be low in the diet as it is currently recommended. This study provides evidence that a MBD aimed at health promotion and disease prevention has the potential to provide a healthy nutrition profile with many nutrient concentrations sufficient to compensate for low caloric intake.

Reports on the cancer preventive abilities of the MBD may be due in part to its anti-inflammatory profile. Compared to the average American diet this study found a large difference in DII scores (−1.88 vs. 1.00), indicating relatively strong anti-inflammatory properties of the MBD. Based on previous global intake estimates, the MBD score corresponds to roughly the 25th percentile of the DII and the typical American diet to just under the 75th percentile (42). When the DII was calculated for one day of a simulated macrobiotic, fast food, and Mediterranean diet, similar findings were seen with the MBD strongly anti-inflammatory and the fast food diet strongly pro-inflammatory (47). Research on cancer prevention has highlighted the importance of reducing inflammation, especially through consumption of foods with strong anti-inflammatory properties (48–50). Previous studies and current recommendations (51) suggest high vegetable (52) and whole grain (53,

54) intake is anti-carcinogenic. Overall, the MBD stresses that 40–60% of daily calories should be from vegetables and whole grains, with animal products consumed only in small amounts monthly (18). Based on recommendations in the 2010 Dietary Guidelines, the MBD had fewer calories from fat (14%) than recommended (27.5%), while the average American diet had more (33%) (39). In addition, the saturated fat content of the MBD was much lower than the average American diet. The Dietary Guidelines also suggest that 55% of calories should come from carbohydrates (55). The average American diet had a lower percentage (49%), while the MBD plan was much higher (71%). Based on the high dietary fiber and low total sugar amounts seen in the MBD nutrient profile, carbohydrate sources appear to be primarily complex carbohydrates. This nutrient profile aligns with the MBD's focus on vegetables and whole grains and contributes greatly to the MBD's anti-inflammatory score.

In addition to its anti-inflammatory nutrient profile, the MBD was very low in calories, but still maintained sufficient concentrations for most nutrients, due to its high nutrient density. Lower caloric intake may aid in the reduction of body weight over time in individuals consuming a MBD similar to the one modeled in the study. Overweight and obesity have been shown to be positively associated with higher levels of chronic inflammation (56). A recent article reported a positive protective effect of the MBD on outcomes related to diabetes mellitus (57). Participants eating a macrobiotic diet saw a favorable change in body weight, lipid values, reduced oxidative stress, and improved insulin secretion. After 6 months of the macrobiotic intervention, significant reductions were seen in body weight (9.0%), total cholesterol (16.4%), LDL cholesterol (22.7%), and triglycerides (37.0%); and an increase was seen in HDL (97.8%) (57). Findings from our study add to this literature indicating the MBD, when consumed as recommended, has the potential to aid in disease prevention and control, in part through its potential to be low in calories while high in nutrient density, an important consideration of any dietary recommendation, given the emphasis placed on reducing caloric intake in order to lose weight by various disease-prevention recommendations (58).

Despite the anti-inflammatory profile of the MDB, there were some nutrient excesses and deficiencies that pose concerns. While most carotenoids were high with the MDB, lycopene was especially low, except in summer where it was still lower than the amounts seen with NHANES. The MBD recommendations include avoidance of the nightshade family, which includes tomatoes, a prime source of lycopene (59). Research indicates lycopene may be anti-carcinogenic, especially in relation to prostate cancer (60). In addition to low lycopene, the MBD plan also was low in vitamin D, vitamin B12, and calcium. The avoidance of meat and dairy in the MBD most likely contribute to the low levels of these nutrients. While vitamin D and calcium have the potential to be low in the average American diet, they were even lower in the MBD. Recent research has highlighted the potential cancer prevention benefits of vitamin D, with diet shown as an important source (61). The low-calcium, high-fiber content of the MBD also may have negative health impacts given the potential for a high-fiber diet to reduce the absorption of calcium as well as iron, magnesium, and zinc (62). This lower calcium intake and absorption has the potential to decrease bone mineral density, impair normal muscular function, and negatively impact cardiovascular health (63, 64). In addition to low vitamin D and calcium, the MBD also showed low levels of vitamin

