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Sustainability of Hospital Catering Services: Water and Carbon Footprint

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ABSTRACT

It is important that mass catering services in hospitals adhere to health quality standards and are carried out sustainably and reliably, aligning with the planning of patients' nutritional treatments in clinical services. This study aims to analyze the carbon and water footprints of menus used in hospital catering services. The research was conducted across all four seasons, with 31-day months included to standardize the number of days in the selection of seasonal menus. Among the menus, one of the most frequently prepared meals using traditional production methods was selected separately for lunch and dinner. In the study, carbon and water footprint calculations were performed for pre-selected meals used in hospital catering services. During spring, summer, autumn, and winter, the carbon footprint levels of the first meal group were significantly higher than those of the second and third meal groups ($p<0.001$). Similarly, in all seasons, the water footprint levels of the first meal group were significantly higher than those of the second and third meal groups ($p<0.001$). Hospital catering services, which primarily serve patients, staff, and visitors within mass nutrition systems, play a vital role in protecting health, supporting medical nutrition treatments, and contributing to the sustainable nutrition chain. In this context, to ensure sustainability in hospital catering services, it is essential to develop guidelines tailored to public catering systems and consider the carbon and water footprints of these menus.

Keywords: Sustainability, Carbon footprint, Water footprint, Catering, Hospital

Hastane Yemek Hizmetlerinin Sürdürülebilirliği: Su ve Karbon Ayak İzi

ÖZ

Hastanelerdeki toplu yemek hizmetlerinin sağlık kalite standartlarına uygun, sürdürülebilir ve güvenilir bir şekilde gerçekleştirilmesi, klinik hizmetlerdeki hastaların beslenme tedavilerinin planlamasıyla uyumlu olması önemlidir. Bu çalışma, hastane yemek hizmetlerinde kullanılan menülerin karbon ve su ayak izlerini analiz etmeyi amaçlamaktadır. Araştırma, dört mevsim boyunca gerçekleştirilmiş ve mevsimsel menü seçiminde gün sayısını standartlaştırmak için 31 günlük aylar dahil edilmiştir. Menüler arasında, geleneksel üretim yöntemleriyle en sık hazırlanan yemeklerden biri, öğle ve akşam yemekleri için ayrı ayrı seçilmiştir. Çalışmada, hastane yemek hizmetlerinde kullanılan önceden seçilmiş yemekler için karbon ve su ayak izi hesaplamaları yapılmıştır. İlk yemek grubunun karbon ayak izi seviyeleri, ilkbahar, yaz, sonbahar ve kış mevsimlerinde, ikinci ve üçüncü yemek gruplarına göre anlamlı derecede daha yüksek bulunmuştur ($p<0.001$). Benzer şekilde, tüm mevsimlerde, ilk yemek grubunun su ayak izi seviyeleri, ikinci ve üçüncü yemek gruplarına göre anlamlı derecede daha yüksek bulunmuştur ($p<0.001$). Hastane yemek hizmetleri, toplu beslenme sistemleri içinde öncelikli olarak hastalara, personele ve ziyaretçilere hizmet vererek sağlığın korunmasında, tıbbi beslenme tedavilerinin desteklenmesinde ve sürdürülebilir beslenme zincirine katkıda bulunmada hayati bir rol oynamaktadır. Bu bağlamda, hastane yemek hizmetlerinde sürdürülebilirliği sağlamak için kamu yemek sistemlerine özel yönergeler geliştirilmesi ve bu menülerin karbon ve su ayak izlerinin dikkate alınması gereklidir.

Anahtar Kelimeler: Sürdürülebilirlik, Karbon ayak izi, Su ayak izi, Yemek hizmetleri, Hastane

INTRODUCTION

It is of great importance that mass nutrition services carried out within the scope of quality standards in health in hospitals are carried out sustainably and reliably following the planning of the patient's nutritional treatment in clinical services. In hospital menus, both healthy nutrition-specific and disease-specific therapeutic diet meals should be prepared and standardized in quality, taste, and variety that will increase the consumption of patients and should be offered to the consumption of patients [1]. In addition, taking measures to ensure a sustainable service in all processes in hospital catering services is one of the issues that have gained importance in recent years [2].

The term sustainability was first used in the late 1980s by the Brundland Commission in its report "Our Common Future". Sustainability is defined as "the frugal, regenerative use of renewable resources" and in another definition, it is defined as "the conservation of assets needed by economic, social and ecological systems, at least at the level needed" [3]. In the "Brundtland Report" published by the World Commission on Environment and Development (WCED) in 1987, the concept of sustainable development was defined as "a development that focuses on meeting the needs of the present without compromising the ability of future generations to meet their own needs" [4].

Sustainable development is not only multidimensional but also dynamic. Wealth, development, and success, which are generally measured by the level of gross domestic product, need to be renewed to include social and environmental indicators. In this respect, ecological footprint and carbon footprint appear as indicators that measure environmental sustainability. Ecological footprint is defined as the area of fertile land and water used for the reproduction of consumed resources and the disposal of wastes. The concept of carbon footprint is called a subset of the "ecological footprint" proposed by Wackernagel in the early 1990s [5]. Climate change, which manifests itself as an important problem of the world, refers to "the changes in the global climate system and consequent changes in ecosystems due to the excessive increase in the accumulation of greenhouse gases in the atmosphere due to anthropogenic effects" [6]. The rapid rise in global temperature is due to the increasing greenhouse effect due to the release of anthropogenic greenhouse gases into the atmosphere. The carbon footprint of a product or service refers to its total greenhouse gas (GHG) emissions at each stage of its lifecycle: production, use/consumption, and disposal. Global Warming Potential (GWP) is calculated mathematically and its unit is carbon dioxide equivalent (CO_{2}-e) [7]. Current dietary trends indicate a 95.0 percent increase in global demand for meat and animal food products, which will increase food-related GHG to 80.0 percent by 2050 [8]. An indicator of sustainability in societies is the measurement of the amount of water used within the country and on a global scale. The concept of water footprint was first introduced by Hoekstra in 2002 to identify water use along the supply chains of products and services. The concept of water footprint is an expression of both direct water use and indirect water use in the production process in all processes from raw material processing, direct operations and consumer use of the product. Methodologies for calculating the water footprint of products have been developed by Hoekstra et al. In the case of agricultural products, the water footprint is usually expressed in m^3/ton or litres/kg. Other ways to express the water footprint of a product are water volume/kcal (for food products in the context of diets) or water volume/joule (for electricity or fuels) [9,10]. The water footprint of a product is also defined as the volume of freshwater used to produce the product, measured along the full supply chain. The water footprint shows not only the volume of water used but also the type of water used, where, and when it is used. The blue, green, and grey water footprints are the three components of the water footprint that represent water use and quality [11]. Blue water footprint refers to the consumption of blue water resources (surface and groundwater) along the supply chain of a product. Green water footprint refers to the consumption of green water resources (rainwater stored in the soil as soil moisture). Grey water footprint refers to pollution and is defined as the volume of freshwater required to assimilate a load of pollutants according to current ambient water quality standards [12]. Approximately one-third of the total water footprint of agriculture in the world is generated by the production of animal products. It is reported that the water footprint of any animal product is more than the water footprint of plant products with equivalent nutritional value [13].

