



## Food portion adequacy and its carbon footprint: Case study from a traditional Portuguese restaurant

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### ABSTRACT

The study of the relationship between excessive food portions, nutritional and environmental impact can demonstrate to consumers the need to rethink food choices.

The aim of this study was to analyse the restaurant menu composition in terms of: portions, nutritional adequacy and the carbon footprint (CFP).

In general, the restaurant menu exceeded energy, protein, lipid, and salt requirements. The menu with the most CFP was the one with 3 types of meat and chorizo and the menu with the low CFP was the menu consisting of a vegetable's starter and a main course with adequate portions.

Pursuant to market data, the percentage of Portuguese people eating out at least once a week was 23%, while at a global scale 50% of the population eats out, at least once a week (Stanton, 2016). Regarding the type of meal, the Portuguese preferred dining out (68%), which is in line with the European average (Stanton, 2016).

Out of the home meals are generally considered less healthy than homemade ones (Pinto and Ávila, 2015), because they tend to have higher content of energy, lipids, salt, and sugars providing lower intake of micronutrients (Berkowitz et al., 2016; Dunford et al., 2010; Goffe et al., 2017; Urban et al., 2013). Eating out seems to be associated with increased body mass index (Segui net et al., 2016), weight gain (Bezerra et al., 2012) and a lower intake of vegetables and fruits (Naska et al., 2015). The main reason for the higher energy content of out of the home meals it's due to the provision of excessively high food portions (Ledikwe et al., 2005). Furthermore, the lack of consumer knowledge about food portions contributes to the same issue (Ledikwe et al., 2005). Besides the relevance of the cooperation between food industry, restaurants, and food marketing, it is also determinant that consumers understand and accept the importance of suitable portions for a better health condition (Ledikwe et al., 2005). The readjustment of excessive high food portions would also be an important contribution to the reduction of food waste (Berkowitz et al., 2016; Dhir et al., 2020).

Beyond the nutritional importance, the food intake has also a meaningful environmental impact, largely contributing to the greenhouse effect (Llanaj et al., 2018). Food systems contribute with 19–29%

of greenhouse gas (GHG) emission, it's responsible for more the 70% of water use and 80% of deforestation caused by man (Vermeulen et al., 2012). Carbon dioxide (CO<sub>2</sub>) emissions have frequently been applied to quantify the environmental impact of food production and consumption (FAO, 2022).

The aim of the present study was to analyse the menus from a private traditional Portuguese restaurant from a hotel in Alentejo, in terms of food portions adequacy and nutritional composition based on estimated energy requirements (EER). It was also aimed to analyse their carbon footprint (CFP) based on CO<sub>2</sub> gas emissions.

Over eight days, data was collected (edible raw weight, in grams) of all the ingredients from the seven menus available at the restaurant. Nutritionally balanced portions were estimated based on the EER medium value for the general population of 2200 kcal (Rodrigues et al., 2006) and considering EFSA dietary reference values for nutrients (EFSA, 2017). For each menu, energy, macronutrients, and salt values were calculated considering the Portuguese Food Composition Table content (INSA, 2019). To calculate the menu carbon footprint the calculator *TUCO Greenhouse Gas* (TUCO) was used (TUCO, 2021).

Portion adequacy of each menu was determined by the ratio of served portion and balanced portion, therefore the menus with adequacy near 1 were the more suitable (Table 1).

In general, the average of menu portion adequacy of this restaurant was  $0.78 \pm 0.10$ . The most suitable menu presented an adequacy of 0.93, since the portion of each ingredient was nutritionally balanced,

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**Table 1**  
Portion adequacy of each menu.

Menus	Main Ingredients	Portion adequacy
1	Egg, fish, chorizo, bread, vegetables	0,80
2	Egg, fish, chorizo, bread, potato, vegetables	0,86
3	Chorizo, ham, egg, meat (3 varieties), chickpeas, potato, bread, vegetables	0,62
4	Fish, egg, bread, potato, vegetables	0,93
5	Pork meat, chorizo, bread, potato, vegetables	0,69
6	Fish, bread, vegetables	0,75
7	Pork meat, rice, vegetables	0,80
<b>Mean</b>		0,78
<b>Standard deviation</b>		0,10
<b>Minimum</b>		0,62
<b>Maximum</b>		0,93

except salt portion that was excessive. The least balanced menu has 0.62 of adequacy, corresponding to greater portions of ingredient source of animal source of protein, lipids (e.g. red meat, Portuguese chorizo) and salt.

