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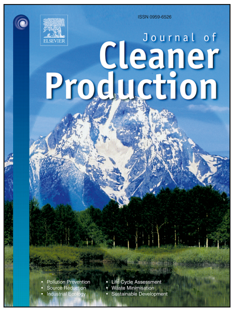

Nutritional and environmental co-benefits of shifting to "Planetary Health" Spanish tapas

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Author contributions

LBB wrote the main manuscript, PFP and AB were involved in the methodology, and all authors (AB, MR, EL, RA and PFP) reviewed the manuscript.

Nutritional and environmental co-benefits of shifting to "Planetary Health" Spanish tapas

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Highlights:

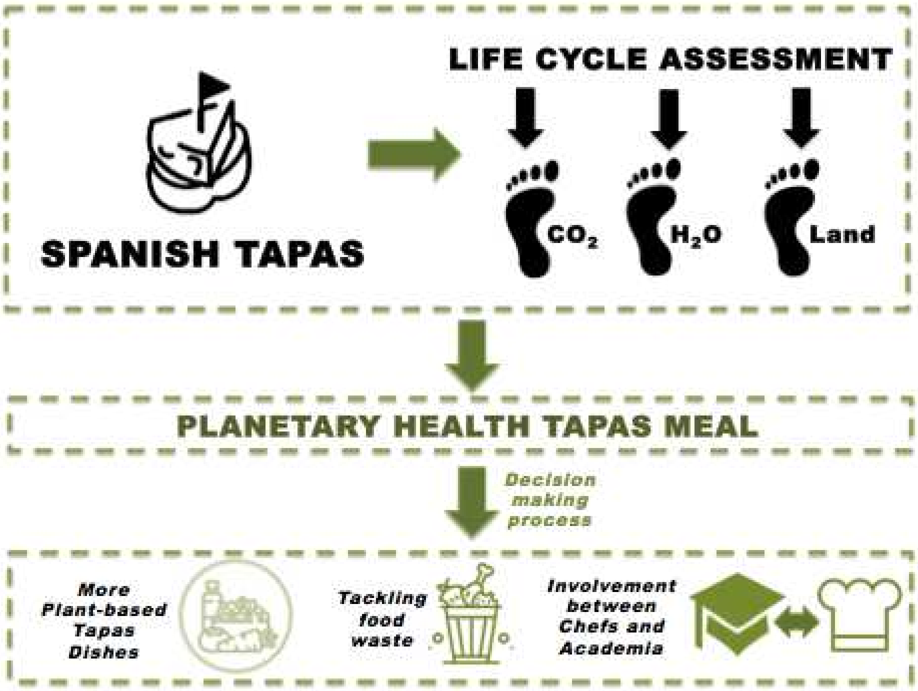
- An energy- and nutrient-based FU is used to assess the LCA of tapas meals
- Meals can only be environmentally compared if they have the same nutritional function
- Primary production and the restaurant stages contribute the most to GWP.
- Large environmental benefits when shifting to a more plant-based tapas meal
- Reducing food losses and waste can bring large environmental benefits

Abstract

While strong focus has been recently given to the environmental burdens of diets, more research is needed at the daily eating patterns, specifically, at the meal level. In this regard, this study attempts to enlarge this knowledge by evaluating the environmental performance of meals eaten away from home. In particular, this paper focuses on the case of shared dishes, known as tapas, eaten in a Spanish restaurant. To do so, the life cycle assessments (LCA) of 15 tapas meals are performed, and a functional unit based on the caloric energy intake and the nutritional quality of the meals is applied. This novelty, at the meal level, allows the integration of both environmental and the nutritional aspects, and, therefore, the comparison between meals differing in energy and nutrient content. Additionally, to better assess and compare the performance of the meals, this study estimates the benchmarks for the three evaluated environmental impacts - Global Warming Potential (GWP), Blue Water Footprint (BWF) and Land Use (LU) – based on the Planetary Health Diet. The results suggest that shifting towards a planetary health tapas meal, a more plant-based one, can significantly reduce GWP, BWF and

LU. The restaurant stage, followed by the primary production, largely contributes to GWP, and food losses and waste (FLW) plays an important role, contributing significantly to all three impacts. Strategies towards energy efficiency at the restaurant, innovation in the menus, and reducing FLW are required, as well as further engagement between the HORECA sector and the academia to work in line towards sustainable eating patterns.

