

Research Article

Implementation of Healthy and Sustainable Dishes in a Multicultural University Cafeteria: A Pilot Study Using Sensory Science

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Abstract

Food choices are closely linked to individual cultural factors. In university students of different nationalities, finding a balance so that their choices are healthy and sustainable is a challenge that can be addressed by working on consumer perception. The aim of this study proposes to evaluate the acceptance of dishes prepared based on the Mediterranean diet, in the student's cafeteria of a university with students from all over Latin America. An on-place evaluation panel was carried out in the main cafeteria of the university with 71 students from 12 Latin-American countries for three sustainable lunch menus. In each menu evaluation, a six-compartment tray containing the source of carbohydrates, animal protein, plant-based protein, and vegetables was provided. The attributes evaluated for each food group were: appearance, color, odor, flavor, and overall liking, using a 9-point hedonic scale. Moreover, the overall liking, flavor intensity, and the general quality of the menu were evaluated. For overall liking and flavor intensity, a 9-point scale was used, and for quality a 10-point scale. In general, the dishes received fair acceptance, and participants stated they liked them; however, animal protein had a higher acceptance over carbohydrates and vegetables. Most participants would like these foods to be served in place of fast food in the student cafeteria.

Keywords: Food quality; Sensory evaluation; Sustainable menus; Students' cafeteria

Abbreviations

MD: Mediterranean Diet

Introduction

Food choices are determined by personal and environmental factors, which can change throughout life. The sense of taste plays an important role in food choice because flavor perception involves a complex interplay between aroma, flavor, and food texture, resulting in a hedonic experience that accumulates over time [1]. Therefore, the sensory properties of food directly influence its acceptability. According to Tepper and colleagues, accepting or rejecting a food leads the individuals to select their diet, and indirectly the nutritional value [2].

The taste intensity of prepared foods is proven to be linked to the amount and type of nutrients they possess [3,4]. The intensities for sweetness and saltiness reflect the presence of nutrients, mainly mono and disaccharides, and sodium [5]. However, these relationships between tastes and types of nutrients are more difficult to explain in complex foods or dishes, where there is taste suppression [6]. Therefore, to evaluate a specific dish, it is appropriate to use sensory science, to understand how sensory properties influence the consumer's acceptance and behavior [7,8].

Worldwide, there is a transition in people's diets, including the adaptation of eating patterns between cultures, the emergence of

new dishes, and a change in eating behaviors [9]. Dishes based on the Mediterranean Diet (MD) have had notoriety in recent times. This diet has aroused interest since the study related to dietary fat and nutrition, conducted by Keys & Grande [10]. The MD kitchen bases are vegetables, fruits, cereals, nuts and legumes, and moderate consumption of seafood and dairy products. Also, olive oil as a source of fat is essential, while the consumption of meat and alcohol, except wine (mostly red), is moderate [11].

Most of researches on MD refer to the health benefits of its implementation, in terms of a lower incidence of chronic diseases [12-14]. Other studies commented on the adherence that it can have in different countries with other food cultures. Middleton and colleagues found that participants from the East of England perceived the adherence of the MD as a positive experience regardless of the difficulty in adapting to it [15]. In another study, a relationship was found between adherence to MD with a lower incidence of cardiovascular disease in the United Kingdom [16]. However, Sotos-Pietro and colleagues commented that there are few studies on the adherence of MD in non-Mediterranean countries and racial/ethnically-different in the U.S [17]. On the other hand, the adherence of the MD in young university students is determined by different factors such as the influence of their home country, the activities they carry out, as well as extrinsic motivators [18]. Besides, the reality of university students living on-campus can vary significantly regarding their eating habits.

Considering the complexity and factors involved in university students' food choices, this study seeks to evaluate the acceptance of dishes prepared based on the MD, in the student's cafeteria of a university with students from Latin America. Sensory science was used to understand the acceptance and quality of these dishes and evaluate the acceptability of a new menu based on MD in the student's cafeteria.