B12. Vitamin B12 plays an important role in nerve health, red blood cell formation, and DNA synthesis and has been noted before as a potential area for deficiency with the MBD (65). Deficiency of vitamin B12 also can be masked by high levels of folate (65, 66), which were seen in the MBD. The emergence of "gourmet macrobiotic" cuisine and recommendations that highlight the emotional and spiritual balance with food versus rigorous dietary restrictions may provide more balance and higher levels of the key nutrients found to be deficient in MBD aimed at disease prevention and control (30–32, 67). In addition, liberalizing the diet to include foods such as cold-water fish may actually increase the anti-inflammatory potential of the diet through increases in omega-3 fatty acids.

Also of potential concern in the MBD are high phosphorus and sodium intakes. In general, these nutrients are found primarily in highly processed cereal and grain products (68), while in the MBD the high level of intake may be due to the consumption of pickled foods, sea vegetables, high-sodium seasonings, and whole grains. The low-calcium, high-phosphorus content of the MBD has the potential to negatively influence bone and cardiovascular health (68). In both the MBD and the American diet, potassium was below the RDA for men and women while sodium exceeded the RDAs. Research on the anti-inflammatory properties of foods indicates seasonings such as turmeric, garlic, and other herbs and spices are highly anti-inflammatory (69–73). Use of these seasonings as substitutions for the high-sodium and phosphorus containing seasonings found in the MBD is a way to not only achieve more healthful ratios between these nutrients, but also to further improve the anti-inflammatory properties of the diet.

While the findings from this study provide important information on the nutrient profile of the MBD and point to components of the diet that are anti-inflammatory and potentially cancer preventative, there are limitations to the interpretation of these results. The MBD we analyzed was created using dietary recommendations and the literature, not actual diets. However, understanding the implications of adhering to the recommendations is a crucially important first step that must come before large-scale interventions with people, in part to understand if inadequacy is due to the dietary prescription or non-adherence to the recommendation. We compared this model of the MBD to that of data from NHANES and established RDAs. The use of ideals (i.e., MBD plan, RDAs) provides an understanding of the potential for the MBD to meet recommendations while providing disease prevention benefits. However, our findings must be interpreted cautiously as they do not include the range in intake that would come from actual consumption data nor do our comparisons take into account modified needs that may come with advanced disease or intensive treatments.

The Way to Health and other literature consulted in the creation of the MBD provided guidelines that did not differ for men compared to women. Dietary recommendations vary by sex for some nutrients, but not for most, and we found few instances where the MBD met the needs of one sex and not the other, or greatly exceeded the needs of one sex (i.e. reached upper tolerable limits) and not the other. Future studies should examine differences that occur in the application of MBD recommendations among men compared to women.

This study found the nutrient profile from a MBD aimed at disease prevention and control was anti-inflammatory and contributed to increased intake of many health-protective nutrients when compared to the average American diet and dietary recommendations. Next steps in this research include applying the DII to data derived from individuals consuming both a macrobiotic diet for disease prevention and control as well as more liberal interpretations to examine if our current findings can be replicated or improved upon in real world scenarios. In addition, future studies should assess dietary intake as well as biomarkers for inflammation to further understand the link between anti-inflammatory diets and disease prevention.

ACKNOWLEDGEMENTS

This research was conducted at the University of South Carolina in the Cancer Prevention and Control Program. This work was supported by funding from the University of South Carolina Cancer Prevention and Control Program. Dr. Hébert was supported by an Established Investigator Award in Cancer Prevention and Control from the Cancer Training Branch of the National Cancer Institute (K05 CA136975). The original concept of macrobiotics and health was funded by the Special Interest Program for research on Complementary and Alternative Medicine with Curative Intent, from the Centers for Disease Control (U48/CCU409664 SIP 6-00); the grant was awarded to Drs. Teas and Hebert.