Keywords: food away from home, life cycle assessment, meal, nutrition, sustainable food


LIFE CYCLE ASSESSMENT
SPANISH TAPAS
CO_2
H_2O
Land
PLANETARY HEALTH TAPAS MEAL
Decision making process
More Plant-based Tapas Dishes
Tackling food waste
Involvement between Chefs and Academia

Words: 4946

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1. Introduction

Recently, a lot of attention has been given to the environmental impact of dietary patterns, especially to climate change. In this regard, the last IPCC report (IPCC, 2019) , in addition to the main stream research findings (Batlle-Bayer et al., 2019a; Song et al., 2019; Springmann et al., 2018), suggests the need of changing current dietary patterns towards more plant-based ones, in order to mitigate global warming.

Most studies, when evaluating these environmental benefits of diet shifting, follow the Life Cycle Assessment (LCA) methodology (Hallström et al., 2015), mainly focusing on changes in the diet as a whole. Few investigate this issue at meal level, and even less study out of home eating patterns. The latter type of LCA studies mainly focus on catering (Fusi et al., 2016; Mistretta et al., 2019; Saxe et al., 2019; L. Sturtewagen et al., 2016), and just one article is applied to restaurants (Calderón et al., 2017).

In addition to the environmental aspect, the nutritional quality is a crucial aspect to consider in food LCAs (Heller et al., 2013). Most meal-based LCA studies (i.e, Calderón et al., 2017; and Schmidt Rivera et al., 2014) compare the same dish or meal being prepared in different ways, such as home-, ready- or industrially-made. Hence, they do not integrate any nutritional assessment, assuming the compared meals have the same nutritional value. The same happens in the cases studied by Jungbluth et al.(2016) and García-Herrero et al. (2019), who only evaluate the environmental impact of an average meal served in a canteen.

When comparing different meals, several methodological approaches are applied by different authors. Schmidt Rivera and Azapagic (2019) compared chilled ready-made meals. They did not consider the nutritional value, and used a mass-based functional unit (FU; 360g) as a basis of comparison between meals. Sturtewagen et al.(2016) also used a mass-based FU, but added the nutritional quality of the meals within their assessment. They highlighted the difficulty of integrating both environmental and nutritional aspects within a single result. Virtanen et al. (2011) and Saarinen et al. (2012) applied the so-called lunch dish model approach to integrate the nutritional aspect within their environmental assessments. This method consists in configuring meals according to a certain amount of ingredients that ensure the nutritional recommendations. For instance, Virtanen et al. (2011) compared 30 lunch meals for 13-15-year- old young students, whose composition was based on vegetables (50%), starch (25%) and protein-based products (25%), with an energy intake of 740 kcal . In spite of the more integrated approach of this method, it does not allow the comparison among meals with different nutritional profiles. For example, Saarinen et al.(2012) could not compare the lunch plate model dishes with the actual school lunches, since the last ones did not provide the nutritional recommendations, in terms of calories and nutrients.

To overcome this deficiency, first, the current study aims to integrate both environmental and nutritional aspects in LCA of meals, by adapting to the meal level the diet-based FU proposed by Batlle-Bayer et al. (2019b). This will allow comparing the environmental impacts of meals that differ in energy intake and nutritional value. Three environmental impacts are analyzed, Global Warming Potential (GWP), Blue Water Footprint (BWF), and Land Use (LU), as well as the amount of food loss and waste (FLW), as an additional indicator.

