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Food and mood: A nutritional and mood assessment of a 30-day vegan space diet

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ABSTRACT

The purpose of this study was to examine the effects of eating a total vegan "space diet", *ad libitum*, on nutrient intake, weight and mood in a group of 16 non-vegetarians. The 10-day diet was repeated three times within the 30 day study. A weekly mood questionnaire was administered to the 16 subjects of the study and to a control group prior, during and post consumption of the vegan diet. Consumption of the diet produced a mean weight loss of 1.7 kg. In addition, two mood factors changed significantly between the pre-study, study and post-study periods: vigor and fatigue. The effect of the diet on mood appeared to be more related to the weight loss than to the effects of diet. The nutritional profile of the diet was satisfactory with the exception of its low calcium level and high fiber level.

Introduction

This study is part of a project aimed at the optimization of a diet for a bioregenerative life support system on the lunar or Martian surface. The high closure bioregenerative diet scenario adopted for this project depended mostly on crops produced in a hydroponic station on the Martian planetary surface. The optimization of the diet was based on several factors, including acceptability, variety, astronauts' specific nutritional requirements and low cost, in addition to macronutrient and micronutrient balance (Smith & Zwart, 2008). A list of 220 previously developed and tested foods was used as a pool for devising the 30-day diet (Hunter, Olabi, Spies, Rovers, and Levitsky, 1999 and Waters, Olabi, Hunter, and Dixon, 2002). A closed diet study was suitable for assessing consumption and its related nutritional intake and for examining the effect of the diet on the subjects' weights, mood and sense of well-being.

Vegan diets are usually nutritionally adequate in dietary fiber, carbohydrates, folic acid, vitamin C, vitamin E and magnesium. However, they are typically low in protein, saturated fat, and of particular concern calcium, vitamin B12 (Key, Appleby, & Rosell, 2006) and vitamin D since major sources are animal products (Crowe et al., 2010). It is essential for space travelers to receive adequate nutrition due to their exposure to a closed food system and to environmental factors (Smith & Zwart, 2008); posing challenges to maintaining energy, sodium, potassium, water requirements (Lane & Feeback, 2002) and vitamin D (Smith & Zwart, 2008). Water, energy and potassium requirements do not differ from the recommended levels on Earth; however, sodium should be reduced because high intakes are associated with increased urinary calcium excretion (Lane & Feeback, 2002), and vitamin D remains a challenge for space travelers despite supplementation due to the lack of sunlight exposure which is essential for vitamin D synthesis (Smith & Zwart, 2008).

A change from a typical omnivorous American diet to a totally vegan diet could be a source of concern to the space program due to several reasons: weight loss, low acceptability of vegan foods and effect on mood. People who consume a vegetarian diet consume fewer calories and have a reduced body weight (Tonstad, Butler, Yan, & Fraser, 2009). A loss in body weight could have negative effects on the physical performance of astronauts. Vegetarians tend to have a lower BMI than non-vegetarians (Tonstad et al., 2009) despite the fact that obesity is present among some vegetarians Jebb, Rennie, and Cole (2004) and Shetty (2002). A low-fat vegan diet has been shown to result in significant mean

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weight loss of 5.8 kg in 14 weeks compared to 3.8 kg in a control group ($p < 0.05$) following the former National Cholesterol Education Program (Barnard, Scialli, Turner-McGrievy, Lanou, & Glass, 2005) with both lean mass loss (0.7 ± 1.9 vs. 0.2 ± 1.7 kg) and body fat loss (2.9 ± 2.4 vs. 2.3 ± 2.1 kg) measured.

As for the effect of an omnivorous–vegan diet switch on emotion and mood, Beezhold and Johnston (2012) observed a significant improvement in three of the mood scales in a vegetarian group of subjects, but not in the control group, suggesting an improved mood state. On the other hand, others (Michalak, Zhang, & Jacobi, 2012) found that vegetarians displayed higher rates of depressive and anxiety disorders despite the fact that the authors did not establish a causal relationship between the vegetarian diet and the etiology of these disorders. One important aspect of the effect of diet on mood is the adaptation and acceptability of vegetarian or low-fat diets (Hallfrisch et al., 1988; Pietinen et al., 1984). Young normal-weight healthy adults reported long-term acceptability and adherence to a vegetarian diet (Smith, Burke, & Wing, 2000). The results of this study suggested that young adults maintained vegetarian diets longer (1 year) than weight-loss diets (1–3 months). Several studies have examined dietary adaptation or compliance to lower fat or vegan diets including therapeutic diets in patients (Barnard et al., 2009), and thus dietary adaptation is expected to be greatly affected by the motivation of the patients making generalization very difficult.

The objective of this work was to examine the effects of consuming a 30-day vegan diet in a group of non-vegetarian subjects on nutrient intake, body weight, and mood.