REFERENCES

1. Eisenberg DM, Kessler RC, Foster C, Norlock FE, Calkins DR, et al. Unconventional medicine in the U.S.: Prevelance, costs and patterns of use. N Engl J Med. 1993; 328:246–252. [PubMed: 8418405]
2. Eisenberg DM. Advising patients who seek alternative medical therapies. Annals Int Med. 1997; 127:61–69.
3. Elder ND, Gillcrist A, Minz R. Use of alternative health care by family practice patients. Arch Fam Med. 1997; 6:181–184. [PubMed: 9075455]
4. Landier W, Tse AM. Use of complementary and alternative medical interventions for the management of procedure-related pain, anxiety, and distress in pediatric oncology: An integrative review. J Pediatric Nursing. 2010; 25:566–579.
5. Navo MA, Phan J, Vaughan C, Palmer JL, Michaud L, et al. An assessment of the utilization of complementary and alternative medication in women with gynecologic or breast malignancies. J Clin Oncol. 2004; 22:671–677. [PubMed: 14966090]
6. Hietala M, Henningson M, Ingvar C, Jonsson PE, Rose C, et al. Natural remedy use in a prospective cohort of breast cancer patients in southern Sweden. Acta Oncologica. 2011; 50:134–143. [PubMed: 20500030]
7. Wanchai A, Armer JM, Stewart BR. Complementary and alternative medicine use among women with breast cancer: a systematic review. Clin J Oncol Nursing. 2010; 14:E45–E55.
8. Holland, JC. Psycho-oncology. Brietbart, W.; Jacobsen, PB.; Lederberg, MS.; Loscalzo, M.; Massie, MJ.; McCorkle, R., editors. New York, NY: Oxford University Press; 1998.
9. Holland, JC.; Geary, N.; Furman, A. Alternative cancer therapies. In: Holland, J.; Rowland, J., editors. Handbook of Psychooncology. Oxford: Oxford University Press; 1989. p. 508-515.
10. Carpenter CL, Ganz PA, Bernstein L. Complementary and alternative therapies among very long-term breast cancer survivors. Breast Cancer Res Treat. 2009; 116:387–396. [PubMed: 18712472]
11. Weitzman S. Complementary and alternative (CAM) dietary therapies for cancer. Pediatric Blood Cancer. 2008; 50(2 Suppl):494–497. [PubMed: 18064662]
12. Bowman BB, Kushner RF, Dawson SC, Levin B. Macrobiotic diets for cancer treatment and prevention. J Clin Oncol. 1984; 2:702–711. [PubMed: 6374060]
13. Carter JP, Saxe GP, Newbold V, Peres CE, Campeau RJ, Bernal-Green L. Hypothesis: dietary management may improve survival from nutritionally linked cancers based on analysis of respresentative cases. J Am Coll Nutr. 1993; 12:209–226. [PubMed: 8409076]
14. Kushi, M.; Jack, A. The Cancer Prevention Diet: Michio Kushi's Nutritional Blueprint for the Prevention and Relief of Disease. New York, NY: St. Martin's Press; 1993.