Materials and Methods

This study was carried out in the student's main cafeteria at a Honduran university, whose undergraduate program boasts a student population from 29 countries, mainly from the American continent. The University has food services in the student cafeteria which provide the main meal plan for all students, also they has supermarkets, cafes, and restaurants that offer additional meals to students.

The whole university population is around 1500 students, where each year have in general 300 students. All the students reside on campus from January until December for four years, this campus is located 30 km aside from the capital city, Tegucigalpa. The university consist of four main careers in the field of agriculture: agronomy, agribusiness, environmental sciences and food science and technology.

In order to the ethic issue, the sensory evaluation was performed at the student's cafeteria, in a room especially prepared for this purpose, following the methodology described by the International Organization for Standardization, ISO 8589:2012 [19], and good sensory practices [20]. Data collection took place from 27 to 29 May 2020. This study was reviewed and approved by the Zamorano University Graduate Research Directorate.

Panelists

A total of 71 untrained panelists participated in this study and complete a consent form, all of them were undergraduate students. Due to the COVID-19 crisis only the 30% (n=91) of first year students stay in the campus dorms when the panel was conducted, and the participants who decide to participate represent the 78% of the students in campus. All the biosafety protocols and social distancing were followed during the data collection. These panelists were generally aware of healthy and sustainable eating due to a previous talk they attended led by the Human Nutrition Laboratory team from the university. More than half of the panelists were males (55%; n=39) and hailed from 12 Latin American countries. El Salvador accounted for nearly one-third (31%), followed by Ecuador (20%), Honduras (13%), and Bolivia (10%). Colombia, Guatemala, and Panama each had the same amount (4%) of panelists. The least represented countries were Belize, Haiti, Paraguay, Peru, and the Dominican Republic, with a representation of 3%, per country.

Sample preparation

Three lunch menus were evaluated, prepared with the principles of the MD. Each of the dishes contained a cooking paste (sofrito) of tomato, onion, coriander, garlic, and olive oil. Table 1 presents the menu offered in each of the sessions.

Consumption Behavior

Before conducting the acceptance test, using the plate-waste method, the panelists answered a questionnaire with three multiple-

choice questions about consumer behaviors to characterize the panelist group.

Sensory analysis, acceptance test

The 71 panelists performed an acceptance test for each lunch menu. In each menu evaluation, a six-compartment tray containing carbohydrates, animal protein, plant-based protein, and vegetables was provided. Plant-based protein was only evaluated in menu 2. Samples for each food group were served according to the appropriate portions [21]. The attributes evaluated for each food group were: (1) appearance, (2) color, (3) odor, (4) flavor, and (5) overall liking. The panelists tested the samples in the following order: carbohydrates, animal protein, plant-based protein, and vegetables. For the evaluation, a virtual ballot on participants' smartphones was used. The link for the ballot was sent to their email one day prior to the evaluation of each menu. All attributes were evaluated using a 9-point hedonic scale ranging from 1 = "Extremely Dislike," 6 = "Slightly Like" to 9 = "Extremely Like," for the answers that best reflected their judgment.

Subsequently, the overall liking, flavor intensity, and the general quality of the menu were evaluated. For overall liking, a 9-point hedonic scale was used (ranging from 1 = "Extremely Dislike" to 9 = "Extremely Like"). In addition, a 9-point scale for intensity was used (ranging from 1 = "Very Weak" to 9 = "Extremely Strong"). Finally, for quality, a 10-point scale was used (ranging 1 = "Poor" to 10 = "Excellent") for the answers that best reflected their judgment.

After completing the acceptance test, the panelists took a survey of three questions about the consumption of these foods in their home country, the dishes' expectations, and the feasibility of replacing fast food with the proposed menus in order to seek a way to stop the highest consumption of this type of food that is very common in universities all around the world.

Statistical analysis

The Statistical Analysis Software SAS[®] version 9.4. was used. A descriptive analysis of frequencies and percentages was conducted for the survey, which was administrated at the end of the acceptance test. A randomized complete block design was performed on each food group in the different menus, using Duncan's multiple range test to evaluate each of the attributes (appearance, color, odor, flavor, and overall liking). Also, a correlation analysis of general acceptance based on appearance, color, odor, and taste was developed. Duncan's multiple range test was conducted for quality, overall liking, and flavor intensity.

