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Comparison of vegetarian and omnivorous menus in nutrients, diet quality and environmental impact

Comparação de cardápios vegetarianos e onívoros em termos de nutrientes, qualidade da dieta e impacto ambiental

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ABSTRACT

Objective
A sustainable meal menu is important as it addresses various environmental and social concerns associated with food production and consumption. This study aims to compare the nutritional, environmental, and diet quality of omnivorous and vegetarian menus concerning sustainable nutrition.

Methods
One-month meal data was obtained from a university's website. The dietary quality of the menus was determined by Healthy Eating Index-2015. The meals' macro and micronutrients, and antioxidant capacities were analyzed with the BeBiS programme. Carbon, water and ecological footprint calculations were made using the food quantities obtained from the recipes of the menus.

Results
Omnivorous menus were higher in energy, in total protein, essential amino acids, total fat, saturated fat, cholesterol, n-6, vitamin E, riboflavin, niacin, B_6, B_{12}, iron, phosphorus, and zinc. Vegetarian menus were higher in fiber. There was no significant difference between the two menus regarding total Healthy Eating Index-2015 scores. The carbon, water and ecological footprint of omnivorous menus is significantly higher than the footprint of vegetarian menus.

Conclusion
When omnivorous and vegetarian menus were compared according to environmental, and diet quality vegetarian menus were more sustainable. Although both menus are not different in terms of HEI-2015, the amount of protein is lower in vegetarian menus. By diversifying with quality protein sources like legumes, eggs, pseudocereals, or oilseeds, professional-prepared vegetarian menus are required. In order to reduce the carbon, water and ecological footprints of omnivorous menus, reducing animal-based foods, including more plant-based foods and ensuring diversity, as in vegetarian menus, will contribute to sustainable nutrition.

Keywords: Carbon footprint. Ecological damage. Healthy eating ındex. Sustainable development ındicators. Water use.

RESUMO

Objetivo

Um cardápio de refeição sustentável é importante porque aborda várias preocupações ambientais e sociais associadas à produção e ao consumo de alimentos. Este estudo tem como objetivo comparar a qualidade nutricional, ambiental e dietética de cardápios onívoros e vegetarianos com relação à nutrição sustentável.

Métodos

Os dados das refeições de um mês foram obtidos no site de uma universidade. A qualidade da dieta dos cardápios foi determinada pelo Healthy Eating Index-2015. Os macro e micronutrientes e as capacidades antioxidantes das refeições foram analisados com o programa BeBiS. Os cálculos de carbono, água e pegada ecológica foram feitos usando as quantidades de alimentos obtidas das receitas dos cardápios.

Resultados

Os cardápios onívoros foram mais ricos em energia, proteína total, aminoácidos essenciais, gordura total, gordura saturada, colesterol, n-6, vitamina E, riboflavina, niacina, B_6*,* B_{12}*, ferro, fósforo e zinco. Os cardápios vegetarianos eram mais ricos em fibras. Não houve diferença significativa entre os dois cardápios com relação às pontuações totais do Healthy Eating Index-2015. A pegada de carbono, hídrica e ecológica dos cardápios onívoros é significativamente maior do que a pegada dos cardápios vegetarianos.*

Conclusão

Quando os menus onívoros e vegetarianos foram comparados de acordo com a qualidade ambiental e da dieta, os menus vegetarianos foram mais sustentáveis. Embora ambos os menus não sejam diferentes em termos de HEI-2015, a quantidade de proteína é menor nos menus vegetarianos. Ao diversificar com fontes de proteína de qualidade, como legumes, ovos, pseudocereais ou oleaginosas, são necessários cardápios vegetarianos preparados por profissionais. Para reduzir as pegadas de carbono, hídrica e ecológica dos cardápios onívoros, a redução dos alimentos de origem animal, a inclusão de mais alimentos de origem vegetal e a garantia da diversidade, como nos cardápios vegetarianos, contribuirão para uma nutrição sustentável.

Palavras-chave: *Pegada de carbono. Dano ecológico.* Healthy eating ındex. *İndicadores de desenvolvimento sustentável. Usos da água.*

INTRODUCTION

Unsustainable and unhealthy food consumption is one of the factors that threaten human health and the life of the world. The diets composed predominantly of more processed and refined foods, also containing a low share of foods of plant origin cause 12 million premature deaths and a third of Greenhouse Gas (GHG) emissions every year. It also directly or indirectly causes a decrease in biodiversity, water scarcity, excessive use of pesticides, nutrient pollution and climate change [1]. Therefore, such environmental factors should also be taken into account when generating the menus. The area where these factors can be considered into on the largest scale is nutrition services. Changing food services by taking environmental problems into account through national or local public policies will make a great contribution in this field. In order to reduce the negative environmental impacts of food during the production and consumption stages and increase sustainability, it is recommended to use plant-based vegetarian menus that offer more fruit and vegetable options and exclude animal products, processed meats and foods containing saturated fat [2-4]. In addition, vegetarian menus are also beneficial in preventing chronic non-communicable diseases. A vegetarian diet reduces the risk of coronary heart disease, type 2 diabetes, and obesity [5]. It also improves many health outcomes, including increased life expectancy [6]. In 2019, the EAT-Lancet Commission on Food, Planet, and Health proposed a diet that is predominantly composed of plant-based foods. The diet follows a flexitarian approach, adapted to the full spectrum of plant-based diets [7]. The mechanism that creates the positive effects of vegetarian nutrition has not been fully explained. A vegetarian diet limits unhealthy foods of animal origin, such as smoked or over-salted meat, and encourages the consumption of protective foods, such as fruits, vegetables, or whole grains [8]. A vegetarian diet usually contains low amounts of saturated fat and cholesterol, high dietary fiber, and many health-promoting phytochemicals. All these factors are among the reasons that create positive health effects. However, since some foods are restricted in a vegetarian diet, some deficiencies may occur in the nutrient content. Protein, vitamin B_{12}, vitamin D, omega-3 (n-3) fatty acids, calcium, iron, and zinc deficiency are potential problems for vegetarian diets [9].