15. Porrata-Maury C, Hernandez-Triana M, Rodriguez-Sotero E, Vila-Dacosta-Calheiros R, Hernandez-Hernandez H, et al. Medium- and short-term interventions with ma-pi 2 macrobiotic diet in type 2 diabetic adults of bauta, havana. J Nutr Metab. 2012; 2012:1–10.
16. Levy EM, Cottrell MC, Black PH. Psychological and immunological associations in men with AIDS pursuing a macrobiotic regimen as an alternative therapy: a pilot study. Brain, Behavior, & Immunity. 1989; 3:175–182.
17. Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, et al. Fruit and vegetable intakes, C-reactive protein, and the metabolic syndrome. Am J Clin Nutr. 2006; 84:1489–1497. [PubMed: 17158434]
18. Kushi LH, Cunningham J, Hebert JR, Lerman R, Bandera EV, Teas J. The macrobiotic diet in cancer. J Nutr. 2001; 13:3056S–3064S. [PubMed: 11694648]
19. Saxe GA, Hebert JR, Carmody JF, Kabat-Zinn J, Rosenzweig PH, et al. Can diet, in conjunction with stress reduction, affect the rate of increase in prostate specific antigen after biochemical recurrence of prostate cancer? J Urol. 2001; 166:2202–2207. [PubMed: 11696736]
20. Berkow SE, Barnard ND, Saxe GA, Ankerberg-Nobis T. Diet and survival after prostate cancer diagnosis. Nutr Rev. 2007; 65:391–403. [PubMed: 17958206]
21. Brown PT, Bergan JG. The dietary status of "new" vegetarians. J Am Dietet Assoc. 1975; 67:455–459.
22. Robson JR, Konlande JE, Larkin FA, O'Connor PA, Liu HY. Zen macrobiotic dietary problems in infancy. Pediatrics. 1974; 53:326–329. [PubMed: 4205579]
23. Robson JR, Konlande JE, Larkin FA, O'Connor PA, Liu HY, et al. Zen macrobiotic diets. Lancet. 1973; 1:1327. [PubMed: 4126126]
24. Salmon P, Rees JR, Flanagan M, O'Moore R. Hypocalcaemia in a mother and rickets in an infant associated with a Zen macrobiotic diet. Irish J Med Sci. 1981; 150:192–193. [PubMed: 7275567]
25. Sherlock P, Rothschild EO. Scurvy produced by a Zen macrobiotic diet. JAMA. 1967; 199:794–798. [PubMed: 6071292]
26. Dagnelie PC, van Staveren WA, Vergote FJ, Dingjan PG, van den Berg H, Hautvast JG. Increased risk of vitamin B-12 and iron deficiency in infants on macrobiotic diets. Am J Clin Nutr. 1989; 50:818–824. [PubMed: 2801586]
27. Dagnelie PC, van Staveren WA, Verschuren SA, Hautvast JG. Nutritional status of infants aged 4 to 18 months on macrobiotic diets and matched omnivorous control infants: a population-based mixed-longitudinal study. I. Weaning pattern, energy and nutrient intake. Eur J Clin Nutr. 1989; 43:311–323. [PubMed: 2544417]
28. Dagnelie PC, van Staveren WA, Hautvast JG. Stunting and nutrient deficiencies in children on alternative diets. Acta Paediatrica Scandinavica Supplement. 1991; 374:111–118. [PubMed: 1957614]
29. Kirby M, Danner E. Nutritional deficiencies in children on restricted diets. Pediatric Clin North America. 2009; 56:1085–1103.
30. Aihara, C. The Do of Cooking (Ryorido): Autumn. Oroville, CA: The George Ohsawa Macrobiotic Foundation; 1977.
31. Aihara, C. The Calendar Cookbook: A Year's Menu of the Vega Macrobiotic Center. Oroville, CA: The George Ohsawa Macrobiotic Foundation; 1979.
32. Aihara, C. Key to Good Health: Macrobiotic Kitchen. Oroville, CA: The George Ohsawa Macrobiotic Foundation; 1982.
33. Kushi, A.; Esko, W. The Changing Seasons Macrobiotic Cookbook. Wayne, NJ: Avery Publishing Group; 1985.
34. Kushi, A.; Jack, A. Aveline Kushi's Complete Guide to Macrobiotic Cooking for Health, Harmony, and Peace. New York, NY: Warner Books; 1985.
35. Leblanc JC, Yoon H, Kombadjian A, Verger P. Nutritional intakes of vegetarian populations in France. Eur J Clin Nutr. 2000; 54:443–449. [PubMed: 10822295]
36. Way to Health Part I: Course Material for the Kushi Institute's Way to Health Part I Seminar. Becket, MA: Kushi Institute; 1997.
37. Verona, V. Nature's Cancer Fighting Foods. New York: Reward-Penguin Books; 2001.