MATERIALS and METHODS

Place and Time of the Study

This study was planned and conducted in a Research and Application Hospital in Isparta to examine the carbon and water footprints of the menus used in hospital catering services between August 2020 and March 2021. Approval for the research was obtained from Gazi University Ethics Commission with the research code 2020-168 on 21.02.2020. The legal permission for the study to be conducted in hospital kitchen menus was obtained on 26.06.2020 with the decision numbered 26515734-605.01-E. The entire budget of the study belongs to the researcher.

General Plan of Study

In the study, carbon and water footprint calculations of pre-selected meals applied in hospital catering services were made by the researcher in person. The study was conducted in 4 seasons. To standardize the number of application days in the selection of seasonal menus, 31-day months were included in the study. August menu for the summer season, October menu for the autumn season, January menu for the winter season, and March menu for the spring season were taken into consideration.

In the hospital, 3 food groups are applied to 3 meal alternating menus without a set selection. Only the selected meals at lunch and dinner were included in the study. Due to the frequent repetition of some of the meals in the menus and the presence of meals with similar workflow and raw material content in the food groups, one of the most frequently produced meals using traditional production methods was selected separately for lunch and dinner. If the selected meal was repeated in that month, it was not re-evaluated. The standard recipe of the selected meal and the amounts of nutrients in a portion were obtained from the institutional authority through the executive dietician.

In the study, the first group of meal types consisted of large pieces of meat meals, small pieces of meat meals, meatballs, chicken meals, fish meals, meaty vegetable meals, meaty legume meals, egg meals, and liver meals, the second group of meal types consisted of pasta, rice, soups, vegetable meals with olive oil, legume meals with olive oil, Turkish ravioli, pastries, and flatbreads, and the third group consisted of salads, milk desserts, pastry desserts, compotes, and pleasantries, fruits, and others (yogurt, pickles, etc.).

Carbon and Water Footprint Calculation

The average carbon and water footprint factors published in the extant literature were utilised in the carbon and water footprint calculations of the selected meals included in the study. As Turkey-specific data on the carbon and water footprint factors of foods is lacking, the carbon and water footprint factors obtained from meta-analyses [14, 15] and studies [16, 17] in the existing literature were used. These sources provided robust and widely recognized estimates that were deemed appropriate for the scope of this investigation. The carbon footprint factors for each food item were quantified in units of kilograms per product (kg-product), while the water footprint factors were measured in cubic meters per ton (m^3/ton). This differentiation in units reflects the distinct nature of carbon and water usage associated with food production and consumption. To ensure consistency and accuracy in the footprint calculations, each of these food-specific factors was meticulously converted into grams per product (gram-product). This conversion was essential for facilitating precise calculations at the portion level. The carbon and water footprint factors for each food are expressed in kilograms per product and cubic metres per ton, respectively.In the study, each of the food-specific factors was converted into a gram per product to calculate the carbon and water footprints of one portion of the meals included in the standard meal recipes applied in the institution. Subsequently, these standardized footprint factors were applied to determine the carbon and water footprints of individual meal portions. The meals analyzed were based on standard meal recipes that are routinely implemented within the institution under study. By adopting this methodological approach, the research was able to provide detailed insights into the environmental impacts of each meal component, thereby enabling a comprehensive assessment of the overall sustainability of the institution's meal offerings.

From the ingredients in the recipes, pepper paste, black cumin, noodles, hazelnut, semolina, baking powder, kadayif, cocoa, black pepper, kemal pasha, cornichon pickles, curry sauce, lemon salt, pasta, Turkish ravioli, parsley, puff pastry, corn starch, leek, proline, saffron, tomato paste, grape vinegar, soda, sumac, granulated sugar, vermicelli, cinnamon powder, salt, vanilla, allspice, phyllo dough, and turmeric are not included in the calculation since they do not have food-specific carbon footprint factors. Also, among the ingredients in the recipes, trout, pumpkin, black cumin, coconut, baking powder, kadayif, cocoa, kashar cheese, kemal pasha, red cabbage, cumin, cornichon pickles, curry sauce, cream, dried thyme, lemon salt, curd cheese, Turkish ravioli, puff pastry, proline, saffron, grape vinegar, soda, sumac, tahini, vermicelli, salt, allspice, yogurt, phyllo dough, turmeric are not included in the calculation since they do not have food-specific water footprint factors.

Statistical Evaluation of Data

The data were analyzed with IBM SPSS V23. Compliance with normal distribution was analyzed by the Shapiro-Wilk test. The Independent two-sample t-test was used to compare normally distributed data according to binary groups and the Mann-Whitney U test was used to compare non-normally distributed data. One-way analysis of variance was used to compare normally distributed data according to groups of three or more and multiple comparisons were analysed by Duncan test. Kruskal Wallis test was used for the comparison of non-normally distributed data according to groups of three or more. The significance level was taken as $p<0.050$.

Limitations of the Study

Due to the insufficiency of the literature data, when evaluating the water footprint of the meals, grey, green, and blue water footprints were evaluated as total water footprints, not separately. In addition, the lack of water and the carbon footprint of all foods constitutes another limitation.

RESULTS

The data obtained in the study conducted to examine the carbon and water footprints of the menus used in hospital catering services are given below under the relevant headings.

Table 1 shows the carbon footprint values of 1 portion of the meals included in the study according to the groups in terms of CO_2 equivalent/kg. The meal with the highest carbon footprint value of one portion is elbasan tava (4.098) for the first group and the meal with the lowest carbon footprint value is chickpea with chicken (0.077). For the second group, the highest meal was flatbread with minced meat (2.348) and the lowest meal was sawdust pastry with cheese (0.036). For the third group, the highest meal was cacik (1.183) and the lowest meal was quince compote (0.028).

Table 1. Carbon footprint values for each portion of meals according to groups (CO_2 equivalent/kg)