Results

Sensory analysis, acceptance test

Menu 1: The three food groups' appearance and color did not evince significant differences and were evaluated between a scale of "Like Moderately" to "Like Very Much." On the other hand, regarding odor, flavor, and overall liking, there was a significant difference (Figure 1). For the aspect of odor, the means of proteins (7.3) and carbohydrates (7.35) were statistically higher than vegetables (6.79). Also, the proteins, for flavor (7.49) and overall liking (7.42) were evaluated between "Like Moderately" and "Like Very Much," being statistically higher than the means of carbohydrates (6.18 for flavor and 6.80 for overall liking) and vegetables (6.23 for flavor and 6.47 for

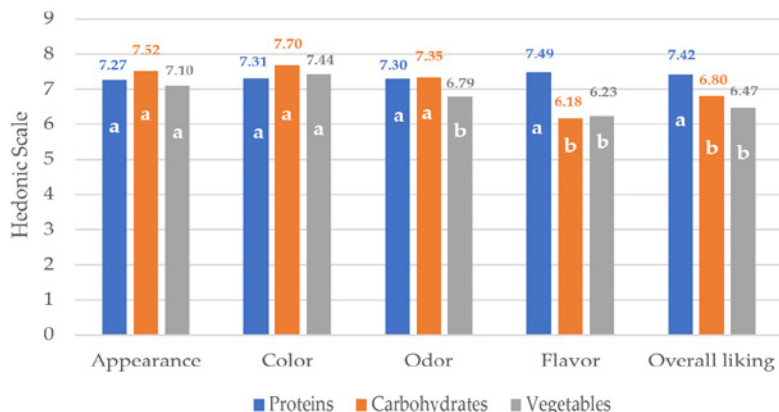


Figure 1: Mean separation Menu 1. Lowercase letters a-b show mean separation. The probabilities were 0.20 (appearance), 0.15 (color), 0.05 (odor), <.0001 (flavor), and 0.0009 (overall liking).

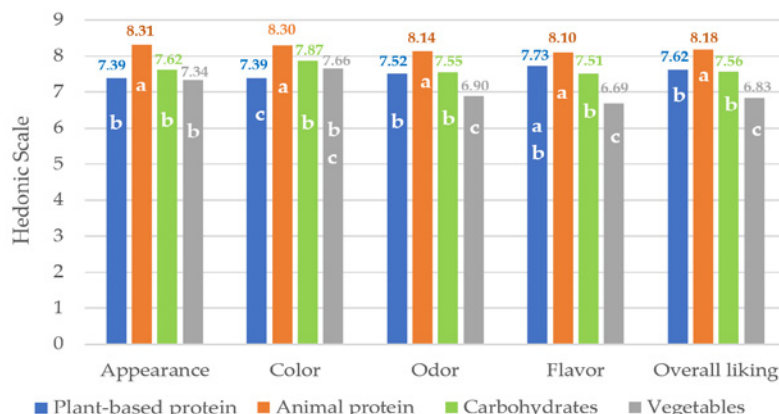


Figure 2: Mean separation Menu 2. Lowercase letters a-c shows mean separation. The probabilities were <.0001 for all attributes.

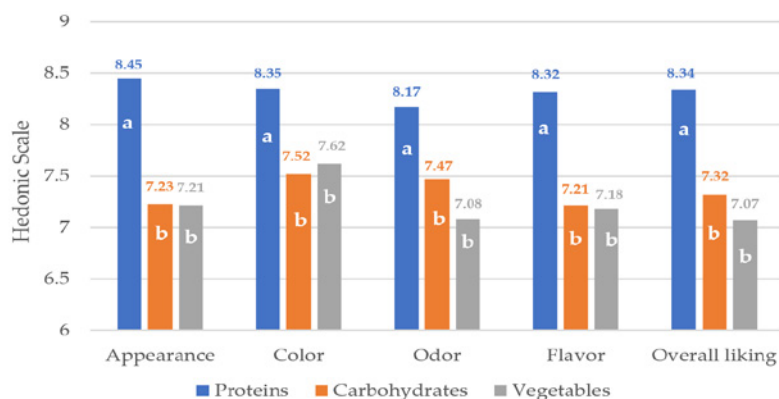


Figure 3: Mean separation Menu 3. Lowercase letters a-c shows mean separation. The probabilities were <.0001 for all attributes.