38. The Nutrition Data System for Research (NDS-R Version 4.03_31). Minneapolis, MN: Developed by the Nutrition Coordinating Center (NCC), University of Minnesota; 2001.
39. U.S. Department of Agriculture, Agricultural Research Service. [cited on 11 September 2013] 2012. Nutrient Intakes from Food: Mean Amounts Consumed per Individual, by Gender and Age. What We Eat in America, NHANES. 2009–2010. Available from: www.ars.usda.gov/ba/bhnrc/fsrg.
40. Dietary Reference Intake Tables: Electrolytes and Water. Washington, DC: National Academy of Sciences. Institute of Medicine. Food and Nutrition Board; 2013.
41. Shivappa N, Steck SE, Hurley TG, Hussey JR, Ma Y. A population-based dietary inflammatory index predicts levels of C-reactive protein in the Seasonal Variation of Blood Cholesterol Study (SEASONS). Public Health Nutr. 2013; 10:1–9.
42. Shivappa N, Steck SE, Hurley TG, Hussey JR, Hebert JR. Designing and developing a literature-derived, population-based dietary inflammatory index. Public Health Nutr. 2013; 14:1–8.
43. Cavicchia PP, Steck SE, Hurley TG, Hussey JR, Ma Y, et al. A new dietary inflammatory index predicts interval changes in high-sensitivity c-reactive protein. J Nutr. 2009; 139:2365–2372. [PubMed: 19864399]
44. Wirth MD, Burch J, Shivappa N, Violanti JM, Burchfiel CM, et al. Association of a dietary inflammatory index with inflammatory indices and metabolic syndrome among police officers. J Occup Environ Med. 2014; 56:986–989. [PubMed: 25046320]
45. Wood L, Shivappa N, Berthon BS, Gibson PG, Hebert JR. Dietary inflammatory index is related to asthma risk, lung function and systemic inflammation in asthma. Clinical & Experimental Allergy. 2014
46. Shivappa N, Prizment AE, Blair CK, Jacobs DR Jr, Steck SE. Dietary Inflammatory Index (DII) and risk of colorectal cancer in Iowa Women's Health Study. Cancer Epidemiol Biomarkers Prev. 2014 pii: cebp.0537.2014.
47. Steck SE, Shivappa N, Tabung FK, Harmon BE, Wirth MD. The Dietary Inflammatory Index: A new tool for assessing diet quality Based on inflammatory potential. The Digest. 2014; 49:1–9.
48. Jia Y, Hu T, Hang CY, Yang R, Li X, et al. Case-control study of diet in patients with cervical cancer or precancerosis in Wufeng, a high incidence region in China. Asian Pac J Cancer Prev. 2012; 13:5299–5302. [PubMed: 23244152]
49. Buckland G, Travier N, Cottet V, Gonzalez CA, Lujan-Barroso L, et al. Adherence to the mediterranean diet and risk of breast cancer in the European prospective investigation into cancer and nutrition cohort study. Int J Cancer. 2013; 132:2918–2927. [PubMed: 23180513]
50. Wang JM, Xu B, Rao JY, Shen HB, Xue HC. Diet habits, alcohol drinking, tobacco smoking, green tea drinking, and the risk of esophageal squamous cell carcinoma in the Chinese population. Eur J Gastroenterol Hepatol. 2007; 19:171–176. [PubMed: 17273005]
51. Hastert TA, Beresford SA, Patterson RE, Kristal AR, White E. Adherence to WCRF/AICR cancer prevention recommendations and risk of postmenopausal breast cancer. Cancer Epidemiol Biomarkers Prev. 2013; 22:1498–1508. [PubMed: 23780838]
52. Tomita LY, Roteli-Martins CM, Villa LL, Franco EL, Cardoso MA. Associations of dietary dark-green and deep-yellow vegetables and fruits with cervical intraepithelial neoplasia: modification by smoking. Br J Nutr. 2011; 105:928–937. [PubMed: 21092390]
53. Aarestrup J, Kyro C, Christensen J, Kristensen M, Wurtz AM, et al. Whole grain, dietary fiber, and incidence of endometrial cancer in a Danish cohort study. Nutr Cancer. 2012; 64:1160–1168. [PubMed: 23163844]
54. Zaineddin AK, Buck K, Vrieling A, Heinz J, Flesch-Janys D, et al. The association between dietary lignans, phytoestrogen-rich foods, and fiber intake and postmenopausal breast cancer risk: a German case-control study. Nutr Cancer. 2012; 64:652–665. [PubMed: 22591208]
55. [cited 2013 August 27] Dietary Guidelines for Americans 2010: U.S. Department of health and human services. Available from: www.dietaryguidelines.gov.
56. Nguyen XM, Lane J, Smith BR, Nguyen NT. Changes in inflammatory biomarkers across weight classes in a representative US population: a link between obesity and inflammation. J Gastrointest Surg. 2009; 13:1205–1212. [PubMed: 19415399]