Group 1		Group 2		Group 3	
Meal Name	CO_2 equivalent/kg	Meal Name	CO_2 equivalent/kg	Meal Name	CO_2 equivalent/kg
Elbasan Tava	4.098	Flatbread with Minced	2.348	Cacik (Tzatziki)	1.183
Stick Kebab	4.085	Wedding Rice	1.455	Kalburabasti	0.436
Hungarian Goulash (Puree)	4.071	Trotter Soup	0.676	Yogurt	0.404
Tas Kebab	4.062	Fresh Beans with Olive Oil	0.605	Cocoa Pudding	0.380
Forest Kebab	4.051	Imambayildi	0.353	Keshkul	0.326
Shepherd Roast with Vegetables	3.984	Bulgur Rice with Chicken	0.347	Orange	0.320
Boiled Meat	3.948	Manti	0.332	Milk Halva	0.317
Beef Emense Over Rice	3.541	Pasta with Yoghurt	0.305	Semolina Halva	0.275
Minced Meat Sauteed Over Rice	3.418	Oven Pasta	0.302	Oven Rice Pudding	0.250
Sauteed Meat Over Rice	3.411	Puff Pastry with Chicken	0.286	Kazandibi	0.249
Albanian Liver	3.199	Tomato Soup	0.252	Şekerpare	0.244
Abant Kebab	2.978	Lentil Pastry	0.243	Peanut Dream	0.205
Izmir Meatballs	2.869	Yayla Soup	0.214	Mixed Salad	0.145
Dalyan Meatballs (Puree)	2.811	Leek with Olive Oil	0.208	Tulumba	0.143
Izmir Meatballs	2.752	Cheese Pastry	0.204	Seasonal Salad	0.140
Farm Meatballs	2.742	Celery with Olive Oil	0.198	Shepherd Salad	0.137
Grilled Meatballs	2.702	Ayran Soup	0.185	Spoon Salad	0.135
Terbiyeli Meatballs	2.633	Bulgur Rice	0.170	Yoghurt Dessert with Sesame	0.100
Celery with Meat	1.748	Pasta with Cheese	0.158	Yogurt Dessert	0.100
Karnıyarık	1.629	Rice	0.147	Pumpkin Dessert	0.098
Patlıcan Oturtma	1.585	Gemici Soup	0.132	Ashoura	0.092
Minced Spinach with Yoghurt	1.568	Vermicelli Soup	0.117	Peach	0.086
Egg with Minced Meat	1.561	Peas with Olive Oil	0.115	Carrot Cabbage Salad	0.083
Fresh Beans with Meat	1.511	Cauliflower with Olive Oil	0.114	Watermelon	0.064
Peas with Meat	1.435	Rice Soup	0.113	Pear	0.058
Cauliflower with Mince	1.425	Bulgur Rice with Vermicelli	0.110	Kadayif	0.053
Okra with Meat	1.406	Wire Vermicelli Soup	0.104	Wire Kadayif	0.053
Sour Pumpkin with Meat	1.400	Cheese and Walnut Noodles	0.102	Kemalpasha	0.048
Potato with Meat	1.397	Meyhane Rice	0.097	Mixed Compote	0.039
Kabak Kalye	1.396	Noodles with Cheese	0.096	Quince Compote	0.028
Chickpeas with Meat	1.386	Bulgur Rice with Lentils	0.096		
Dried Beans with Meat	1.367	Kidney Beans with Olive Oil	0.092		
Meat Fajita (Saffron Rice Garnish)	0.988	Pasta with Tomato	0.090		
Chicken Nuget (with Vegetable Garnish)	0.953	Ezogelin Soup	0.087		
Chicken Fajita	0.874	Lentil Soup	0.081		
Chicken Over Rice	0.870	Bulgur Rice with Chickpeas	0.081		
Chicken Casserole	0.832	Dried Beans with Olive Oil	0.070		
Boiled Chicken	0.827	Pasta with Sauce	0.064		
Sauced Chicken	0.822	Tutmaç Soup	0.058		
Creamy Chicken (with Pasta Garnish)	0.809	Flatbread with Cheese	0.052		
Tavuk Dünyası	0.809	Flatbread with Spinach	0.041		
Trout (with Potato Garnish)	0.710	Sawdust Pastry with Cheese	0.036		
Chicken Galantine (Puree)	0.622				
Chicken Meatloaf	0.622				
Chicken Bowl with Spinach	0.607				
Chicken Cauliflower with Bechamel Sauce	0.452				
Potato with Chicken	0.327				
Roman Style Spinach	0.319				
Chickpeas with Chicken	0.077				

Table 2 shows the mean ($\bar{X}$), standard deviation (SD), and upper and lower values of the carbon footprint of 1 portion of the meals included in the study according to the groups in terms of CO_2 equivalent/kg. For the first group, the highest average carbon footprint of a portion of the carbon footprint was for large meat meals (4.047±0.067) and the lowest was for fish meals (0.683±0.027). For the second group, the highest meal type was flatbreads (0.814±1.329) and the lowest meal type was legume meals with olive oil (0.078±0.015). For the third group, the highest meal type was yogurt, pickles, and other meals (0.434±0.316), while the lowest meal type was compote and pleasantries (0.034±0.008).

Table 3 shows the mean ($\bar{X}$), standard deviation (SD), median, and lower and upper values of the carbon footprint (CO_2 equivalent/kg) of one portion of the meals included in the study according to the groups and seasons. In the spring season, the highest average carbon footprint of one portion for the first group was large meat meals (4.072), while the lowest was egg meals (0.320). For the second group, the highest carbon footprint was flatbreads (2.349) and the lowest was legume meals with olive oil (0.056). For the third group, the highest meal type was yogurt, pickles, etc. ($\bar{X}$±SD=0.314±0.128) and the lowest meal type was fruits ($\bar{X}$±SD=0.029±0.041). In the summer season, the highest average carbon footprint of a portion of the meal for the first group was large pieces of meat meals (4.098), while the lowest was fish meals (0.656). For the second group, the highest meal type was Turkish ravioli (0.332) and the lowest meal type was flatbreads (0.041). For the third group, the highest meal type was yogurt, pickles, etc. ($\bar{X}$±SD=0.794±0.551), while the lowest meal type was compote and pleasantries (0.040). In the autumn season, the highest average carbon footprint of one portion for the first group was large pieces of meat meals ($\bar{X}$±SD=4.010±0.087), while the lowest was fish meals (0.684). For the second group, the highest meal type was Turkish ravioli (0.332) and the lowest meal type was pasta ($\bar{X}$±SD=0.080±0.032). For the third group, the highest meal type was yogurt, pickles, etc. ($\bar{X}$±SD=0.314±0.127) and the lowest meal type was fruits ($\bar{X}$±SD=0.072±0.020). For the first group, the highest mean or median of the carbon footprint of a portion of meal in the winter season is small pieces of meat meals (median=3.988), while the lowest is legume meals with meat (median=0.643). For the second group, the highest meal type was Turkish ravioli (0.332) and the lowest meal type was flatbreads (0.052). For the third group, the highest meal type was yogurt, pickles, etc. ($\bar{X}$±SD=0.314±0.127), while the lowest meal types were fruits ($\bar{X}$±SD=0.029±0.041), compote, and pleasantries (0.029). There was no statistically significant difference between the seasons according to the means and medians of the carbon footprint of one portion of all meal types in the first group, second group, and third group ($p>0.05$).

Table 2. Mean ($\bar{X}$), standard deviation (SD), and lower upper values distribution of carbon footprint (CO_2 equivalent/kg) for each portion of meals according to groups

Carbon Footprint for Each Portion (CO_2 equivalent/kg)				
Meal Group	Meal Types	S	$\bar{X}$±SD	Lower-Upper
Group 1	Large Piece Meat Meals	4	4.047±0.067	3.949-4.098
	Small Piece Meat Meals	12	3.839±0.344	2.978-4.086
	Meatballs	13	2.855±0.256	2.634-3.418
	Chicken Meals	23	0.739±0.187	0.327-0.988
	Fish Meals	3	0.683±0.027	0.656-0.711
	Vegetable Meals with Meat	22	1.485±0.106	1.334-1.749
	Legume Meals with Meat	7	1.140±0.475	0.078-1.386
	Egg Meals	2	0.941±0.878	0.319-1.562
	Liver Meals	3	3.199±0.000	3.199-3.199
Group 2	Pastas	15	0.131±0.083	0.058-0.305
	Rice	17	0.272±0.419	0.072-1.455
	Soups	24	0.155±0.167	0.039-0.677
	Vegetable Meals with Olive Oil	6	0.266±0.188	0.115-0.605
	Legume Meals with Olive Oil	7	0.078±0.015	0.056-0.092
	Manti	4	0.332±0.000	0.332-0.332
	Pastries	5	0.179±0.100	0.036-0.287
	Flatbreads	3	0.814±1.329	0.041-2.349
Group 3	Salads	12	0.132±0.023	0.083-0.145
	Milk Desserts	12	0.209±0.109	0.092-0.381
	Pastry Desserts	16	0.158±0.118	0.048-0.436
	Compote and Pleasantries	2	0.034±0.008	0.029-0.039
	Fruits	9	0.052±0.032	0.058-0.320
	Others (Yoghurt, Pickles, etc.)	8	0.434±0.316	0.223-1.183