overall liking), which equaled each other and were evaluated between “Like Slightly” and “Like Moderately”.

Menu 2: Among the three food groups in the study (animal protein, plant-based protein, carbohydrates, and vegetables), a

significant difference was found in the evaluated attributes (Figure 2). For appearance, animal protein presented the highest mean with a score of 8.31, while the means for plant-based protein, carbohydrates, and vegetables were 7.39, 7.62, and 7.34, respectively, so statistically equal. Regarding color, animal protein (8.30) had the highest mean,

followed by carbohydrates (7.87), and vegetables (7.66), so these last two stood statistically equal. On the other hand, for flavor, the animal protein (8.1) and plant-based protein (7.73) had the highest means and were statistically equal. The flavor was followed by carbohydrates (7.51), which was statistically equal to plant-based (6.69) and had the lowest mean. Finally, the odor and overall liking presented the same mean separation across the different food groups, where animal protein had the highest mean (8.14 for odor and 8.18 for overall liking), followed by plant-based protein (7.53 for odor and 7.62 for overall liking), and carbohydrates (7.55 for odor and 7.56 overall liking); and vegetables rated with the lowest scores (6.90 for odor and 6.83 for overall liking).

Menu 3: Among the three food groups evaluated, a significant difference was found in all their attributes (Figure 3). The aspects of appearance, color, flavor, and overall liking presented the same mean separation among the food groups, where protein obtained the highest mean (8.45 appearance, 8.35 color, 8.32 flavor, 8.34 overall liking). On the other hand, carbohydrates and vegetables obtained the lowest mean scores for these attributes and were statistically equals.

Correlation between attributes and food groups for overall liking

For menu 1, the protein obtained a moderate positive correlation in all the attributes regarding overall liking. On the other hand, the carbohydrates with appearance and flavor presented a moderate correlation, while color and odor had a weak positive correlation. Only flavor obtained a strong positive correlation for vegetables, while the other attributes presented a moderate positive correlation (Table 2).

For menu 2, the plant-based and animal proteins presented a moderate positive correlation towards overall liking. Appearance, odor, and flavor presented a strong positive correlation, while color obtained a moderate positive correlation (Table 2). Only flavor presented a strong positive correlation for vegetables, and the other attributes evinced a moderate positive correlation for overall liking.

For menu 3, the protein obtained a strong positive correlation in flavor, while the other attributes a moderate positive one. On the other hand, the carbohydrates presented a strong positive correlation for odor and flavor and a moderate positive correlation for appearance and color. Vegetables obtained a strong positive correlation for flavor and appearance and a moderate positive correlation for color and odor.

Menu rating

Three standards (intensity, overall liking, and quality) were performed for each of the menus, and all three were statistically

Table 1: Description of the menus according to each food group.

	Menu 1	Menu 2	Menu 3
Carbohydrates	Baked potato	White rice	Whole wheat pasta cooked with <i>sofrito</i> , broccoli, carrots, and zucchini
Animal Protein	Stewed chicken with <i>sofrito</i>	Grilled pork fajitas	Grilled chicken breast
Plant-based protein	NA	Stewed lentils with <i>sofrito</i>	NA
Vegetables	Grilled vegetables (broccoli, zucchini, and carrots) with olive oil and oregano	Green salad (lettuce, cucumber, olives, and onion)	Tomato and black olives
Beverage	Passion fruit juice/water	Blackberry juice/ water	Tamarind juice/ water

NA: Not applicable, because no plant-based protein was served on that menu.