As important as human needs are in nutrition, the footprints left by the food consumed in nature are as important for sustainability [10]. Unhealthy and unsustainably produced foods pose a global threat to people and the planet [11]. Generally, consistent evidence shows that a diet higher in plant-based foods (e.g., vegetables, fruits, legumes, seeds, nuts, whole grains) and lower in animal-based foods (especially red meat) has less impact on the environment [12]. Therefore, vegetarian menus likely have more positive effects on the environment.

In recent years, school menus have begun to be affected by changes in food choices and serve with alternative menus that suit consumers' food choices. Especially vegetarian/vegan menus are offered as an alternative in many school menus. Although the main purpose of school menus is to ensure adequate and balanced nutrition for students and staff, they are also indirectly a privileged environment for the development of nutritional habits of students and staff in schools [13]. School menus serving a large number of people have a significant impact on the food supply [14]. Considering the size of the service area, the nutritional quality of the menus and their potential for positive or negative impact on the environment become even more important. In addition, since individuals eating at these cafeterias do not have alternative options, developing the menus will lead to more effective results. These menus must be prepared and developed by a nutritionist who is an expert on this subject. Recently, studies examining menus' nutritional quality and environmental effects have increased. Benvenuti et al. [12] in Italy, Dahmani et al. [15] in France, and González-García et al. [16] in Spain examined vegetarian and non-vegetarian school menus in terms of nutritional quality and environmental impacts. The data obtained from the results of these studies will provide ideas to institutional directors and nutritionists about designing menus according to the principles of diet quality, diversity, and sustainability. In the literature review conducted using the keywords ''school menu, vegetarian menu, diet quality, environmental impact,'' no study examined and compared the effects of vegetarian and non-vegetarian menus of restaurants or school cafeterias on the nutritional quality and environmental impacts in Turkey.The data of this study will serve as a resource for experts in menu design.

This study aims to examine the vegetarian and non-vegetarian menus of a university that offers omnivorous and vegetarian menus and compare them regarding macro and micronutrients, diet quality, and environmental impact.

METHODS

In this study, omnivorous and vegetarian menus served at lunch in the student cafeteria of a state university, where an average of 4,000 meals are produced in one meal, were evaluated. The study's inclusion criteria were serving a vegetarian menu and available recipes on the website. At the beginning of the study, universities in Turkey that offer vegetarian alternative menus to their students and staff were investigated. There are 129 state universities in Turkey. 15 of these universities offer vegetarian menus. However, only 5 of them declare their vegetarian menus on their websites.

The websites of these 5 universities were investigated for whether the menus included recipes. It was determined that only one university included recipes on its website. These recipes used portion sizes for 1 person. Therefore, this university was included in the study. In the menus, four dishes are served in one meal. There is no selection of dishes. The first dishes consists of soups, the second dishes (main courses) consists of meat and chicken dishes, vegetable dishes, legume dishes etc., the third dishes consists of rice, pasta, pastry etc., and the fourth dishes consists of salad, dessert, yoghurt etc. The difference between omnivorous and vegetarian menus is only due to the change in main courses. The other three dishes are the same on both menus. Vegetarian menus contain only a small amount of eggs and dairy products. They do not include other foods of animal origin. The meal distribution is self-service. This study used the recipes of the omnivorousand vegetarian menus presented in January 2023. Deficiencies were determined by checking the accuracy of the recipes, and these deficiencies were completed by asking for the food engineer working in the university cafeteria.

The meals' macro and micronutrients, ORAC value, and antioxidant capacities were analyzed with the BeBiS 9.2 program using the recipes of the menus.

The dietary quality of the menus was determined by Healthy Eating Index (HEI)-2015. This index was developed by the United States Department of Agriculture (USDA) and is updated every five years, and the most current version is HEI-2015. HEI-2015 consists of 13 dietary components. Of these 13 components, 9 contain the nutrients recommended to be included in a healthy diet, and 4 contain the nutrients that should be consumed limitedly. Total fruit, whole fruit, dark green and legumes, total vegetables, whole grains, dairy, seafood and plant proteins, total protein foods, and fatty acids are the components that should be found in sufficient amounts in the diet. Refined grains, added sugar, sodium, and saturated fats are recommended for limited consumption. When scoring in the HEI-2015 categories, a high score from a category indicates that consumption of this food or nutrient is in the recommended range [17]. The total score is between 0-100. HEI-2015 score less than 50, between 50 and 70, and more than 70 was categorized as inadequate, average and optimal, respectively [18].