In Table 4, it is examined whether there is a difference between the meal groups according to the carbon footprint (CO_2 equivalent/kg) values of the meal types included in the study within each season. In the spring season, the carbon footprint level (median) of one portion of the meal types in the first meal group is 1,489, while the level in the second meal group is 0,159 and in the third meal group is 0.145. In the summer season, the carbon footprint level (median) of one portion of the meal types in the first meal group is 1.418, in the second meal group it is 0.114, and in the third meal group, it is 0.118. In the autumn season, the carbon footprint level (median) of one portion of the meal types in the first meal group was 1.426, while the level was 0.097 in the second meal group and 0.140 in the third meal group. In the winter season, the carbon footprint level (median) of one portion of the meal types served in the first meal group is 1.407, in the second meal group it is 0.092, and in the third meal group, it is 0.142. In the spring, summer, autumn, and winter seasons, the carbon footprint levels of the first group portion were significantly higher than the carbon footprint levels of the second group and third group portion ($p<0.001$).

Table 5 shows the water footprint values of 1 portion of the meals included in the study according to the groups in m^3/ton. The meal with the highest water footprint value of one portion is stick kebab for the first group (2500.804) and the meal with the lowest water footprint value is chickpea with chicken (119.323). For the second group, the highest meal was wedding rice (985.745) and the lowest meal was Turkish ravioli (56.431). For the third group, the highest meal was mixed compote (618.683) and the lowest meal was cacik (52.175).

Table 6 shows the mean ($\bar{X}$), standard deviation (SD), and lower and upper values of the water footprint of 1 portion of the meals included in the study according to the groups in m^3/ton. For the first group, the highest water footprint average of a portion of water footprint was for large meat meals (2447.275±29.554) and the lowest was for fish meals (230.435±0.000). For the second group, the highest meal type was legume meals with olive oil (425.194±10.051) and the lowest meal type was Turkish ravioli (56.431±0.000). For the third group, the highest meal type was compotes and pleasantries (361.958±363.065) and the lowest meal type was yogurt, pickles, and other meals (52.175±0.000).

Table 3. Mean ($\bar{X}$), standard deviation (SD), median and lower upper values of carbon footprint (CO_2 equivalent/kg) for each portion of meals according to groups and seasons.

Mea Group	Meal Types	Spring S	Spring $\bar{X}$±SD Median (Lower-Upper)	Summer S	Summer $\bar{X}$±SD Median (Lower-Upper)	Autumn S	Autumn $\bar{X}$±SD Median (Lower-Upper)	Winter S	Winter $\bar{X}$±SD Median (Lower-Upper)	p
Group 1	Large Piece Meat Meals	1	4.072	1	4.098	2	4.010±0.087	-	-	-
	Small Piece Meat Meals	4	3.762 (2.980-3.990)	2	4.057 (4.050-4.060)	4	3.989 (3.410-4.090)	2	3.988 (3.980-3.990)	0.225**
	Meatballs	2	3.080 (2.740-3.420)	3	2.789 (2.750-2.810)	2	2.818 (2.770-2.870)	6	2.722 (2.630-3.420)	0.313**
	Chicken Meals	6	0.818 (0.450-0.990)	5	0.827 (0.360-0.870)	4	0.829 (0.710-0.950)	8	0.716 (0.330-0.870)	0.665**
	Fish Meals	1	0.711	1	0.656	1	0.684	-	-	-
	Vegetable Meals with Meat	3	1.533±0.039	7	1.471±0.083	7	1.476±0.111	5	1.490±0.164	0.869*
	Legume Meals with Meat	2	1.365 (1.360-1.370)	1	1.386 (1.386-1.386)	2	1.288 (1.210-1.370)	2	0.643 (0.080-1.210)	0.228**
	Egg Meals	1	0.320	1	1.562	-	-	-	-	-
	Liver Meals	1	3.199	1	3.199	1	3.199	-	-	-
Group 2	Pastas	5	0.186±0.113	4	0.110±0.058	2	0.080±0.032	4	0.108±0.058	0.350*
	Rice	4	0.133 (0.070-0.180)	4	0.244 (0.070-1.450)	5	0.084 (0.070-0.140)	4	0.123 (0.070-1.280)	0.619**
	Soups	5	0.117 (0.040-0.250)	8	0.114 (0.060-0.680)	7	0.104 (0.060-0.670)	4	0.080 (0.060-0.100)	0.481**
	Vegetable Meals with Olive Oil	2	0.407 (0.210-0.600)	-	-	1	0.116	3	0.198 (0.110-0.350)	0.248***
	Legume Meals with Olive Oil	1	0.056	2	0.081 (0.070-0.090)	2	0.082 (0.070-0.090)	2	0.082 (0.070-0.090)	0.773**
	Manti	1	0.332	1	0.332	1	0.332	1	0.332	-
	Pastries	2	0.184 (0.120-0.240)	1	0.205 (0.205-0.205)	2	0.161 (0.040-0.290)	-	-	1.000***
	Flatbreads	1	2.349	1	0.041	-	-	1	0.052	-
Group 3	Salads	3	0.123±0.035	4	0.140±0.004	3	0.122±0.034	2	0.143±0.004	0.653*
	Milk Desserts	2	0.237±0.204	3	0.223±0.119	2	0.172±0.112	5	0.204±0.104	0.954*
	Pastry Desserts	6	0.202±0.104	3	0.068±0.029	3	0.211±0.200	4	0.122±0.092	0.342*
	Compote and Pleasantries	-	-	1	0.040	-	-	1	0.029	-
	Fruits	2	0.029±0.041	3	0.069±0.015	2	0.072±0.020	2	0.029±0.041	0.318*
	Others (Yoghurt, Pickles, etc.)	2	0.314±0.128	2	0.794±0.551	2	0.314±0.127	2	0.314±0.127	0.388*

*One-way analysis of variance, **Kruskal Wallis test, ***Mann-Whitney U test.

Table 0. Comparison of the median values of carbon footprint (CO_2 equivalent/kg) for each portion of the first, second, and third groups according to the seasons.