Table 2: Attributes Correlation for overall liking in the different food groups.

Overall Liking	Appearance	Color	Odor	Flavor
Menu 1				
Animal Protein	0.65	0.6	0.59	0.77
	<.0001	<.0001	<.0001	<.0001
Carbohydrates	0.54	0.46	0.48	0.74
	<.0001	<.0001	<.0001	<.0001
Vegetables	0.68	0.71	0.65	0.87
	<.0001	<.0001	<.0001	<.0001
Menu 2				
Plant-based Protein	0.65	0.57	0.66	0.74
	<.0001	<.0001	<.0001	<.0001
Animal Protein	0.65	0.56	0.57	0.7
	<.0001	<.0001	<.0001	<.0001
Carbohydrates	0.81	0.73	0.82	0.92
	<.0001	<.0001	<.0001	<.0001
Vegetables	0.62	0.54	0.66	0.85
	<.0001	<.0001	<.0001	<.0001
Menu 3				
Animal Protein	0.8	0.7	0.64	0.84
	<.0001	<.0001	<.0001	<.0001
Carbohydrates	0.77	0.71	0.81	0.9
	<.0001	<.0001	<.0001	<.0001
Vegetables	0.84	0.71	0.73	0.93
	<.0001	<.0001	<.0001	<.0001

significant (Table 3). Among the three standards, quality obtained the highest score of the three menus with 7.75, 8.96, and 8.89 for menu 1, menu 2 and menu 3, respectively; followed by overall liking and intensity (Table 3).

Survey after acceptance test

After each menu’s acceptance test, most of the panelists (70.42 to 83.10%) stated that the consumption thereof was common in their home countries and that the dishes met most of their expectations (77.46 to 95.77%). However, the panelists would only be willing to opt for menu 2 (74.65%) and menu 3 (70.42%) instead of the available fast food whenever some food festivities were being held (Table 4).

Discussion

The immediate attributes that the consumer considers as quality indicators in their food are appearance and color, especially in

Table 3: Means separation from menu standards.

	Menu 1	Menu 2	Menu 3
	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.
Intensity	5.31±1.80 c	6.17±1.61 c	5.94±1.40 c
Overall liking	6.52±1.33 b	7.70±1.05 b	7.75±1.04 b
Quality	7.75±1.57 a	8.96±1.05 a	8.89±1.70 a
% C.V.	16.27	11.54	12.33
Probability	<0.0001	<0.0001	<0.0001

Lowercase words a-c shows mean separation between columns (menus).

meats, fruits, and vegetables [22], which can be evidenced through the quality standard of the menus in this study. Color can influence food perception and open new ideas for making new dishes and their acceptance by consumers [23]. Considering that the sofrito used has a considerable portion of tomato, whose lycopene gives the dish a red color, it can be stated that it influenced the dishes' quality. Hoppu and colleagues found that participants, in sampling differently-colored solutions, most frequently rated (37%) the red solution as the most pleasant [24], since the hue and intensity of color in the foods can have an impact on the consumers' expectations [25].

However, the complexity of sofrito, due to its herbs, onion, and its garlic content, could considerably influence the dish's odor. Sanahuja and colleagues mentioned that sofrito's cooking process causes the compounds of this food matrix to concentrate, such as its bioactive compounds, but this process also promotes their volatilization [26]. The use of sofrito in the three food menus was also considered for its beneficial health effects [27,28], and its use in the MD, despite not being consumed in all Latin American countries.

Olive oil is another ingredient in the menus that could influence the dishes' overall liking, which is generally produced and consumed in the Mediterranean countries, mainly in Spain and Italy [29]. In Latin America, the consumption of olive oil has not been studied, and the acceptance of its sensory characteristics in the Latin American population is not known. However, the International Olive Council provided methods for an organoleptic assessment of extra-virgin olive oil, which are direct or retronasal aromatic olfactory sensation (artichoke, almond, chamomile, citrus fruit, eucalyptus, etc.), gustatory sensation (bitter and sweet), qualitative retronasal sensation (retronasal persistence), and tactile or kinesthetic sensations (fluidity and pungency) [30]. Among them, the attributes that are less accepted

by consumers are pungency and bitterness [31], even though these characteristics can contain a greater quantity of phenolic compounds and positive health consequences [32].