In this study, carbon, water and environmental footprint calculations were made using the food quantities obtained from the recipes of the menus and these coefficients given in Garzillo et al. [19]. To calculate the amounts of carbon, water, and ecological footprint, the food gram amounts of each menu were multiplied by their carbon, water, and ecological footprint. Finally, the menu's total carbon, water, and ecological footprint was calculated. Their approach typically involves the following key components:

Life Cycle Assessment (LCA): The method adopts a life cycle perspective, considering the entire life span of a product – from raw material extraction to production, distribution, use, and disposal.

Defining Boundaries: Clear boundaries are set to define which stages of the life cycle will be included in the analysis.

Data Collection: Extensive data is gathered regarding resource consumption (such as water and energy) and emissions at each stage of the life cycle. This data can come from various sources, including direct measurements, industry reports, and existing databases.

Emissions and Resource Use Calculation: The collected data is analyzed using appropriate factors to quantify the total carbon emissions, water usage, and ecological impact expressed in equivalent units.

Impact Assessment: The results are interpreted to assess the overall environmental impact, allowing for comparison between different products or practices and highlighting areas for improvement.

Recommendations: Based on the findings, suggestions can be made for reducing environmental impacts, such as optimizing resource use, improving efficiency, or changing materials.

The coefficients of five similar foods replaced those of five foods for which no available estimates were available. Coefficients of mint instead of parsley, wheat flour instead of corn flour, rice instead of bulgur, beans instead of chickpeas, and wheat flour instead of tarhana were used. The values calculated for raw and unprepared foods that can reach the point of sale were used. Footprints for all foods were averaged with international values.

Statistical analyses were performed using IBM®SPSS® (version 25.0). N and percent (%) values were used for descriptive data, mean±standard deviation (Mean ±SD), and Median (Minimum-Maximum) values were used for continuous data. The Shapiro-Wilk test assessed whether the continuous variables were normally distributed. Student's t-test was used for normally distributed variables, and Mann Whitney U test was used for non-normally distributed variables. The statistical significance level in the analysis was $p<0.05$.

RESULTS

This study evaluated omnivorous and vegetarian menus served at lunch in a state university student cafeteria, where an average of 4,000 meals are produced in one meal. Four meals are served in one meal on the menus. The difference between the omnivorous and vegetarian menus is due to changing only the main dishes. The other three dishes are the same in both menus. There is only one vegetarian alternative for the main dish and no other alternative since the other dishes are suitable for the vegetarian menu. Vegetarian menus only contain small amounts of eggs and dairy products. They do not include other foods of animal origin.

The menu served at lunch in a university cafeteria for one month (31 days) was evaluated. The frequency of the meals on the menu is shown in Table 1. Although soups constitute all 1st dish meals, the types vary, and soups made with grains are served most frequently. Second dish meals are theomnivorous main meal and vegetarian alternatives. Omnivorous main meals contain more variety (n=7). Vegetarian alternatives (n=4) were found to have less variety. The most kebab (n=9) was served of the omnivorous meals, while the least fish and liver dish (n=1) was served. Vegetarian alternatives consist of vegetables (n=17), legumes (n=10), vegetables with legumes (n=3), and vegetables with grains (n=1). Only vegetables constitute more than half of vegetarian alternatives, with a rate of 54.8%. 3rd dishes mainly consist of rice, pasta, and pastries. Meals containing vegetables and legumes were served only once. 4th dish consist of salad, dessert, yogurt, and beverages.

A comparison of some nutritional elements, ORAC value, and antioxidant capacity values of omnivorous and vegetarian menus are given in Table 2. Omnivorous menus have higher energy, total fat, Polyunsaturated Fatty Acids (PUFA), Monounsaturated Fatty Acids (MUFA), saturated fat, cholesterol, omega-6 (n-6), vitamin E, riboflavin, niacin, B_6, B_{12}, iron, phosphorus and zinc values than vegetarian menus ($p<0,05$). Vegetarian menus have a higher percentage of energy from carbohydrates and total fiber than omnivorous menus ($p<0.05$). There is no significant difference between omnivorous and vegetarian menus in terms of carbohydrates, percentage of energy from fat, omega-3 (n-3), vitamins A and C, thiamine, folate, sodium, potassium, calcium, selenium, magnesium, antioxidant capacity, and ORAC value ($p>0.05$).

Table 1 – Frequency of meals in the one-month menu.