	Season	Group 1 S	Group 1 Median (Lower-Upper)	Group 2 S	Group 2 Median (Lower-Upper)	Group 3 S	Group 3 Median (Lower-Upper)	p
CO_2 Footprint	Spring	21	1.489^a (0.319-4.072)	21	0.159^b (0.039-2.349)	15	0.145^b (0.000-0.404)	<0.001*
	Summer	22	1.418^a (0.108-4.098)	21	0.114^b (0.041-1.455)	16	0.118^b (0.039-1.183)	<0.001*
	Autumn	23	1.426^a (0.245-4.086)	20	0.097^b (0.036-0.668)	12	0.140^b (0.054-0.436)	<0.001*
	Winter	23	1.407^a (0.078-3.994)	19	0.092^b (0.052-1.277)	16	0.142^b (0.000-0.404)	<0.001*

*Kruskal-Wallis test, a-b: There is no difference between groups with the same letter

Table 7 shows the mean ($\bar{X}$), standard deviation (SD), median, and lower upper values of the water footprint (m^3/ton) of one portion of the meals included in the study according to the groups and seasons. In the spring season, the highest average water footprint of one portion for the first group was large meat meals (2459.529) and the lowest was fish meals (230.435). For the second group, the highest meal type was flatbreads (792.428) and the lowest meal type was Turkish ravioli (56.431). For the third group, the highest meal type was milk desserts ($\bar{X}$±SD=326.149±18.736), while the lowest meal type was salads ($\bar{X}$±SD=131.303±6.288). In the summer season, the highest mean or median of the water footprint of one portion for the first group was small pieces of meat meals (median=2469.135) and the lowest was fish meals (230.435). For the second group, the highest meal type was rice ($\bar{X}$±SD=439.631±378.735) and the lowest meal type was Turkish ravioli (56.431). For the third group, the highest meal type was compotes and pleasantries (618.684), while the lowest meal type was yogurt, pickles, etc. (52.176). In the autumn season, the highest mean or median of the water footprint of a portion of water footprint for the first group was small pieces of meat meals (median=2470.705) and the lowest was fish meals (230.435). For the second group, the highest meal type was vegetable meals with olive oil (483.026), while the lowest meal type was Turkish ravioli (56.431). For the third group, the highest meal type was milk desserts ($\bar{X}$±SD=300.801±54.583), while the lowest meal type was yogurt, pickles, etc. (52.175). In the winter season, the highest mean or median of the water footprint of one portion of the first group was small pieces of meat meal (median=2469.135) and the lowest was legume meal with meat (median=583.598). For the second group, the highest meal type was legume meals with olive oil (median=423.850) and the lowest meal type was Turkish ravioli (56.431). For the third group, the highest meal type was milk desserts ($\bar{X}$±SD=303.633±33.485) and the lowest meal type was compotes and pleasantries (105.232). There was no statistically significant difference between the seasons according to the means and medians of the water footprint of one portion of all meal types in the first group, second group, and third group ($p>0.05$).

Table 5. Water footprint values for each portion of meals according to groups (m^3/ton)

Group 1		Group 2		Group 3	
Meal Name	m^3/ton	Meal Name	m^3/ton	Meal Name	m^3/ton
Stick Kebab	2500.804	Wedding Rice	985.745	Mixed Compote	618.683
Tas Kebab	2493.257	Imambayildi	887.710	Melon	481.000
Elbasan Tava	2466.800	Flatbread with Minced	792.428	Ashoura	339.397
Hungarian Goulash (Puree)	2459.529	Peas with Olive Oil	483.026	Keshkul	333.670
Shepherd Roast with Vegetables	2448.152	Kidney Beans with Olive Oil	433.253	Tulumba	329.385
Forest Kebab	2445.012	Dried Beans with Olive Oil	414.450	Kalburabasti	320.640
Boiled Meat	2403.243	Bulgur Rice with Chicken	401.945	Cocoa Pudding	312.901
Albanian Liver	2305.617	Ayran Soup	393.304	Pumpkin Dessert	303.500
Beef Emense Over Rice	2238.116	Trotter Soup	391.559	Milk Halva	298.865
Minced Meat Sauteed Over Rice	2137.400	Rice	343.525	Peanut Dream	287.199
Sauteed Meat Over Rice	2137.105	Cheese and Walnut Noodles	335.088	Kazandibi	279.395
Izmir Meatballs	2055.794	Oven Pasta	327.707	Şekerpare	265.483
Abant Kebab	1830.356	Leek with Olive Oil	324.556	Oven Rice Pudding	262.205
Farm Meatballs	1793.819	Fresh Beans with Olive Oil	292.267	Apple	192.400
Dalyan Meatballs (Puree)	1748.165	Noodles with Cheese	288.688	Watermelon	192.400
Izmir Meatballs	1706.668	Lentil Pastry	284.555	Mandarin	192.400
Terbiyeli Meatballs	1694.146	Celery with Olive Oil	271.810	Banana	192.400
Grilled Meatballs	1672.565	Puff Pastry with Chicken	266.449	Orange	192.400
Dried Beans with Meat	1095.127	Cheese Pastry	247.329	Peach	192.400
Celery with Meat	1056.837	Pasta with Cheese	244.503	Fresh Grape	192.400
Chickpeas with Meat	1048.453	Cauliflower with Olive Oil	216.370	Pear	184.400
Karnıyarık	1034.306	Bulgur Rice with Lentils	207.163	Yoghurt Dessert with Sesame	166.219
Egg with Minced Meat	1029.048	Lentil Soup	204.131	Yogurt Dessert	166.219
Patlıcan Oturtma	1012.270	Bulgur Rice with Chickpeas	200.637	Semolina Halva	158.064
Fresh Beans with Meat	956.686	Ezogelin Soup	190.834	Mixed Salad	136.910
Chicken Nuget (with Vegetable Garnish)	945.871	Tutmaç Soup	181.788	Shepherd Salad	135.981
Meat Fajita (Saffron Rice Garnish)	935.935	Bulgur Rice with Vermicelli	178.760	Kadayif	135.500
Sour Pumpkin with Meat	927.030	Flatbread with Cheese	170.650	Wire Kadayif	135.500
Okra with Meat	916.512	Pasta with Tomato	162.070	Carrot Cabbage Salad	132.495
Peas with Meat	910.454	Rice Soup	162.043	Spoon Salad	132.445
Potato with Meat	906.581	Yayla Soup	158.956	Seasonal Salad	124.505
Kabak Kalye	906.145	Bulgur Rice	158.867	Quince Compote	105.232
Cauliflower with Mince	896.414	Pasta with Sauce	158.082	Kemalpasha	89.100
Minced Spinach with Yoghurt	888.695	Meyhane Rice	157.770	Cacik (Tzatziki)	52.175
Sauced Chicken	778.883	Pasta with Yoghurt	150.537		
Creamy Chicken (with Pasta Garnish)	774.901	Vermicelli Soup	126.484		
Tavuk Dünyası	774.901	Wire Vermicelli Soup	126.484		
Chicken Fajita	770.010	Tomato Soup	123.877		
Boiled Chicken	738.787	Flatbread with Spinach	122.986		
Chicken Casserole	733.493	Gemici Soup	107.052		
Chicken Over Rice	716.460	Sawdust Pastry with Cheese	73.633		
Chicken Meatloaf	590.065	Manti	56.431		
Chicken Galantine (Puree)	589.034				
Chicken Bowl with Spinach	512.328				
Chicken Cauliflower with Bechamel Sauce	409.067				
Potato with Chicken	352.081				
Zucchini with Bechamel Sauce	346.915				
Roman Style Spinach	335.360				
Trout (with Potato Garnish)	230.435				
Chickpeas with Chicken	119.323				

In Table 8, it is examined whether there is a difference between the meal groups according to the water footprint (m^3/ton) values of the meal types included in the study within each season. In the spring season, the water footprint level (median) of one portion of the meal types in the first meal group was 1012.270, in the second meal group the level was 247.329, and in the third meal group, the level was 192.400. In the summer season, the water footprint level (median) of one portion of the meal types in the first meal group was 941.859, in the second meal group it was 181.788 and in the third meal group, it was 184.400. In the autumn season, the water footprint level (median) of one portion of the meal types in the first meal group was 1034.306, in the second meal group it was 202.384 and in the third meal group, it was 192.400. In the winter season, the water footprint level (median) of one portion of the meal groups in the first meal group was 916.512, in the second meal group the level was 216.370 and in the third meal group, the level was 192.400. In the spring, summer, autumn, and winter seasons, the water footprint levels of the first group one portion were significantly higher than the water footprint levels of the second group and third group one portions ($p<0.001$).