Overall, this restaurant menus exceed energy, protein, lipids, and salt needs (Table 2). On average, lipids contribute with the highest percentage of the total energy content (TEC). Otherwise, the TEC percentage of carbohydrates was lower than the nutrition recommendations.

The menu with the highest CO<sub>2</sub> emission was the one composed with 3 different types of meat (pork, beef, and lamb) and Portuguese chorizo (Table 3). Conversely, the menu with the greater sustainability index was the menu constituted by a vegetable's starter (asparagus) and a main course (fish, egg and potato) with adequate portions.

Based on the collected data, was verified that the menu with the higher energy content are the ones that present inadequate portions. It has been described that eating in a social setting, with a greater variety of appetizing food, combined with the consumption of alcoholic beverages can lead to higher energy intake (Ledikwe et al., 2005).

Reducing food portions is not always the best solution, because in addition to the size of food portions it is necessary to consider the high energy density of the same portions. (Ledikwe et al., 2005).

One strategy is to reduce the food energy density of menu without affecting the palatability and the price of the meal, for example, by combining fat reduction with the addition of vegetables. Additionally, to nutritional benefits, customers would have a satiated increase (Ledikwe et al., 2005). For example, in Stubenitsky et al. study, the fat and energy of a fish meal were substantially reduced. No customer dissatisfaction was verified, the meal still corresponded to their expectations and is likely that customers will choose that meal again (Stubenitsky et al., 2000). Fast-food restaurants that presented an alternative method to

**Table 2**  
Comparison between nutritional value and TEC % with the nutritionally balanced value.

	Energy	Protein	Lipids	Carbohydrates	Salt
<b>Nutritionally balanced mean</b>	770Kcal	24,1 g	19,3 g	125,2 g	1,75 g
<b>Standard deviation</b>	374kcal	17,1	22,7	27,5	1,4
<b>Menus mean</b>	1514 Kcal	65,1 g	79,0 g	135,3 g	6,2 g
<b>Balanced TEC %</b>	–	10–15%	15–30%	55–75%	–
<b>Menus TEC %</b>	–	17%	47%	36%	–
<b>Balanced maximum</b>	770 Kcal	28,9 g	25,7 g	144,4 g	1,75 g
<b>Menu's maximum</b>	2004 Kcal	91,8 g	104,4 g	173,3 g	9,3 g
<b>Balanced minimum</b>	770 Kcal	19,3	12,8	105,9	1,75 g
<b>Menu's minimum</b>	758 Kcal	37,3 g	31,2 g	81,5 g	5 g

**Table 3**  
CO<sub>2</sub> emissions (kg/person) of each menu.

Menus	CO <sub>2</sub> emission (Kg/person) <sup>a</sup>
<b>Menu 1</b>	3,04 ± 0,18
<b>Menu 2</b>	2,73 ± 0,15
<b>Menu 3</b>	5,19 ± 0,31
<b>Menu 4</b>	1,56 ± 0,17
<b>Menu 5</b>	3,37 ± 0,25
<b>Menu 6</b>	2,17 ± 0,14
<b>Menu 7</b>	3,94 ± 0,34
<b>Mean Menus ± dp</b>	3,14 ± 1,10

<sup>a</sup> Sum of the CO<sub>2</sub> emission of each ingredient and standard deviation.

reduce the fat absorption of fry potatoes led to a significant reduction of energy and fat intake of each client (Morley-John et al., 2002).

In our study, restaurant's menus had, in average, energy density about 744 Kcal above EER. Some clients might need higher energy intake and higher portions, but considering excessive energy identified on the menus and the high obesity prevalence, from the region and Portugal (Lopes C. et al., 2017), we can consider that is excessive for the majority off the clients. Furthermore, it was noted that all the menus had a high percentage of lipids and were rich in salt. In general, the menus had a low amount of fruits and vegetables. This menu scenario is compatible with food pattern that contributes to excessive weight. Consuming meals outside the home is positively associated with energy intake (Orfanos et al., 2007) and consumers who frequently eat away from home are more likely to be obese (Kim D. and Ahn B, 2020).