57. Porrata C, Sanchez J, Correa V, Abuin A, Hernandez-Triana M, et al. Ma-pi 2 macrobiotic diet intervention in adults with type 2 diabetes mellitus. MEDICC Rev. 2009; 11:29–35. [PubMed: 21483296]

58. Obesity and Cancer – A Guide for Oncology Providers. American Society of Clinical Oncology. Available from: www.asco.org/sites/www.asco.org/files/obesity_provider_guide_final.pdf.

59. Childers, N. The Nightshades and Health. N.J.: Horticulture Publications; 1977.

60. Giovannucci E, Rimm EB, Liu Y, Stampfer MJ, Willett WC. A prospective study of tomato products, lycopene, and prostate cancer risk. J Natl Cancer Inst. 2002; 94:391–398. [PubMed: 11880478]

61. Lamberg-Allardt C. Vitamin D in foods and as supplements. Prog Biophys Mol Biol. 2006; 92:33–38. [PubMed: 16618499]

62. Mudgil D, Barak S. Composition, properties and health benefits of indigestible carbohydrate polymers as dietary fiber: A review. Int J Biol Macromol. 2013; 61:1–6. [PubMed: 23831534]

63. Li K, Kaaks R, Linseisen J, Rohrmann S. Associations of dietary calcium intake and calcium supplementation with myocardial infarction and stroke risk and overall cardiovascular mortality in the Heidelberg cohort of the European Prospective Investigation into Cancer and Nutrition study (EPIC-Heidelberg). Heart. 2012; 98:920–925. [PubMed: 22626900]

64. Parsons TJ, van Dusseldorp M, van der Vliet M, van de Werken K, Schaafsma G. Reduced bone mass in Dutch adolescents fed a macrobiotic diet in early life. J Bone Miner Res. 1997; 12:1486–1494. [PubMed: 9286766]

65. van Dusseldorp M, Schneede J, Refsum H, Ueland PM, Thomas CM, et al. Risk of persistent cobalamin deficiency in adolescents fed a macrobiotic diet in early life. Am J Clin Nutr. 1999; 69:664–671. [PubMed: 10197567]

66. Stabler SP. Vitamin B12 deficiency. N Engl J Med. 2013; 368:2041–2042. [PubMed: 23697526]

67. Pirello, C. Cooking the Whole Foods Way: Your Complete Everyday Guide to Health Delicious Eating with 500 Recipes, Menus, Techniques, Meal Planning, Buying Tips, Wit, Wisdom. New York, NY: The Berkeley Publishing Group (Penguin Putnam, Inc.); 1997.