Second, this study attempts to increase the LCA knowledge at the restaurant level. In Spain, food away from home (FAFH) has been growing in the last decades. Nowadays, Spanish citizens go out for lunch or dinner quite regularly, about 2-3 times a week, being tapas the most popular type (FACYRE et al., 2018). Tapas are defined as "small portions of food that are served together with a drink" (RAE, 2019), and commonly shared with friends or family. Therefore, it is a combination of eating and socializing patterns that makes tapas a crucial event within the Spanish culture. Hence, this study considers tapas as the most representative case study of FAFH within the Spanish context. Ultimately, this study aims to set a nutritional and environmental benchmark for meals. To do so, an optimal meal has been designed, based on the recent published study on the Planetary Health diets (Willett et al., 2019).

2. Methods

2.1. Goal and scope

The two goals of this study were, first, to assess and compare the environmental performance of meals away from home (MAFH) that differ in energy and nutritional values, and, second, to set a nutritional and environmental benchmark for meals. To do so, tapas eaten in a Spanish restaurant were considered as a case study. Since eating tapas means sharing several dishes, this study considered two levels of analysis: the dish and the meal. In accordance to FEHR (2016), a tapas meal was assumed to be composed of 4 dishes and bread, shared by two people, and a beer per person.

To determine the most popular tapas, a typical tapas restaurant in Barcelona was visited. In line with the outcomes of the study of Spanish Federation of Hospitality and Restoration (FEHR, 2016), the following dishes were qualitatively considered as the most common ones: spicy potatoes (POT), croquettes (CRO), mussels (MUS), Spanish potato salad (SAL), octopus (OCT) and Spanish omelet (OME). By combining these 6 dishes in a 4-dishes meal, a total of 15 meals (**Table *1*:**) were considered to be part of the study.

Table 1:
Tapas meals built as a combination of 4 tapas dishes.

Meal	Dish 1	Dish 2	Dish 3	Dish 4
1	CRO	SAL	MUS	OCT
2	CRO	OME	MUS	OCT
3	CRO	POT	MUS	OCT
4	SAL	OME	MUS	OCT
5	SAL	OME	MUS	CRO
6	POT	OME	MUS	OCT
7	CRO	SAL	OME	OCT
8	POT	SAL	MUS	OCT
9	POT	CRO	MUS	SAL
10	POT	CRO	MUS	OME
11	POT	CRO	OCT	SAL
12	POT	CRO	OCT	OME
13	POT	SAL	MUS	OME
14	POT	SAL	OCT	OME
15	POT	CRO	SAL	OME

2.2. Functional Units

At the dish level, the functional unit (FU) was defined as a certain part of the served tapas dish to be eaten for one person at a restaurant. The three proposed functional units were: 100g, 100 kcal of edible food, and the portion size.

At the meal level, the FU was defined as the consumption of a tapas meal that provides the sufficient caloric energy intake and nutritional quality for one meal. To apply this FU, the energy- and nutrient- (E&N-)based FU, proposed by Batlle-Bayer et al. (2019b) at the diet level, was adapted to the meal level.

To do so, first, the environmental impact of a meal (EI_{meal}) for a person was defined as the sum of the environmental impacts of all the portions eaten per tapas dish ($EI_{dish1-4}$), bread (EI_{bread}) and beer (EI_{beer}) [Eq.1]. Second, the EI_{meal} was corrected ("c-" in the equations) by the energy and nutritional scores [Eq.2].