Types of Meals on the Menu	Frequency (n=31)	Percentage of Serving (%)
1. Dish		100
Soup made by grains	11	35.5
Soup made by legumes	5	16.1
Soup made by grains and legumes	6	19.4
Vegetable soup	8	25.8
Soup made by vegetables and legumes	1	3.2
2. Dish (Omnivorous course)		100
Vegetable dish with ground meat	4	12.9
Meatball	4	12.9
Kebab	9	29.0
Fish	1	3.2
Poultry (chicken and turkey)	8	25.8
Legumes with meat	4	12.9
Liver dish	1	3.2
2. Dish (Vegetarian course)		100
Vegetables	17	54.8
Vegetables with grains	1	3.2
Vegetables with legumes	3	9.7
Legumes	10	32.3
3. Dish		100
Rice pilaf	8	25.8
Cracked wheat pilaf	4	12.9
Pasta	9	29.0
Rice pilaf with vegetables	1	3.2
Cracked wheat pilaf with vegetables	1	3.2
Pasta with vegetables	1	3.2
Patty	3	9.7
Vegetables	2	6.5
Legumes	1	3.2
Legumes and grains	1	3.2
4. Dish		100
Salads	12	38.7
Salads with grains	2	6.5
Salads with yoghurt	2	6.5
Salads with legumes (piyaz)	1	3.2
Fruit dessert	1	3.2
Pastry sweets	3	9.7
Yoghurt	3	9.7
Fruits	2	6.5
Compote	1	3.2
Mineral Water	3	9.7
Carbonated drink with added sugar	1	3.2

The total protein value of omnivorous menus is higher than vegetarian menus (p<0.001). The plant protein value of vegetarian menus is higher than omnivorous menus (p<0.001). Omnivorous menus contain higher amounts of essential amino acids than vegetarian menus (p<0.001).

A comparison of HEI-2015 scores of omnivorous and vegetarian menus is given in Table 3. When HEI-2015 categories were evaluated, total vegetables, saturated fats, seafood, and plant protein scores were higher in vegetarian menus than omnivorous ones. Total protein foods and refined grains scores were higher in omnivorous menus than in vegetarian menus (p<0.05). The two menus had no significant difference regarding total and whole fruit, dark greens and legumes, whole grains, dairy, fatty acids, sodium, added sugars, and total HEI-2015 scores (p>0.05).

Table 2 – Comparison of some nutrients and antioxidant capacity values of omnivorous and vegetarian menus.