68. Calvo MS, Uribarri J. Public health impact of dietary phosphorus excess on bone and cardiovascular health in the general population. Am J Clin Nutr. 2013; 98:6–15. [PubMed: 23719553]

69. Surh YJ, Han SS, Keum YS, Seo HJ, Lee SS. Inhibitory effects of curcumin and capsaicin on phorbol ester-induced activation of eukaryotic transcription factors, NF-kappaB and AP-1. Biofactors. 2000; 12:107–112. [PubMed: 11216470]

70. Davis JM, Murphy EA, Carmichael MD, Zielinski MR, Groschwitz CM, et al. Curcumin effects on inflammation and performance recovery following eccentric exercise-induced muscle damage. Am J Physiol Regul Integr Comp Physiol. 2007; 292:R2168–R2173. [PubMed: 17332159]

71. Arora RB, Kapoor V, Basu N, Jain AP. Anti-inflammatory studies on Curcuma longa (turmeric). Indian J Med Res. 1971; 59:1289–1295. [PubMed: 5132235]

72. Son EW, Mo SJ, Rhee DK, Pyo S. Inhibition of ICAM-1 expression by garlic component, allicin, in gamma-irradiated human vascular endothelial cells via downregulation of the JNK signaling pathway. Int Immunopharmacol. 2006; 6:1788–1795. [PubMed: 17052669]

73. van Doorn MB, Espirito Santo SM, Meijer P, Kamerling IM, Schoemaker RC, et al. Effect of garlic powder on C-reactive protein and plasma lipids in overweight and smoking subjects. Am J Clin Nutr. 2006; 84:1324–1329. [PubMed: 17158412]

Table 1

Comparison of Energy-Adjusted Nutrients[a] in a Macrobiotic Diet Plan with Intake in a Nationally Representative Sample

	Macrobiotic Diet[b]					NHANES Data-	NHANES Data –
Nutrient	**Spring**	**Summer**	**Fall**	**Winter**	**Overall**	**Men[c]**	**Women[c]**
Energy (kcal/day)	1719	1227	1496	1332	1444	2733	1813
% from Fat	12.1	12.8	17.1	15.6	14.4	33.1	33.0
% from Carbohydrate	73.7	70.4	67.7	70.6	70.6	47.4	50.7
% from Protein	14.2	16.8	14.8	13.8	14.9	15.7	15.3
Total SFA (g)	2.5	2.7	3.4	3.2	2.9	12.0	12.0
Total PUFA (g)	6.6	6.8	9.8	7.8	7.8	7.8	8.4
Total Omega-3 FA (g)	0.6	0.6	0.8	0.7	0.7	0.7	0.8
Total Omega-6 FA (g)	6.0	6.3	9.0	7.2	7.1	7.0	7.5
PUFA 18:2 (linoleic acid) (g)	6.0	6.3	8.9	7.2	7.1	6.9	7.4
PUFA 20:4 (arachidonic acid)(g)	0	0	0	0	0	0.1	0.1
Omega-3:Omega-6	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total sugars (g)	20.4	21.9	18.5	21.9	20.6	52.0	57.6
Total Dietary Fiber (g)	34.1	34.1	37.1	33.3	34.7	7.3	8.7
Vitamin D (calciferol) (mcg)	0.9	1.5	1.3	1.4	1.3	2.1	2.5
Folate (mcg) DFE	293	273	512	334	355	249	266
Thiamin (vitamin B1) (mg)	1.0	0.9	1.1	1.0	1.0	0.8	0.8
Riboflavin (vitamin B2) (mg)	0.7	0.7	1.2	0.9	0.9	1.0	1.0
Niacin (vitamin B3) (mg)	11.6	11.2	13	11.4	11.8	12.6	11.5
Vitamin B6 (mg)	1.3	1.4	1.6	1.4	1.4	1.0	1.0
Vitamin B12 (cobalamin) (mcg)	0.7	1.5	1.3	0.4	1.0	2.5	2.6
Vitamin C (mg)	77.6	72.9	82.8	73.3	77.0	35.7	43.5
Beta-Carotene (provitamin A) (mcg)	9197	9289	10747	8718	9508	837	1204
Alpha-Carotene (provitamin A)(mcg)	2427	2588	2341	2099	2363	170	232
Beta-Cryptoxanthin (provitamin A)(mcg)	46.5	126.2	15.5	5.6	46.0	34.2	47.7
Lutein+Zeaxanthin (mcg)	8299	4710	6985	5437	6535	552	842
Lycopene (mcg)	1.9	1510.2	1.3	1.6	322.2	2812	2588
Calcium (mg)	429	438	416	371	414	442	506