The Energy Score (ES; Eq.3) is the ratio between the energy content of the tapas meal (E_{meal}) and the one of the recommended meal (E_{rec}). The E_{meal} is the sum of the energy content of all the components of the meals. Caloric energy values were retrieved from the Spanish food composition database (BEDCA, 2018). The E_{rec} was assumed to be 820.6 kcal, a third of the daily average energy intake for an adult between 30 and 45 years old (EFSA, 2017), the most common age range that eats tapas in a restaurant (FEHR, 2016). Hence, it was assumed that one third of daily calories are taken in one meal and no snacks are consumed in between meals. In order to penalize energy overconsumption, when E_{meal} was higher than E_{rec}, the ES was inversed [Eq.4].

$$EI_{meal} = EI_{dish1-4} + EI_{bread} + EI_{beer} \qquad [Eq.1]$$

$$\mathrm{c} - \mathrm{EI}_{meal} = \frac{\mathrm{EI}_{meal}}{\alpha * \mathrm{NS}} \qquad [Eq.2]$$

$$\alpha = \mathrm{ES} = \frac{E_{meal}}{E_{rec}} \qquad if\ E_{meal} < E_{rec} \qquad [Eq.3]$$

$$\alpha = \frac{1}{ES} \qquad if\ E_{meal} \geq E_{rec} \qquad [Eq.4]$$

$$\mathrm{NS} = \frac{NRM9.3_{meal}}{NRM9.3_{rec}} \qquad [Eq.5]$$

The nutritional score (NS; Eq.5) was defined as the ratio between the nutritional quality of a tapas meal and the recommended one, which was based on the planetary health diet recently published by the EAT-Lancet Commission (Willett et al., 2019). To assess their nutritional quality, the Nutritional Rich Meal index was defined, NRM9.3 [Eq.6]. It is based on the NRF9.3 (Drewnowski, 2009), and it follows the same rationale by Van Kernebeek et al. (2014) when defining the Nutritional Rich Diet index (NRD9.3).

NRM9.3 is based on 9 nutrients to encourage their consumption (protein, fibre, Vit A, C and Ca, Fe, Mg and K), and 3 nutrients to limit (saturated fat, added sugar and salt). TNR9 [Eq.7] is the sum of percentages of recommended meal values (RV_i) for nutrients to encourage, and TNL3 [Eq.8] is the sum of percentages of Maximum Values (MV_j) per meal for nutrients to limit. As proposed by Drewnowski (2009), the intakes of encouraging nutrients were capped - they were set to their RV - when their values were higher than their RV. This allowed to not credit overconsumption.

Table 2 shows the RV_i and MV_j.

$$NRM9.3 = TNR9 - TNL3 \qquad [Eq.6]$$

$$TNR9 = \sum_{i=1}^{i=9} \frac{nutrient[dish1-4; bread; beer]_{i,capped}}{RV_i} * 100 \qquad [Eq.7]$$

$$TNL3 = \sum_{j=1}^{j=3} \frac{nutrient[dish1-4; bread; beer]_{j,capped}}{MV_j} * 100 \qquad [Eq.8]$$

Table 2:
Recommended (RV_i) and maximum values (MV_j) for an adult (≥ 18 years) of nutrients per meal. Based on the daily values from EFSA (2017).

Nutrients	**Units**	**RV_i**
Protein	g $meal^{-1}$	17.6
Fibre	g $meal^{-1}$	8.3
K	mg $meal^{-1}$	1166.7
Ca	mg $meal^{-1}$	316.7
Fe	mg $meal^{-1}$	3.7
Mg	mg $meal^{-1}$	116.7
Vit A	µg $meal^{-1}$	233.3
Vit C	mg $meal^{-1}$	35.8
Vit E	mg $meal^{-1}$	4.0
Nutrients	**Units**	**MV_j**
STA	g $meal^{-1}$	8.0
Added sugar	g $meal^{-1}$	30.0
Na	mg $meal^{-1}$	800.0

2.3. System Boundary

The system boundary of this study is built from cradle to grave: it includes processes from primary production to the management of the food wasted at the restaurant.