Nutrients	Omnivorous Menu		Vegetarian Menu		Test statisticµ	*p*
	Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)		
Energy (cal)	1007.6±143.5	972.1 (825.7-1306.9)	798.3±150.1	774.3 (551.1-1143.8)	145.000	<0.001*
Carbohydrates						
Carbohydrate (g)	87.6±23.8	82.3 (37.5-135.3)	85.7±24.8	81.8 (52.4-138.2)	0.312	0.756
Carbohydrate (%)	35.2±6.3	36.0 (18.0-48.0)	43.5±6.7	43.0 (34.0-59.0)	-5.051#	<0.001*
Fiber (g)	12.3±4.9	11.1 (6.3-26.2)	16.0±5.6	15.2 (6.6-29.0)	290.500	0.007*
Proteins						
Protein (g)	44.4±7.5	44.1 (31.5-68.8)	21.1±5.2	20.6 (10.5-31.8)	1.000	<0.001*
Protein (%)	18.4±4.1	17.0 (14.0-31.0)	11.1±2.6	11.0 (6.0-16.0)	26.000	<0.001*
Plant protein (g)	15.4±4.8	14.8 (3.4-26.0)	18.7±5.3	18.1 (5.5-30.7)	-2.575#	0.013*
Isoleucine (mg)	2206.9±410.0	2165.6 (1434.7-3581.6)	988.8±308.8	967.5 (443.2-1875.9)	5.000	<0.001*
Leucine (mg)	3431.7±631.4	3374.0 (2231.6-5275.0)	1528.0±446.1	1537.5 (674.1-2519.9)	13.710#	<0.001*
Lysin (mg)	3315.4±776.0	3224.1 (1878.1-5912.2)	1217.2±516.9	1077.7 (447.7-2198.2)	5.000	<0.001*
Methionine (mg)	968.2±220.7	950.7 (561.6-1618.1)	304.4±85.6	296.3 (144.5-559.4)	15.616#	<0.001*
Phenylalanine (mg)	1987.2±359.2	1950.9 (1408.1-3057.4)	1000.4±297.2	970.7 (452.6-1646.7)	10.000	<0.001*
Threonine (mg)	1834.8±329.8	1779.7 (1236.7-2872.3)	765.8±235.8	775.8 (351.5-1291.8)	14.680#	<0.001*
Tryptophan (mg)	499.3±93.1	500.1 (350.5-787.3)	221.7±53.0	221.7 (120.4-342.5)	0.000	<0.001*
Valine (mg)	2347.8±415.3	2300.9 (1560.4-3467.7)	1074.0±309.5	1073.1 (502.8-1818.3)	13.693#	<0.001*
Histidine (mg)	1259.7±236.7	1221.8 (784.6-1992.4)	489.8±162.1	488.7 (205.1-818.1)	14.942#	<0.001*
Fats						
Total fat (g)	52.4±9.9	53.8 (33.2-80)	40.3±8.2	38.6 (30.8-67.0)	149.000	<0.001*
Total fat (%)	46.4±6.1	46.0 (33.0-58.0)	45.5±6.1	45.0 (33.0-56.0)	0.584#	0.561
Polyunsaturated fat (g)	21.2±3.7	21.6 (15.6-30.5)	18.2±4.9	18.1 (9.1-28.7)	2.712#	0.009*
Monounsaturated fat (g)	16.9±3.6	16.9 (11.2-26.8)	13.2±3.4	12.8 (8.2-22.0)	210.000	<0.001*
Saturated fat (g)	11.0±3.9	11.1 (4.4-22.3)	6.4±2.9	5.7 (3.8-16.7)	118.000	<0.001*
Cholesterol (g)	123.4±69.2	106.6 (37-359.9)	22.2±40.1	5.0 (0.0-193.6)	52.000	<0.001*
Omega 3 (g)	0.5±0.3	0.5 (0.3-1.4)	0.5±0.3	0.4 (0.2-1.4)	368.000	0.113
Omega 6 (g)	20.7±3.5	21.2 (15.2-29.2)	17.7±4.9	17.9 (8.3-27.3)	2.700#	0.009*
Vitamins						
Vitamin A (μg)	1397.8±4489.6	513.4 (87.7-25416.3)	683.5±511.2	563.4 (87.2-2306.2)	416.000	0.364
Vitamin E (eq. mg)	24.7±3.7	25.2 (18.8-31.7)	21.9±5.3	23.1 (12.2-31.3)	2.446#	0.017*
Thiamine (mg)	0.5±0.1	0.5 (0.4-0.9)	0.5±0.1	0.5 (0.2-0.8)	468.000	0.860
Riboflavin (mg)	0.7±0.7	0.5 (0.4-4.5)	0.4±0.2	0.3 (0.2-1.1)	183.000	<0.001*
Niacin (mg)	20.5±6.4	19.1 (13.2-39.1)	7.8±2.2	7.5 (4.8-18.1)	12.000	<0.001*
Vitamin B_6 (mg)	1.0±0.3	0.9 (0.7-2.0)	0.7±0.2	0.7 (0.5-1.2)	212.000	<0.001*
Vitamin B_{12} (μg)	7.2±15.8	4.3 (0.5-91.0)	0.2±0.3	0.0 (0.0-1.0)	10.500	<0.001*
Folate (μg)	190.3±162.5	146.6 (63.9-964.1)	199.7±71.9	186.4 (85.9-324.1)	359.000	0.087
Vitamin C (mg)	72.0±45.2	57.3 (19.6-253.2)	83.8±59.3	63.1 (21.5-255.3)	429.000	0.468
Minerals						
Sodium (mg)	2300.4±510.8	2382.2 (1346.1-3235.4)	2183.8±522.3	2149.2 (1241.4-3050.3)	0.889#	0.378
Potassium (mg)	1612.0±379.9	1596.8 (1116.3-2548.6)	1417.7±339.5	1399.2 (786.2-2182.8)	344.000	0.055
Calcium (mg)	180.7±76.3	174.3 (89.5-435)	199.7±72.6	180.5 (84.5-334.9)	406.000	0.294
Magnesium (mg)	159.8±36.2	149.8 (112.4-239.8)	152.7±36.6	150.1 (105.1-229.8)	421.000	0.402
Iron (mg)	7.4±2.5	6.8 (3.8-15.7)	5.9±1.9	5.4 (2.8-9.8)	310.500	0.017*
Phosphorus (mg)	573.9±105.9	550.7 (439.7-877.1)	407.9±113	416.8 (198.3-643.1)	139.000	<0.001*
Zinc (mg)	7.6±2.6	8.0 (3.5-11.3)	3.3±0.9	3.2 (1.7-5.1)	58.000	<0.001*
Selenium (mg)	3.6±4.6	1.3 (0.0-15.2)	2.9±4.1	0.0 (0.0-13.5)	427.000	0.424
Antioxidant status						
Antioxidant capacity (mmol)	1.0±0.6	1.0 (0.4-3.4)	1.4±1.0	1.1 (0.3-3.4)	377.000	0.145
ORAC	2098.9±2106.8	1435.9 (259.9-9052.9)	2577.4±2250.2	1748.4 (237.5-8499.1)	386.000	0.183

Note: **p*<0.05; µStudent's *t* test was used for normal distribution; #Mann Whitney U test was used for non-normally distribution.

Table 3 – Comparison of Healthy Eating Index-2015 scores of omnivorous and vegetarian menus.