Table 6. Distribution of mean ($\bar{X}$), standard deviation (SD), and lower and upper values of water footprint (m^3/ton) for each portion of meals according to groups.

			Water footprint of 1 Portion (m^3/ton)	
Meal Group	Meal Types	S	$\bar{X}$±SD	Min-Max
Group 1	Large Piece Meat Meals	4	2447.275±29.554	2403.243-2466.800
	Small Piece Meat Meals	12	2371.883±205.310	1830.356-2500.804
	Meatballs	13	1825.884±167.693	1672.565-2137.400
	Chicken Meals	23	675.423±167.101	346.915-945.871
	Fish Meals	3	230.435±0.000	230.435-230.435
	Vegetable Meals with Meat	22	906.030±178.840	140.402-1056.837
	Legume Meals with Meat	7	928.807±357.639	119.323-1095.127
	Egg Meals	2	682.204±490.512	335.36-1029.048
	Liver Meals	3	2305.617±0.000	2305.617-2305.617
Group 2	Pastas	15	232.867±76.951	150.537-335.088
	Rice	17	364.040±306.855	157.770-985.745
	Soups	24	208.842±101.212	107.052-393.304
	Vegetable Meals with Olive Oil	6	412.623±249.499	216.370-887.710
	Legume Meals with Olive Oil	7	425.194±10.051	414.448-433.254
	Manti	4	56.431±0.000	56.431-56.431
	Pastries	5	223.859±85.392	73.633-284.555
	Flatbreads	3	362.021±373.504	122.986-792.428
Group 3	Salads	12	132.546±5.168	124.505-136.910
	Milk Desserts	12	310.378±31.721	262.205-339.398
	Pastry Desserts	16	210.144±92.336	89.100-329.385
	Compote and Pleasantries	2	361.958±363.065	105.232-618.684
	Fruits	9	221.095±91.649	184.400-481.000
	Others (Yoghurt, Pickles, etc.)	8	52.175±0.000	52.175-52.176

Table 7. Mean ($\bar{X}$), standard deviation (SD), median and lower upper values of water footprint (m^3/tonne) of 1 portion of meals according to groups and seasons.

		Spring		Summer		Autumn		Winter		p
Meal Group	Meal Types	S	$\bar{X}$±SD Median (Lower-Upper)	S	$\bar{X}$±SD Median (Lower-Upper)	S	$\bar{X}$±SD Median (Lower-Upper)	S	$\bar{X}$±SD Median (Lower-Upper)	
Group 1	Large Piece Meat Meals	1	2459.529	1	2466.800	2	2431.386 (2431.386-2431.386)	-	-	-
	Small Piece Meat Meals	4	2341.564(1830.356-493.257)	2	2469.135 (2445.012-2493.257)	4	2470.705 (2137.105-2500.804)	2	2469.135 (2445.012-2493.257)	0.631**
	Meatballs	2	1965.610 (1793.819-2137.400)	3	1748.165 (1706.668-1793.819)	2	1901.932 (1748.069-2055.794)	6	1727.417 (1672.565-2137.400)	0.433**
	Chicken Meals	6	727.624 (409.067-935.935)	5	733.493 (346.915-778.883)	4	756.844 (733.493-945.871)	8	653.263 (352.081-774.901)	0.348**
	Fish Meals	1	230.435	1	230.435	1	230.435	-	-	-
	Vegetable Meals with Meat	3	957.556 (888.695-1012.270)	7	910.454 (888.695-1012.270)	7	906.581 (140.402-1034.306)	5	916.512 (888.695-1056.837)	0.890**
	Legume Meals with Meat	2	1071.500(1047.873-1095.127)	1	1048.453	2	1071.5 (1047.873-1095.127)	2	583.598 (119.323-1047.873)	0.325**
	Egg Meals	1	335.360	1	1029.048	-	-	-	-	-
	Liver Meals	1	2305.617	1	2305.617	1	2305.617	-	-	-
Group 2	Pastas	5	233.903±78.441	4	234.137±87.004	2	247.290±124.166	4	223.091±80.318	0.990*
	Rice	4	423.825±382.687	4	439.631±378.735	5	217.790±72.821	4	411.477±392.675	0.695*
	Soups	5	181.788 (123.877-393.304)	8	160.500 (107.052-391.559)	7	190.834 (123.877-393.304)	4	197.483 (126.484-393.304)	0.572**
	Vegetable Meals with Olive Oil	2	308.412 (292.267-324.556)	-	-	1	483.026	3	271.810 (216.370-887.710)	0.800***
	Legume Meals with Olive Oil	1	433.253	2	423.851 (414.447-433.253)	2	423.852 (414.450-433.253)	2	423.850 (414.450-433.250)	0.893**
	Manti	1	56.431	1	56.431	1	56.431	1	56.431	-
	Pastries	2	265.942 (247.329-284.555)	1	247.330	2	170.041 (73.633-266.449)	-	-	0.667***
	Flatbreads	1	792.428	1	122.986	-	-	1	170.650	-
Group 3	Salads	3	131.303±6.288	4	132.461±5.642	3	135.129±2.328	2	130.708±8.772	0.811*
	Milk Desserts	2	326.149±18.736	3	317.488±33.113	2	300.801±54.583	5	303.633±33.485	0.837*
	Pastry Desserts	6	227.748±82.912	3	130.273±38.825	3	261.842±109.502	4	204.867±111.643	0.358*
	Compote and Pleasantries	-	-	1	618.684	-	-	1	105.232	-
	Fruits	4	192.400 (184.400-192.400)	5	192.400 (184.400-481.000)	6	192.400 (184.400-481.000)	4	192.400 (184.400-192.400)	0.844**
	Others (Yoghurt, Pickles, etc.)	-	-	1	52.176	1	52.175	-	-	-

*One-way analysis of variance, **Kruskal Wallis test, ***Mann-Whitney U test

Table 8. Comparison of median values of water footprint (m^3/ton) for each portion of the first, second, and third groups according to seasons

Season		Group 1		Group 2		Group 3		p
		S	Median (Lower-Upper)	S	Median (Lower-Upper)	S	Median (Lower-Upper)	
Water Footprint	Spring	21	1012.270^a (230.435-2493.257)	21	247.329^b (56.431-985.745)	15	192.400^b (124.505-339.397)	<0.001*
	Summer	22	941.859^a (230.435-2493.257)	21	181.788^b (56.431-985.745)	17	184.400^b (52.176-618.684)	<0.001*
	Autumn	23	1034.306^a (140.402-2500.804)	20	202.384^b (56.431-483.026)	15	192.400^b (52.175-481.000)	<0.001*
	Winter	23	916.512^a (119.323-2493.257)	19	216.370^b (56.431-985.745)	16	192.400^b (89.100-339.397)	<0.001*

*Kruskal-Wallis test, a-b: There is no difference between groups with the same letter.