2.4. Food ingredients

Table *3* describes the list of ingredients and the raw quantities to prepare the six tapas dishes per portion size served at a restaurant. These dishes differ in composition as shown in

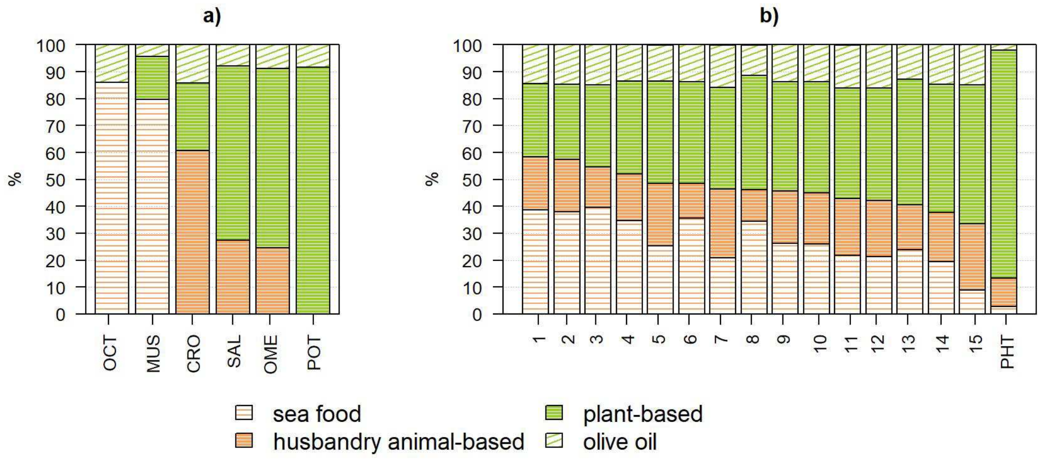

Figure *1*a.

The compositions of the 15 meals, proposed as dish combinations, are shown in Figure 1b. Regarding the recommended tapas meal, it was designed in accordance with the planetary health diet, defined by the EAT-Lancet Commission (Willett et al., 2019). Therefore, the composition of this reference meal (Planetary Health Tapas meal, PHT meal) follows the energy contribution of all food categories recommended in this diet (***Table 4***); 88% of its composition are plant source products (

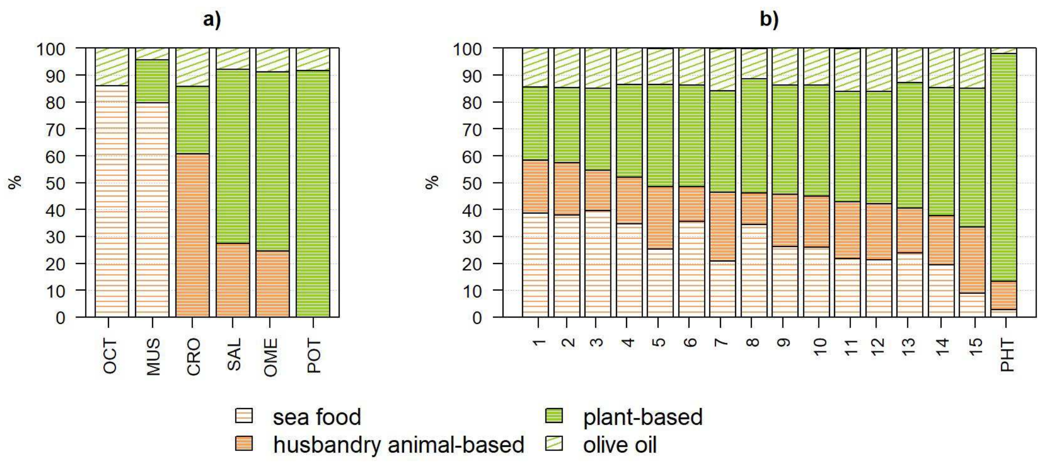

Figure *1*b).