HEI-2015 Categories	Max Scores	Omnivorous Menu (n=31)		Vegetarian Menu (n=31)		Test statistic	*p*
		Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)		
Total Fruit	5	0.9±1.4	0.5 (0.0-5.0)	1.0 ± 1.4	0.6 (0.0-5.0)	442.000	0.580
Whole Fruit	5	0.5±1.5	0.0 (0.0-5.0)	0.5 ± 1.5	0.0 (0.0-5.0)	480.000	0.990
Total Vegetables	5	3.5±1.4	3.4 (0.3-5.6)	4.3 ± 1.2	5.0 (0.4-5.0)	314.000	0.015*
Dark Greens and Legumes	5	3.1±2.0	3.5 (0.0-5.0)	3.9 ± 1.8	5.0 (0.0-5.0)	388.000	0.146
Whole Grains	10	2.7±4.2	0.0 (0.0-10.0)	2.4 ± 3.9	0.0 (0.0-10.0)	479.500	0.987
Dairy	10	1.0±1.5	0.4 (0.0 - 7.0)	1.3 ± 2.1	0.5 (0.0-10.0)	470.500	0.884
Total Protein Foods	5	5.0±0.0	5.0 (5.0 - 5.0)	2.5 ± 2.1	1.7 (0.0-5.0)	139.500	<0.001*
Seafood and Plant Proteins	5	2.3±2.1	1.9 (0.0 - 5.0)	3.4 ± 2.0	5.0 (0.0-5.0)	343.500	0.045*
Fatty Acids	10	9.9±0.3	10.0 (9.0 - 10.0)	10.0 ± 0	10 (10.0-10.0)	434.000	0.078
Refined Grains	10	7.7±2.3	8.4 (0.0 - 10.0)	6.1 ± 3.0	5.5 (0.0-10.0)	319.000	0.022*
Sodium	10	1.4±2.6	0.0 (0.0 - 10.0)	0.9 ± 2.6	0.0 (0.0-10.0)	397.000	0.108
Added Sugars	10	9.2±2.1	10.0 (1.8-10.0)	8.9 ± 2.7	10.0 (0.0-10.0)	475.500	0.919
Saturated Fats	10	7.5±2.8	7.5 (0.5-10.0)	9.2 ± 2.0	10.0 (1.5-10.0)	270.000	0.001*
Total HEI–2015	100	54.7±8.2	52.3 (40.0-69.0)	54.4 ± 9.3	52.9 (42.4 -73.2)	457.500	0.746

Note: **p*<0.05; Mann Whitney U test was used; HEI: Healthy Eating Index.

A comparison of carbon, water, ecological footprint of omnivorous and vegetarian menus is given in Table 4. The carbon, water and ecological footprint of omnivorous menus is significantly higher than the footprint of vegetarian menus (respectively 3234.8 (728.8 - 6341.1), 507.2 (178.3 - 1170.7) gCO_2eq; 2875.1 (916.6 - 4565.8), 787.1 (528.9 - 1214.2) liters; 16.8 (7.4 - 56.8), 3.8 (1.9 - 6.4) $g\text{-}m^2$ $p<0.001$).

Table 4 – Comparison of carbon, water, ecological footprint of omnivorous and vegetarian menus.

Nutrients	Omnivorous Menu		Vegetarian Menu		Test statistic	*p*
	Mean ±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)		
Carbon footprint (gCO_2eq)	3433.3±1854.8	3234.8 (728.8-6341.1)	525.9±212	507.2 (178.3-1170.7)	4.000	<0.001*
Water footprint (liters)	2814.4±1166	2875.1 (916.6-4565.8)	817.1±168.8	787.1 (528.9-1214.2)	14.000	<0.001*
Ecological footprint ($g\text{-}m^2$)	18.6±9.7	16.8 (7.4-56.8)	4.1±1.0	3.8 (1.9-6.4)	0.0	<0.001*

Note: **p*<0.01; Mann Whitney U test was used.