DISCUSSION

In catering services, various activities cause environmental impacts at all stages from raw material procurement, acceptance, storage, food production, distribution, and service. Environmental sustainability in hospital catering services, which are usually carried out as service procurement, is increasingly recognized and researched [18-21]. This study was planned and conducted to examine the carbon and water footprints of menus used in hospital catering services. To the best of our knowledge, this is the first study conducted to determine the carbon and water footprints of menus used in hospital catering services. As a result of the study, the carbon footprint assessment of catering services and the meals on the menu were discussed.

With the increasing awareness of climate change, it is seen that the number of researchers and companies who want to calculate the carbon footprint of food products, determine their impact on global warming, and increase awareness by sharing this data with consumers is increasing and this trend is becoming popular [22]. The high proportion of discarded food waste produces negative environmental impacts that are fuelling climate change. The breakdown of food in landfills produces methane, a powerful GHG with a GWP 104 times higher than carbon dioxide [23]. In the study conducted by Madalı et al. (2021) vegetable dishes with meat, fish, and turkey, and legumes with meat and chicken dishes were found among the food types with high SG emission values. Accordingly, it was determined that the GHG emission of the food types containing animal products was higher than the other food types and the first group meals had higher GHG emission values than the other groups [24]. In a study conducted in the USA, GHG emissions associated with food waste were analyzed using the Life Cycle Assessments approach. The total emissions from the production, processing, packaging, distribution, retail sale, and disposal of food were found to be 112.9 million metric tons (MMT) CO_2 equivalent. Beef was identified as the largest source of loss-related emissions, accounting for 16.0 percent of loss-related emissions, despite accounting for 22.0 percent of food losses per kilogram [25]. In another study conducted in the Netherlands, the current Dutch dietary pattern and the GHG emissions of 4 different dietary patterns were evaluated. Consumption patterns consist of healthy dietary patterns with and without meat, and diets containing nutrients with lower environmental impacts. At the end of the study, it was revealed that eliminating meat products from the diet and/or consuming only foods with low GHG emissions would reduce the average GHG emission by 28.0-46.0%. However, it was also emphasized in the study that consumption patterns in which only foods with low GHG emissions are consumed may cause deficiency in terms of some nutrients [26]. Adequate and balanced menus in hospital catering services ensure reduced GHG emissions [27]. In the study, in parallel with the results of other studies, the first three food types with the highest carbon footprint were determined as large piece meat dishes, small piece meat dishes, and liver dishes. This is an expected result considering that the minimum amount of red meat used in these products is 50 g and the maximum amount is 150 g according to the standard recipes of the institution. There was no statistically significant difference between the seasons according to the means and medians of the carbon footprint of all meal types in the first group, second group, and third group ($p>0.05$). One of the reasons for this result is that the standard recipes of these meals applied in the institution do not show seasonal differences, although the products that are abundant and cheap in season are used in the recipes. Similar to other studies, the carbon footprint levels of the first group were significantly higher than the carbon footprint levels of the second group and the third group in the spring, summer, autumn, and winter seasons ($p<0.001$). The use of meat or the addition of eggs in almost all of the first group meals was considered as one of the factors increasing the carbon footprint of the first group meals.

The commercial sector, which includes health care, public institutions, and restaurants, reportedly consumes 900 million gallons of water per day, ranging from 1.5 gallons per meal for school lunches to 2.0 gallons per meal for all-day restaurants or cafeterias [28]. In addition to the total water used in the production stages of catering services, the total water footprint of the meals varies depending on the type of raw material used in the meals. When calculating the total water footprint, attention is paid to indirect water use in addition to the water used in production and consumption. In other words, both the direct water use and the indirect water use of a product along the production line should also be calculated [29]. In this study, while evaluating the water footprint of meals, grey, green, and blue water footprints were evaluated as total water footprints, not separately. In a study conducted in India, 5 different diets were evaluated in terms of water footprint. The diets were categorized as rice with less variety; rice and fruit; wheat and legumes; wheat, rice and oils; and rice and meat. While the green water footprint of rice-based diets was higher, the blue water footprint of the wheat-based diet was found to be higher. In addition, it was determined that the environmental impact of the rice and meat diet model was higher than the other models [30]. Mekonnen and Hoekstra (2012) reported that the average water footprint per calorie for beef was 20 times higher than for cereals and starchy crops; the water footprint per gram of protein for milk, eggs, and chicken meat was 1.5 times higher than for legumes [15]. In a study conducted in Turkey, it was calculated that the food group that increased the water footprint the most was small piece meat dishes, similar to GHG emissions. Vegetable dishes with meat (11.9%) were shown to increase the water footprint level significantly in the summer season, while large meat dishes (11.4%) and meatballs (11.3%) were shown to affect water footprint levels at similar rates, although the frequency of serving them was lower compared to vegetable dishes with meat [31]. In a study conducted in thirteen cities in Mediterranean countries where the water source is from outside the city, the water footprint of the current diet was determined to be between 3277 L/g and 5789 L/g per capita. These values were shown to be about thirty times higher than local water use. In addition, in this study, 3 different diet types were created, and in the calculations; it was determined that the Mediterranean diet could reduce the water footprint by 19.0% to 43.0%, the pesco vegetarian diet by 28.0% to 52.0% and the vegetarian diet by 30.0% to 53.0% [32]. Uçar and Çapar emphasized that Turkey is not a water-rich country and that it is a good practice to export products that do not provide added value to the country but have a high share in water consumption [33]. In the study, the first three meal types with the highest total water footprint in parallel with the carbon footprint were calculated as large piece and small piece meat dishes and liver dishes; the first group water footprint levels were found to be significantly higher than the second group and third group water footprint levels in all seasons ($p<0.001$). It is known that the water footprint increases as well as the carbon footprint due to the increase in the amount of meat used in meat-containing dishes. Considering that the largest part of the water footprint of consumption in Turkey is caused by agriculture with 89.0%, this is an expected result and consistent with the previously mentioned studies.

CONCLUSIONS

This study was carried out on 62 meals in selected months representing each season and 248 meals in total, produced in the kitchen of a research and application hospital in Isparta. The carbon and water footprint of the meals were calculated and evaluated. In the spring, summer, autumn, and winter seasons, the carbon footprint levels of the first group were found to be significantly higher than the carbon footprint levels of the second and third pots ($p<0.001$). Again, in all seasons, the first-group water footprint levels were significantly higher than the second and third-group water footprint levels ($p<0.001$).

Hospital catering services, which serve primarily patients, staff, and patient visitors within the collective nutrition systems, have an important place both for the protection of health and support for medical nutrition treatment and their effects on the sustainable nutrition chain. Hospital catering services, which primarily serve patients, staff, and patient visitors within collective nutrition systems, have an important place both in terms of health protection and support for medical nutrition therapy and in terms of their effects on the sustainable nutrition chain. Health professionals play a key role in the implementation of sustainable food systems. For this reason, it is important to plan training activities to increase the awareness and knowledge levels of dietitians, physicians, nurses, and other auxiliary health personnel, especially food services nutrition dietitians.

AUTHOR CONTRIBUTIONS

HB, SB contributed to idea conception, design, data collection, data analysis, data interpretation. HB, SB contributed to manuscript drafting and manuscript revision. HB, SB supervised the whole study and revised the final manuscript. All authors approved the final manuscript.