Table 3:
Recipes for the six cooked tapas dishes

Tapas	Served Portion (g)	Energy (kcal)	Raw ingredients (g)
POT	220	655	Potatoes (278), Tomato sauce (24), Olive oil (28)
CRO	130	200	Onion (17), ham (22), flour (26), milk (93), bread (5), olive oil (27)
MUS	310	206	Mussels (270), tomato sauce (53) and olive oil (15)
SAL	260	286	Potatoes (74), vegetables (141), eggs (100), mayonnaise (30), bread (20)
OCT	180	329	Octopus (155), olive oil (25)
OME	275	500	Potatoes (264), onion (44), eggs (114), olive oil (40)

Table 4:
Composition characteristics of the recommended planetary health tapas meal (PHT meal) based on the planetary health diet from the EAT-Lancet Commission (Willett et al., 2019)

Food category	Energy intake contribution (%)	Ingredients in the recommended meal (g)
Vegetables	36	189
Grains (rice, wheat, pasta)	23	120
Fruits	14	70
Legumes	7	37
Dairy products	5	25
Potatoes	4	23
Chicken	3	16
Unsaturated oil	3	15
Fish	2	11
Red meat	1	5
Eggs	1	4
Nuts	1	6

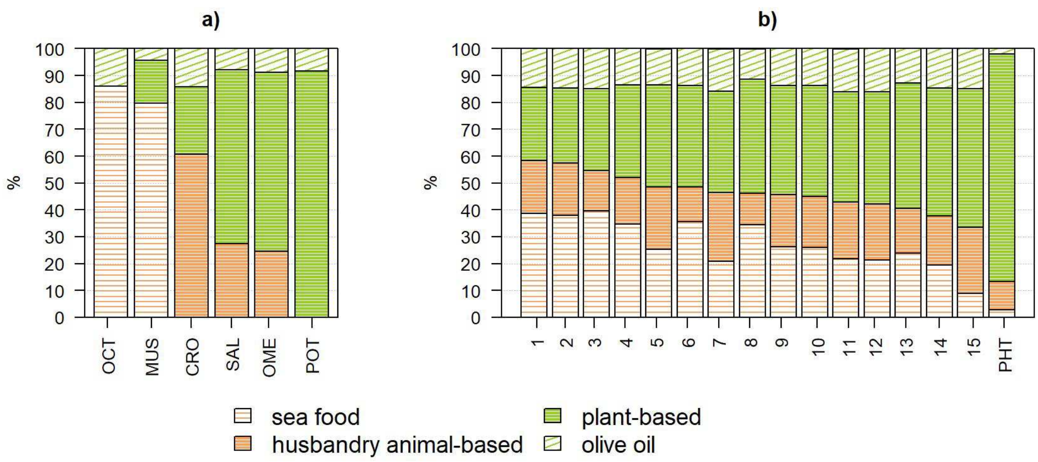

Figure 1:
Food composition (%) of the (a) tapasdishes and (b) the 15 tapas meals and the recommended one, the planetary health tapas (PHT) meal.

2.5. Inventory data

The inventory data for the GWP of all the food ingredients, from primary production to the distribution stage, was based on Batlle-Bayer et al. (2019a) and it is summarized in the supplementary section (TS.1).

For the consumption stage at the restaurant, primary data were not available, and published studies were scarce. Therefore, the cooking energy use, assuming natural gas, was based on Foster et al. (2006): 7.5 and 2 MJ/kg for frying and for boiling, respectively. Besides, as suggested by Calderón et al. (2017), the energy consumed at the establishment was considered within the assessment, since the main objective of the restaurant is to serve food. Since no primary data was available, the electricity consumption of 22.72 MJ per kg of meal served at the restaurant, published by Calderón et al. (2017), was used. This suggests that the energy use for cooking would be about 30% of the total amount used in a restaurant, which is in line with the consumption in Spanish restaurants (de Isabel et al., 2009). In the case of the beer, the electricity consumption for refrigeration at the restaurant was considered to be 0.7 MJ per litre. This was based on the data at the retailer stage from Amienyo and Azapagic (2016), and a refrigeration period of 24 hours before being consumed was assumed. The beer was assumed to be served in bottles and cans, as reported by Notarnicola et al. (2017).