DISCUSSION

This study compared omnivorous and vegetarian menus regarding nutritional, dietary quality and environmental impact in a university serving dishes for approximately 4,000 people. The results showed significant nutritional differences between omnivorous and vegetarian menus. The first thing that stands out in our study is vegetarian menus' lack of nutritional diversity. Vegetarian menus usually consist of vegetables and legumes. In a study comparing the omnivorous main menu and vegetarian alternatives given in childcare centers participating in the Child and Adult Care Food Program (CACFP) in the USA, it was seen that the number of varieties of vegetarian alternatives was 7. Vegetarian alternatives are enriched with alternative products such as oil seeds, cheese types, and tofu. While omnivorous main menus contain a median of 20.5 grams of protein, vegetarian alternative menus have a median of 18.8 grams [20]. In our study, when the vegetarian menus served to adults were examined, it was observed that the average protein amount (median 20.6) was significantly lower than the omnivorous menu (median 44.1). When these two studies are compared, the difference in total protein between the menus in our study is quite high (approximately two times). This is because, in our study, vegetarian alternatives mainly consisted of vegetable dishes (54.8%).Choosing vegetables with high protein can increase the protein content of the menus. Regional vegetables such as knotweed (2.1/100 g), nettle (3.4/100 g), and local mushroom species (2.0/100 g) that are suitable for sustainability and have high protein content can be added to the menus [21]. However, even if these vegetables are added to the menus, they generally contain much less protein than animal-based foods. In addition, it is difficult for food services to access sufficient amounts of local foods. Therefore, the cultivation of these vegetables should be encouraged. A 70 kg adult has a daily protein requirement of 0.8/kg (56 gr protein) [22]. The lunch menu in food service is expected to meet 2/5 of the daily nutrient requirement [23]. Thus, the protein requirement of a meal should be 22.4 g. The protein amount of the omnivorous menu in our study is relatively high (44.1 g). Reducing the amount of animal-based protein in the omnivorous menu by half is sufficient to meet protein requirements. This will also prevent waste and help reduce negative environmental effects. When omnivorous menus were examined, the main dishes containing fish for one day, chicken for eight days, and red meat for the remaining 22 days were served. Since it is known that the negative environmental effects of red meat are higher [19], reducing the menus' red meat content helps reduce the total protein content and create more sustainable menus. Vegetarian menus mostly contain plant-based protein. Since plant-based proteins have lower bioavailability, protein needs are calculated by increasing them by 10-20% [24]. Considering that an adult's needs are 56 grams, it is recommended that those who consume plant-based protein consume approximately 67 grams of protein per day. The protein amount of a menu should contain approximately 27 grams (67x2/5= 26.8 g). In our study, the protein content of the vegetarian menus was below this amount (21.1 g). Besides total protein, essential amino acids are significantly low in the vegetarian menus. Foods such as oil seeds, cheese types, and tofu can be added to vegetarian menus prepared in Turkey to increase protein quality and quantity and to provide diversity. However, soybeans used in tofu production are mostly imported, although they are grown in our country. The use of non-local imported products negatively affects sustainability. The production of soybeans, food with high protein and nutrients, can be encouraged and used more frequently on menus. Although oilseeds and cheese types have a higher carbon footprint (about ten times) than vegetables, they have a much lower carbon footprint (about ten times) than red meat [19]. They can be preferred because they will increase the quality of nutrients and provide a lower negative environmental impact than red meat.In addition, meals containing grains (90.3%) and legumes (42%) are frequently used in vegetarian alternatives. This can improve protein quality by providing a balanced distribution of essential amino acids. In our study, the percentage of energy from carbohydrates and total fiber were higher in vegetarian menus. In a study of Jordanian adults, total fiber value was significantly higher in lacto-ovo vegetarians compared to non-vegetarians, similar to our study [25]. In a study examining NHANES data between 1999-2004; fiber, vitamins A, C, and E, thiamine, riboflavin, folate, calcium, magnesium, and iron were found to be higher in vegetarian diets (The group defined as vegetarian in this study is a lacto-ovo vegetarian) [26]. According to our study, vegetarian menus have a lower vitamin E, riboflavin, and iron container than omnivorous menus. There is no significant difference between the contents of vitamins A and C, thiamine, calcium, and magnesium. In our study, although the vegetarian menus were lacto-ovo vegetarian, the insufficient frequency of dairy products and the infrequent use of eggs is one of the factors that make up this difference. A study determined that total energy, total fat, saturated fat, calcium, and sodium were higher on vegetarian menus than on omnivorous menus [20]. Contrary to expectations, the high rate of these nutrients in vegetarian menus is thought to be due to the increased use of cheese varieties as a meat alternative. Our study used vegetables or legumes as alternatives, and no cheese was used. Therefore, while total energy, total and saturated fat were lower in vegetarian menus, nutrients such as calcium, magnesium, potassium, and sodium were similar to omnivorous menus. Studies show that vitamins B_6 and B_{12} are consumed higher by non-vegetarians [25,27,28]. Similarly, in our study, B_6 and B_{12} were higher in omnivorous menus. This is because vitamin B_{12} is only of animal origin, and vitamin B_6 is mainly found in foods of animal origin.

The antioxidant capacity of plant-based foods is much higher than animal-based foods. Plant-based foods contain more effective antioxidant compounds, while animal-based sources are limited in antioxidant content [29,30]. Considering that the vegetable and fruit contents of vegetarian diets are higher, the antioxidant capacity is expected to be higher. However, in our study, there was no significant difference between vegetarian and omnivorous menus regarding antioxidant capacity and ORAC value. The most critical factor affecting the antioxidant capacity of menus is plant-based foods. The main courses of the vegetarian menus included in this study were generally created by excluding meat products from omnivorous main courses (For example, spinach with olive oil instead of spinach with minced meat) Since the plant-based food content of vegetarian and omnivorous menus is similar, their antioxidant capacity is similar. In addition, the fact that the 4th dishes have a high vegetable and fruit content, which are the same in both menus, makes the antioxidant capacity similar.In our study, while total vegetable, saturated fat, seafood, and plant proteins scores from the HEI-2015 categories were higher in vegetarian menus, Total protein, and refined grain scores were significantly higher in omnivorous menus. The two menus have no significant difference regarding total and whole fruit, dark greens and legumes, whole grains, dairy, fatty acids, sodium, added sugar, and total HEI-2015 scores. In a study comparing the diet quality of vegetarian menus with omnivorous menus, total protein, saturated fat, and total HEI-2015 scores were significantly higher in omnivorous menus [20]. In our study, total vegetables, saturated fat, seafood, and vegetable protein scores were higher on vegetarian menus. This may be due to the frequent serving of vegetables and legumes in vegetarian alternatives. In addition, the frequent use of cheese varieties with a high saturated fat content as an alternative in the other study may cause higher saturated fat scores in omnivorous menus. In a study in which school menus were optimized and compared with omnivorous menus, adding legumes and vegetables to the menus and less beef, saturated fat, sodium, and cheese caused a significant increase in the HEI-2015 score [31]. In a study conducted in Belgium, vegetarian menus were served one day a week in primary school schools. Omnivorous and vegetarian menus were compared regarding total energy, total fat, total fiber, percentage of energy from fat, the ratio of saturated fat to total fat, and nutrition score. When evaluated in terms of energy from fat; the first (Meatballs in tomato sauce), second (Lasagne bolognaise), and fifth (Pork escalope with gravy) menus of the conventional menus; nutritional quality scores of the third (Soya strips with vegetarian gravy), fourth (Veggie chunks with pineapple and sweet and sour vegetables) and fifth (Vegetarian schnitzel) menus of the vegetarian menus are poor. When evaluated in terms of the ratio of saturated fat to total fat; Of all the conventional menus and vegetarian menus, only the second menu (Spinach lasagne) has a poor nutritional quality score. When evaluated regarding total fiber content, all conventional menus have poor nutritional quality scores [32]. The frequent addition of cheese to vegetarian alternatives negatively affects the diet quality of the menus in terms of sodium and fatty acid profile. Enriching vegetarian alternatives with more legumes, oilseeds, or eggs may improve the menu's vitamin and mineral content and fatty acid profile.