Nutrient	Macrobiotic Diet[b] Spring	Summer	Fall	Winter	Overall	NHANES Data-Men[c]	NHANES Data – Women[c]
Phosphorus (mg)	897	912	1027	936	943	654	673
Iron (mg)	12.4	11.3	14.7	12.0	12.7	6.9	7.5
Zinc (mg)	7.5	6.9	7.9	7.4	7.5	5.7	5.5
Sodium (mg)	2693	3169	4619	2574	3266	1669	1672
Potassium (mg)	1965	2061	2437	2002	2116	1228	1327
DII score	−2.30	−0.98	−2.59	−1.48	−1.88	0.64	1.36

NHANES, National Health and Nutrition Examination Survey; SFA, saturated fat; PUFA, polyunsaturated fat; FA, fatty acid; DFE, dietary folate equivalents; DII, dietary inflammatory index

[a] All nutrients energy adjusted to represent amount per 1000 kcal except for % calories from fat, carbohydrate, and protein.

[b] Based on the Kushi Institute's Way to Health

[c] Data from the 2009–2010 NHANESWhat We Eat in America; average of age groups 30–39 and 40–49

Table 2

Comparison of Nutrient Composition of a Macrobiotic Diet Plan with Intake in a Nationally Representative Sample and Recommended Dietary Allowances

Nutrient	Macrobiotic–Overall[a]	NHANES – Men[b]	NHANES – Women[b]	RDA-Men	RDA - Women
Total Carbohydrate (g)	255	324	230	130	130
Total Protein (g)	54	107	69	56	46
Total Dietary Fiber (g)	50	20	16	38[c]	25[c]
Vitamin D (calciferol) (mcg)	1.8	5.8	4.5	15	15
Folate (mcg) DFE	512	681	483	400	400
Thiamin (vitamin B1) (mg)	1.5	2.1	1.4	1.2	1.1
Riboflavin (vitamin B2) (mg)	1.3	2.7	1.9	1.3	1.1
Niacin (vitamin B3) (mg)	17	34	21	16	14
Vitamin B6 (mg)	2.1	2.8	1.7	1.3	1.3
Vitamin B12 (cobalamin) (mcg)	1.4	6.8	4.7	2.4	2.4
Vitamin C (mg)	111	97	79	90	75
Calcium (mg)	598	1207	917	1000	1000
Phosphorus (mg)	1361	1787	1221	700	700
Iron (mg)	18	19	14	8	18
Zinc (mg)	11	15	10	11	8
Sodium (mg)	4716	4561	3032	1500[c]	1500[c]
Potassium (mg)	3056	3356	2406	4700[c]	4700[c]

NHANES, National Health and Nutrition Examination Survey; RDA, Recommended Dietary Allowances; DFE, dietary folate equivalents

[a]Based on the Kushi Institute's Way to Health

[b]Data from the 2009–2010 National Health and Nutrition Examination Survey (NHANES) What We Eat in America; average of age groups 30–39 and 40–49

[c]Adequate Intake value