Having an overview of these two ingredients used to make these dishes, which are part of the MD, an explanation of the grades attributed to each of the participants' menus can be analyzed.

Menu 1

Menu 1 consisted of a dish similar to what is consumed within the home countries of the participants. The Latin American population consume dishes based on chicken, a homemade tomato sauce, and a side dish of vegetables in a great variety of specific recipes from each country [33-35]. Therefore, it can be stated that it is a dish with which participants are familiar. According to Yang & Lee, the sensory evaluation of known foods, or those to which participants are already familiar, directly influences their acceptance [36]. However, of the three dishes evaluated, according to each food group, this dish presented the lowest overall liking mean. In this dish, specifically, there are two main variants: the animal protein was cooked with sofrito and the vegetables with olive oil. The mean of flavor between animal protein and vegetables of menu 1 was lower when compared to the other menus. The study conducted by Sanahuja and colleagues presented six different sofritos, which contained tomato, onion, garlic, olive oil, and some had thyme and rosemary [26]. One of Sanahuja and colleagues' examples was similar to the one used in this study, and the Latin American population does not consume some of these ingredients [26].

Menu 2

As for menu 2, a plant-based protein source was provided; lentils cooked with sofrito was one of this dish's variants. Legumes are widely consumed in Latin America, and their consumption is close to the recommended daily intake [37]. Vegetables were the other variant of this dish, where the green salad included olives. In Latin American region, some South American countries produce this fruit [38]; however, they are not a product of popular consumption at the home countries of these study's participants. Despite these findings, both variants were in lower proportions than the variants in menu 1.

Menu 3

This menu presented variants with the side dish of pasta, which added sofrito, and the black olives added to the vegetables; however,

Table 4: Frequencies of the survey after sensory acceptance test.

	Menu 1		Menu 2		Menu 3	
	n	%	n	%	n	%
Is it usual to consume this type of food in your home country?						
Yes	54	76.06%	59	83.10%	50	70.42%
No	17	23.94%	12	16.90%	21	29.58%
When you tried this dish, did it meet the expectations that you envisioned when you saw it?						
Yes	55	77.46%	68	95.77%	63	88.73%
No	16	22.54%	3	4.23%	8	11.27%
Would you like this dish to be incorporated into the students' cafeteria, especially when there are meals for special festivities instead of fast food?						
Yes	28	39.44%	53	74.65%	50	70.42%
No	43	60.56%	18	25.35%	21	29.58%

no adverse effect was observed. In menu 3, the animal protein obtained a significant mean among all the attributes evaluated. In addition, we compare the animal protein between the different menus, higher means for all attributes are found. It should be noted that the protein was grilled, so the use of ingredients was limited, and there was no factor that could influence the appearance, odor, and flavor that, considered as non-limitational for evaluation purposes, compared to menu 1. The visual appearance of meat plays an important role in the perception of meat quality, and color can be a crucial attribute in predicting sensory quality [39,40]. This was noticeable in all the means of the evaluated attributes of this dish's animal protein. The meat's flavor is complex and dependent on heat treatment, causing many chemical reactions (lipid degradation and Maillard reaction) of lipid compounds and water-soluble components, forming volatile compounds [41].

In the three menus, neophobia could influence the acceptance of some food groups and also the desire to try new foods and, consequently, the desire to adopt new foods in their diet [42]. Rodriguez-Tadeo and colleagues found that where there is a higher level of neophobia, the overall liking is lower for chicken and lentils, salads, fruit, and stews [43]. Therefore, it is necessary to integrate this information to assure an improvement in the consumption of healthy foods. Ortiz and colleagues suggested that the combination of textures, flavors, odors, and colors should be employed through culinary methods and techniques that improve the presentation of the menu and which profit from the organoleptic properties of foods [44]. In a study conducted by Contreras and colleagues, say that the way of presenting a product can contribute to reject or accept the food [45]. This is an important result for designing menus that simulate the desire to consume food.