The menus with the lowest protein foods portion adequacy (menu 3, 5 and 7), with high portion of animal protein sources, were also the menus with the highest environmental impact (more CO<sub>2</sub> emissions). Meat, fish, eggs, and dairy products have a greater influence on the environment, while cereals, legumes, vegetables, and fruits have a lower environmental impact (Masset et al., 2014). On the other hand, menus 1, 2, 4 and 6 presented lower values of CO<sub>2</sub> emission, since they contain components of cereals and vegetables, and more adequate amounts of protein foods. A plant-based diet (vegetables, fruits, legumes, seeds, nuts, whole grains), with lower intake of animal products (especially red meat) and high energy density, is at the same time a healthier food pattern with less environmental impact (Nelson et al., 2016; Pimentel and Pimentel 2003). Foods with a highly environmental impact tend to have lower nutritional quality (Masset et al., 2014). It was verified that the menu with the highest carbon footprint was the menu with the lowest nutritional adequacy and that, in turn, has the lowest adequacy in terms of food portions. In contrast, the menu with the greatest nutritional and portion adequacy is also the one that contributes with less GHG emissions. Pradhan et al. found that very high-calorie diets had higher GHG emissions, while low-calorie diets had the lowest gas emissions (Pradhan et al., 2013). Portugal is a Mediterranean country where the territorial diet described and defended is the Mediterranean diet, also considered a plant-based food pattern (Hachem F. et al., 2019). However, over the years there has been a westernization of the eating habits of the Portuguese, moving away from this dietary pattern (Lopes et al., 2017). Besides being considered one of the most balanced and appropriate food patterns for disease prevention and treatment, it is also considered an environmentally friendly food pattern with a reduced ecological footprint (Burlingame B. et Dernini S., 2022).

It is of great importance to intervene in Portuguese restaurants menus and make them health-promoting spaces and Mediterranean diet spaces, since there is a considerable percentage (23%) of Portuguese who eat away from home and have high energy density menus, rich in lipids and salt that can increase the risk of developing certain diseases.

By reducing, on average, the food portions of the 6 menus with inappropriate portions (24.2% on dessert, 15% on salt, 9,3% of olive oil portion and 19.5% animal component) and simultaneously increasing the portion of vegetables (26.3%) was obtained a reduction of 2.59 kg of

CO<sub>2</sub> emissions per person, and an average of 0.37 kg of CO<sub>2</sub> per person, per menu. In addition, with these changes nutritional improvements were also obtained. An average of 13,7% energy reduction in all menus was achieved; menus had an average decrease of 15,1% of protein, 19,0% of lipids and 8% of carbohydrates. Salt content was also reduced in 6.5%. Policies that aim to improve the nutritional quality of food away from home should be considered.

It is relevant to consider the reformulation of restaurant menus and meals, considering: 1) the way they are described and presented to the client, valuing the vegetable component of the menu (vegetables, cereals, legumes) in detriment of the animal component, as suggested by Viegas C. et Rocha A., 2020.2) reduce food portions and provide adequate information about meals so that people can make informed and healthy choices; 3) improve skills levels of employees; 4) create facilities for leftovers; and other suggestions presented by (Dhir and Taiwar, 2020). All these initiatives in restaurants can lead to a reduction in average daily energy consumption, can reduce the environmental impact, by carbon footprint as by reduction in food waste.

In the presented study, the food portions and carbon footprint from restaurant menus were inadequate. Considering the methodology and findings, this study provides an integrated and supported approach that can be carried out to restaurant menus with the vision to improve their nutritional content, considering its relation to health, and its impact on the environment (carbon footprint and food waste reduction). These results open an interesting and promising path for the rethink restaurant menus.

#### Authors contributions

VC and EB define the methodology. EB collected data. VC and EB analyse the data and wrote the manuscript.

#### Implications for gastronomy document

Nowadays, gastronomy can't be separated from nutrition implications, health, and sustainability. Still a lack of multidisciplinary work between these areas to contribute to health and well-being of the population. The population has a low literacy about these sciences and how they can impact their health. We consider very important to intervene in Portuguese traditional restaurants menus and make them health-promoting spaces. Policies that aim to improve the nutritional quality of food away from home should be considered. There's a need to rethink, and to reformulate menus and meals offer, by reducing food portions and providing adequate meal information, valuing the vegetable component of the menu in detriment of the animal component to enable people to make informed and healthy choices. It is also important to improve skills levels of employees. An intervention in the adequacy of the food portion served in restaurants can lead to a reduction in the average daily energy intake and can reduce the environmental impact.

#### Declaration of competing interest

The authors declare no conflicts of interest.

#### Data availability

The authors do not have permission to share data.

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