Food consumption is responsible for a significant portion of greenhouse gas emissions and water resource use. In particular, the negative environmental impacts of animal-origin foods are much higher than those of plant-origin foods [33]. Recently, there has been increasing interest in estimating the environmental impact of food products and communicating this to consumers to enable them to make more informed choices [34]. Furthermore, the importance of incorporating environmental sustainability into menu planning is beginning to be recognized [31]. Hatjiathanassiadou et al. [14] evaluated 112 traditional and vegetarian menus and showed that the water footprint of traditional food menus was higher than that of vegetarian menus (2752.4±396.8 L/kg; 1113.9±125.8 L/kg).

In another study conducted in the Netherlands, greenhouse gas emissions of four different food consumption scenarios were evaluated. As a result of the research, eliminating meat products from the diet and/or more frequent use of foods with low greenhouse gas values provided a 28-46% reduction in average greenhouse gas emissions [35]. In another study conducted in Turkey, the carbon and water footprints of omnivorous menus served in December and February at a university were found to be 3.4±1.3 CO_2eq/kg, 3.8±1.1m^3/tonne; 3±1.5 CO_2eq/kg, 3.2±1.4m^3/tonne, respectively. The carbon and water footprints of sustainable menus created by restricting animal-based foods from the menus and using seasonal vegetables and fruits served in December and February at a university were found to be 0.9±0.8 CO_2eq/kg, 1.1±0.4 m3/tonne; 1±1.2 CO_2eq/kg, 1.2±0.5 m^3/tonne, respectively. These sustainable menus with low carbon and water footprints are mainly rich in plant-origin foods, such as vegetarian menus [36]. In this study, similar to other studies, the carbon and water footprint of omnivorous menus was significantly higher than that of vegetarian menus (3234.8 (728.8 - 6341.1), 507.2 (178.3 - 1170.7) gCO_2eq; 2875.1 (916.6 - 4565.8), 787.1 (528.9 - 1214.2) liters; p<0.001). In both studies conducted in Turkey, it was observed that the carbon and water footprint values of the omnivorous menus were very close to each other. Both studies observed that the carbon and water footprints of plant-origin menus were considerably lower than the omnivorous menus. However, the lower carbon and water footprint of vegetarian menus compared to sustainable menus is due to the absence of red meat in vegetarian menus.

Evaluation of a single university since only one university's recipes can be accessed and the fact that the preparation and cooking methods are not specified in the recipes received from the university are the limitations of this study. However, this study is the first study comparing vegetarian and non-vegetarian menus in Turkey. This study will contribute to the growing literature on vegetarian nutrition.

CONCLUSION

In conclusion, with the increasing interest in vegetarian nutrition in the world and our country, alternative vegetarian menus have been started to be served. However, a very limited number of universities provide this service. Vegetarian menus were found to be insufficient in terms of variety, total protein, essential amino acids, and many nutrients. However, the fact that vegetarian menus are rich in fiber can be beneficial in improving health. Vegetarian menus have less negative impact on the environment regarding carbon, water, and ecological footprint than omnivorous menus. However, despite these positive environmental impacts of vegetarian menus, enriching their low nutrient content is essential. Regarding vegetarian alternatives, vegetables, and legumes come to mind first in our country. Although using these food groups helps increase the diet quality, not including more alternative food on the menus may be one factor that leads to nutrient deficiencies. When planning vegetarian menus, adding foods such as oil seeds, types of cheeses, eggs, and grains with higher nutritional value (quinoa, wheat germ, etc.) to vegetable and legume meals can enrich the menu regarding nutrients and protein. Supporting the production of local foods and adding them to menus should be encouraged for sustainability. While creating vegetarian menus, it is necessary to develop better-planned menus according to the nutritional needs of the target audience through expert nutritionists in this field.

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