Materials and methods

Subjects

The 30-day study included 16 subjects (9 females, 7 males) with no reported mood disturbance or previous mood disorders or other mental health problems, mostly staff from Cornell University, Ithaca, NY. They were all between 30 and 50 years of age. In addition, they were all omnivores, who consumed meat regularly, and had maintained their weight within a ±2.3 kg range over the previous year. They were not on medications, were not following any special diet, and did not have a dislike for several foods. The study was approved by the Cornell University Committee on Human Subjects. The subjects were briefed about the study's procedure and requirements before confirming their participation. They were told that they were participating in a project aimed at optimizing the diet for astronauts in future long-term space colonies and that the foods to be tested were regular foods that were developed based on a list of potential crops to be grown in a hydroponic station on the planetary surface. They were also informed that they will not be subject to caloric restriction and that the food will be provided in the quantities they wish. In addition, they were informed of the logistics of the procedure followed as outlined below. The diet was based on foods that satisfied the water and energy dietary requirements of long-term space travel (Lane & Feeback, 2002). The subjects' original characteristics are available in Table 1. Moreover, another control group of 15 subjects (3 males, 12 females) who had participated in the earlier taste sessions, and who fulfilled the same prescreening characteristics as the study group (above), participated in filling the mood questionnaire described below.

Table 1
Original subject characteristics; mean ± SE.

	Total ($N = 16$)	Women ($N = 9$)	Men ($N = 7$)
Age (years)	43 ± 1.7	46.8 ± 1.3	38.1 ± 2.4
Height (cm)	171.4 ± 2.0	167.1 ± 2.5	176.8 ± 1.8
Weight (kg)	70.0 ± 2.9	69.0 ± 4.5	71.23 ± 3.5
BMI (kg/m^2)	23.9 ± 1.0	24.7 ± 1.5	22.8 ± 1.0

Food products

The foods used in the 30 days, three 10-day menu cycles, of the study were mostly freshly prepared or frozen/reheated vegan foods. They were prepared by A. Rovers, R. Spies and by students who were hired and trained for this project. Out of the 95 foods included in the 10-day cyclic menu, 12 foods were prepared in bulk 3 weeks prior to the start of the study (by R. Spies and students mentioned above). These foods were kept in a freezer at a temperature of −40 °C until they were needed over the course of the study. Few commercial products, e.g. pita bread, were used for uniformity and convenience. Moreover, on weekends, a few commercial vegan foods were given to subjects to minimize food preparation and ensure food quality/stability. This introduction of commercial foods on the weekends resulted in omitting some foods in one of the three cycles resulting in small changes between the cycles. However, each food appeared at least in two cycles and many foods appeared in all three cycles. Some of the foods, mostly breakfast or snack foods were repeated more than once in every cycle. Low calorie fruit flavored beverages (Snapple®, 84 kJ/bottle), tea, herbal tea, coffee and decaffeinated coffee were available at all meals. Subjects had the option to add a non-dairy creamer (Coffee Mate®, Carnation) or a non-caloric sweetener (Nutra-Sweet®) to their hot beverages. Subjects were given calcium (Wegmans®, 600 mg) and multivitamin supplements (Wegmans®) each morning to avoid any possible vitamin deficiency that could have resulted from a low level of consumption.

The diet was devised to comply, as closely as possible with the astronauts' specific nutritional requirements using the 220 foods developed in our project and while utilizing mostly foods and ingredients which could be produced by a hydroponic agricultural system and simple food processing in a planetary surface habitat. More details on the nature of these foods and the scenario of the project are available in Hunter et al. (1999) and Waters et al. (2002). The foods selected for the study were chosen (a) using 9-point hedonic scale acceptability ratings of previous acceptability tests, and (b) those foods that required a low level of food preparation labor. Some of the foods included in this study were foods that did not receive high acceptability ratings in the previous acceptability sessions (<6 on 9-point hedonic scale). This value was used as a baseline due to its common usage in most institutions where continuous product development and acceptability tests are conducted (Cardello A., Army Natick Labs, personal communication; Bourland C., NASA, personal communication). Food products used in this study were served at the three main meals and for two snacks (morning and afternoon). Given that the food was provided *ad libitum* to the subjects at every meal, they were free to eat as much as they wanted and accordingly no preset caloric intake was expected. In addition, the absence of animal protein was replaced mostly by wheat protein (dough based or seitan, a wheat gluten based meat substitute), lentil based dishes and soy protein present in soy milk and tofu. The number of foods included in each meal category and the list of foods used in the 30-day study are available in the Supplementary material of the paper.

Procedure

The 10-day diet cycle length was based on several considerations, particularly the desire to offer a menu cycle of reasonable length and satisfactory variety. NASA's standard diet plan for Shuttle, Skylab and Mir astronauts divides the mission duration into three similar menu cycles. A 10-day diet cycle length, which repre-