DATA AVAILABILITY

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

ETHICAL APPROVALS

This study was performed in accordance with the Declaration of Helsinki. Approval for the research was obtained from Gazi University Ethics Commission with the research code 2020-168 on 21.02.2020.

CONFLICT of INTERESTS

All authors declare that they have no competing interests.

REFERENCES

[1] Hartwell, H.J., Edwards, J.S., Beavis, J. (2007). Plate versus bulk trolley food service in a hospital: Comparison of patients' satisfaction. *Nutrition*, *23*(3), 211-218.

[2] Jang, Y.J., Kim, W. G., Bonn, M.A. (2011). Generation Y consumers' selection attributes and behavioral intentions concerning green restaurants. *International Journal of Hospitality Management*, *30*(4), 803-811.

[3] Allen, T., Prosperi, P. (2016). Modeling sustainable food systems. *Environmental Management*, *57*(5), 956-975.

[4] Kolk, A., Van Tulder, R. (2010). International business, corporate social responsibility and sustainable development. *International Business Review*, *19*(2), 119-125.

[5] Nijdam, D., Rood, T., Westhoek, H. (2012). The price of protein: Review of land use and carbon footprints from life cycle assessments of animal food products and their substitutes. *Food Policy*, *37*(6), 760-770.

[6] Batat, W. (2020). Pillars of sustainable food experiences in the luxury gastronomy sector: A qualitative exploration of Michelin-starred chefs' motivations. *Journal of Retailing and Consumer Services*, *57*, 102255.

[7] Pandey, D., Agrawal, M., Pandey, J.S. (2011). Carbon footprint: Current methods of estimation. *Environmental Monitoring and Assessment*, *178*(1), 135-160.

[8] Akay, G. (2020). Sustainability in public nutrition and environment. *Selcuk Medical Journal*, *36*(3), 282-287.

[9] Hoekstra, A.Y., Hung, P.Q. (2023). Virtual water trade. In *Proceedings of the International Expert Meeting on Virtual Water Trade* (pp. 1-244).

[10] Egan, M. (2011). The water footprint assessment manual. Setting the global standard. *Social and Environmental Accountability Journal*, *31*(2), 181-192.

[11] Hoekstra, A.Y., Chapagain, A. K., Aldaya, M.M., Mekonnen, M.M. (2009). *Water footprint manual*. Water Footprint Network.

[12] Guillaumie, L., Boiral, O., Baghdadli, A., Mercille, G. (2020). Integrating sustainable nutrition into health-related institutions: A systematic review of the literature. *Canadian Journal of Public Health*, *111*(6), 845-861.

[13] Mekonnen, M.M., Hoekstra, A.Y. (2011). National water footprint accounts: The green, blue and grey water footprint of production and consumption. In M. M. Mekonnen & A.Y. Hoekstra (Eds.), *Value of water research report series* (pp. 25-26). UNESCO-IHE Institute for Water Education.

[14] Mekonnen, M.M., Hoekstra, A.Y. (2011). The green, blue and grey water footprint of crops and derived crop products. *Hydrology and Earth System Sciences*, *15*(5), 1577-1600.

[15] Mekonnen, M.M., Hoekstra, A.Y.A. (2012). Global assessment of the water footprint of farm animal products. *Ecosystems*, *15*(3), 401-415.

[16] Heller, M.C., Keoleian, G.A. (2015). Greenhouse gas emission estimates of US dietary choices and food loss. *Journal of Industrial Ecology*, *19*(3), 391-401.

[17] Moskwa, E., Higgins-Desbiolles, F., Gifford, S. (2015). Sustainability through food and conversation: The role of an entrepreneurial restaurateur in fostering engagement with sustainable development

issues. *Journal of Sustainable Tourism*, *23*(1), 126-145.

[18] Lopez, V., Teufel, J., Gensch, C.O. (2019). How a transformation towards sustainable community catering can succeed. *Sustainability*, *12*(1), 101.

[19] Harmon, A.H., Gerald, B.L. (2007). Position of the American Dietetic Association: Food and nutrition professionals can implement practices to conserve natural resources and support ecological sustainability. *Journal of the American Dietetic Association*, *107*(6), 1033-1043.

[20] Carvalho, L.R. (2018). Management of organic solid waste in the collective feeding sector: Review. *Higiene Alimentar*, *32*, 27-32.

[21] Carino, S., Collins, J., Malekpour, S., Porter, J. (2021). Environmentally sustainable hospital foodservices: Drawing on staff perspectives to guide change. *Sustainable Production and Consumption*, *5*, 152-161.

[22] Röös, E., Sundberg, C., Hansson, P.A. (2014). Carbon footprint of food products. In *Assessment of Carbon Footprint in Different Industrial Sectors* (pp. 85–112). Springer.

[23] Thiel, C.L., Park, S., Musicus, A.A., Agins, J., Gan, J., Held, J., Bragg, M.A. (2021). Waste generation and carbon emissions of a hospital kitchen in the US: Potential for waste diversion and carbon reductions. *PLOS ONE*, *16*(3), e0247616.

[24] Baldwin, C., Wilberforce, N., Kapur, A. (2011). Restaurant and food service life cycle assessment and development of a sustainability standard. *The International Journal of Life Cycle Assessment*, *16*(1), 40-49.

[25] Venkat, K. (2011). The climate change and economic impacts of food waste in the United States. *International Journal on Food System Dynamics*, *2*(4), 431-446.

[26] van de Kamp, M. E., van Dooren, C., Hollander, A., Geurts, M., Brink, E.J., van Rossum, C., Temme, E.H. (2018). Healthy diets with reduced environmental impact? The greenhouse gas emissions of various diets adhering to the Dutch food-based dietary guidelines. *Food Research International*, *104*, 14-24.

[27] Carino, S., Porter, J., Malekpour, S., Collins, J. (2020). Environmental sustainability of hospital foodservices across the food supply chain: A systematic review. *Journal of the Academy of Nutrition and Dietetics*, *120*(5), 825-873.

[28] Rose, D., Heller, M. C., Roberto, C. A. (2019). Position of the Society for Nutrition Education and Behavior: the importance of including environmental sustainability in dietary guidance. *Journal of Nutrition Education and Behavior*, *51*(1), 3-15.

[29] Vanham, D., Del Pozo, S., Pekcan, A. G., Keinan-Boker, L., Trichopoulou, A., Gawlik, B. M. (2016). Water consumption related to different diets in Mediterranean cities. *Science of the Total Environment*, *573*, 96-105.

[30] Madalı, B., Karabulut, Ö. F., Öztürk, E. E., Parlak, L., Erdinç, A. Ş., Dikmen, D. (2021). Assessment of greenhouse gas emissions and water footprint of the menus served in food service systems according to seasons. *Beslenme ve Diyet Dergisi*, *49*(1), 5-14.

[31] Takacs, B., Borrion, A. (2020). The use of life cycle-based approaches in the food service sector to improve sustainability: A systematic review. *Sustainability*, *12*(9), 3504.

[32] Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., Zaks, D. P. (2011). Solutions for a cultivated planet. *Nature*, *478*(7369), 337–342.

[33] Uçar, B., Çapar, G. (2024). Assessment of agricultural virtual water export of Türkiye. *Akademik Gıda*, (Yeşil Dönüşüm Özel Sayısı), 26-32.