The BWF is the amount of fresh surface or ground water used to produce the ingredients and to prepare the tapas dishes and the full meals. Data of blue water for primary production was based on the country-specific data from Mekonnen and Hoekstra (2010a, 2010b). In the case of LU, only land use for primary production (crop and feed) was included. The land requirements per country and feed/food product were based on the average country-specific crop yields from the FAOSTAT (2019). Data on food losses and waste (FLW) were based on Garcia-Herrero et al.(2018), except for the restaurant stage, which was assumed to be 20.1% (Stenmarck et al., 2016).

3. Results & Discussion

3.1. Environmental impacts of the tapas dishes

Figure 2a shows GWP of the 6 tapas dishes, bread and beer according to the three functional units. On a mass basis (100g FU), GWP is higher for the animal-based tapas, being the fish dishes the largest emitters. In the case of the energy-based FU (100 kcal), the emissions vary due to the different caloric energy content per dish. The mussels dish (MUS) becomes the largest emitter because of its low energy value (**Table *3***), and thus a larger amount of the product is needed to provide 100kcal. The same occurs for the beer (BE). On the contrary, the emissions of high-energy dishes (POT, OCT, CRO, OME) are lower on an energy-based FU.

Regarding the contribution of the LC stages to GWP, primary production and the restaurant are the main contributors (Figure 2b). Primary production contributes the most when the animal source of the dish is large, such as in the case of the OCT and MUS dishes. Conversely, the more plant source products contains the dish, the larger the contribution of the restaurant stage. Regarding beer, packaging (considered within the processing stage) was the largest contributor.

In the case of the Blue Water Footprint (BWF; Figure 2c), CRO, OME and SAL dishes have the largest impact. Nevertheless, olive oil was the main contributor to the BWF for all tapas dishes. This is because of the high use of irrigated water to grow olive trees in Spain, about 530 m^3 BW per tonne (Mekonnen and Hoekstra, 2010a), and the assumption of using 4kg of olives to produce 1 liter of olive oil (Tsarouhas et al., 2015). Regarding the land use (Figure 2e), those dishes with animal husbandry products (SAL, CRO, OME; Figure 2f) have the largest impact, because of the land required for feed production.

Figure 2g shows food losses and waste (FLW) of all the tapas dishes for the three FUs. Plant-based dishes have larger amounts of FLW, since plant products have higher losses than meat products (Garcia-Herrero et al., 2018b). Regarding the stages, primary production was the main contributor to FLW, followed by the restaurant (Figure 2h). Finally, the amount of FLW generated in all 6 dishes contributed to 22-27% of GWP, 31-35% of BWF and 30-35% of LU.