Menu standard

When evaluating healthy and sustainable menus in multicultural environments, such as this study does, it should be considered that the menus offered in the institutional food service have a varied gastronomy adapted to the region [46]. This is important since there should be a balance between quality, intensity, and overall liking. In addition, it is key that the consumer appraises the qualities of food, presentation, composition, purity, treatment, and preservation, that make the food palatable to them [47]. Food acceptability by human beings does not follow a unidirectional line, and presents a variable structure, not only between different individuals, but even in the same individual when in different environmental situations [48].

In a study on the satisfaction of university students towards the institutional food service, Cáceres and colleagues found that the satisfaction aspects that obtained the lowest scores were: the variety of the menu, portion size, sensory quality, and temperature of the food served [46]. While, in a study of the perception of school food programs in Colombia, the best results in satisfaction involved sensory components [49]. This is slightly consistent with our findings, where the quality of the menu scored higher than the overall liking and intensity. Besides, the expectations generated when observing the dish were met by most (more than 75%) of this study's panelists.

It is also important to know panelists' perceptions regarding possible substitutions of these healthy dishes instead of junk food, particularly for special festivities and events, where menus 2 and 3

would be preferred by more than 70% of the students. Cáceres and colleagues found that students considered that the products that should be offered in the foodservice menu are, 22.71% mini-menu, 68.06% self-combining salads, 71.34% fruits, 24.28% vegetarian menu, and 24.18% Lacto-Ovo vegetarian menu [46]. Therefore, implementing healthy and sustainable menus generates the institutions' efforts to improve the institution's foodservice.

Menus should be planned according to consumers preferences, with relevance over variety, quality, and taste, as well as the environment [50]. Knowing the dishes with lower acceptance allows for the proposal of changes in the menus, replacing them with others of presumably greater acceptance. Also, knowing the acceptance of diets is one of the ways to introduce modifications that improve the quality of the service offered, preventing complications derived from incorrect nutrition [51].

The sensory attributes of a dish are complex due to the various physical and chemical interactions that can be generated when being prepared and cooked. Likewise, external factors to the untrained panelists, such as their culture, can influence their sensory perception of dishes. Using ingredients other than those that untrained panelists are familiar with can have bring about a slight rejection of the dish in general.

Conclusion

This study showed that despite the fact that some of the ingredients used in the preparation of dishes of the Mediterranean Diet are not commonly consumed in the panelists' home countries, the dishes prepared in the university's food service are very similar to those that are consumed at home. The sensory science was key to understand panelists acceptance of these dishes since it demonstrated that participants expectations of the dishes were met, the quality of the three dishes offered based on the Mediterranean Diet was well evaluated, and that participants are willing to change fast food, when the student's cafeteria prepare it, for two of the three menus presented.

Also, these findings can lead to an adherence to a healthy and sustainable diet if implemented in the student's cafeteria. Their implementation could contribute to improve eating habits, introducing these healthy dishes to students with the added purpose of preventing obesity and other related diseases as well as, to achieve sustainable patterns. The willingness shown by the students towards these menus contributes to the internal agricultural sustainability of the institution and its surroundings. It would also reduce waste and increase the self-sufficiency of the university in its agricultural production chain.

It is important to highlight that universities have a responsibility to provide optimal and quality food services and should be focused on meeting the nutritional needs of students in a healthy and sustainable way.⁵² The gradual use of the ingredients within the dishes provided is recommended so that their acceptance is gradual, achieving the expected acceptance levels, and considering sensory evaluation as a key part in this process. This study also showed that the sensory science can understand participants willingness to adopt healthy habits, such as the consumption of healthy and sustainable diets.

Author Contributions

J.P.E. and A.H.S. conceived and designed the study; J.P.E.

performed data analysis; and J.P.E., J.C.A.G., A.H.S. and S.K.E. wrote the paper. All the authors provided a critical review of the manuscript. All authors have read and agreed to the published version of the manuscript.

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