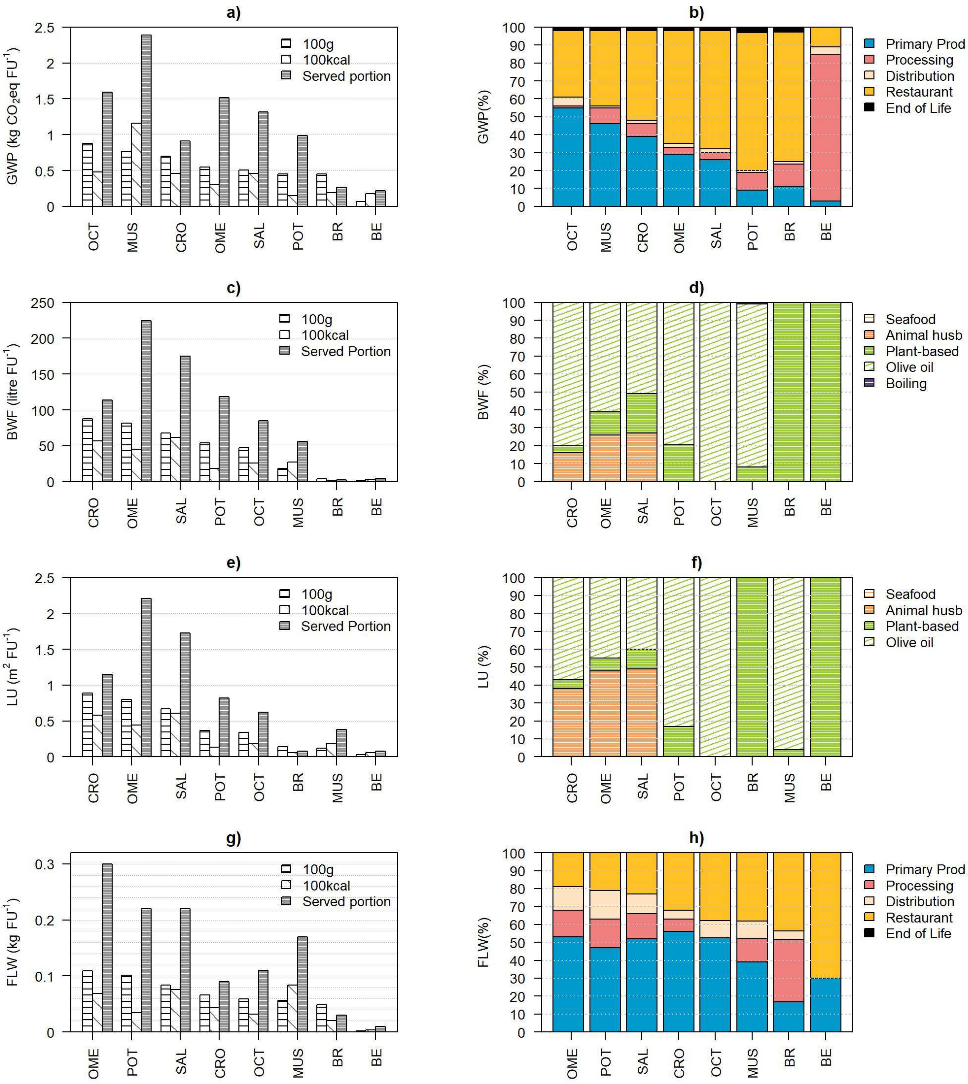

Figure 2:
(a) Global Warming Potential (GWP) of the 6 tapas dishes, bread and beer according to the functional unit (FU): 100g, 100kcal and the served portion; (b) contribution of all life cycle stages to the GWP per tapa, bread and beer. (c) Blue Water use (litre BW) of the tapas dishes, bread and beer according to the functional unit (FU). (d) Contribution of types of ingredients and cooking (boiling) to the land use per dish, bread and beer.(e) Land use (m2) of the tapas dishes, bread and beer according to the functional unit (FU). (f) Contribution of types of ingredients to the land use per dish, bread and beer. (g) Amount of food losses and waste (FLW) along the whole supply chain for the 6 tapas dishes and bread. (h) Contribution of the life cycle stages to FLW.

3.2. Corrected environmental impacts of the tapas meals

Figure 3 shows the three corrected (with nutritional information) environmental impacts of all 15 tapas meals and the recommended planetary health tapas (PHT) meal as the reference one (the red line in Fig.3). Meals 1 and 2 have the largest GWP (Table S2), while meals 15 and 12 have the highest BWF and LU values (Table S3 and S4). When applying the E&N-based FU, the main influencing factor to the environmental performance is not just the composition of the meal alone, as in the case of applying a mass-based FU (see Supplementary Information: Fig. 1S, 2S, and 3S). Instead, the caloric energy and nutritional values of the overall meal become also important factors within the assessment. As shown in Figure S4, the energy and nutritional scores (Eq. 3-5), which are used to correct the environmental impacts (Eq. 2), vary greatly among the meals, and these differences influence the results.

When assessing the environmental effects of changing meals towards a planetary health-based tapas meal (red line in Figure 3), the GWP, BWL and LU impacts would reduce, in average, by 47%, 66% and 47%, respectively (see also TS2, TS3, TS4, TS5 and Figure 5S).

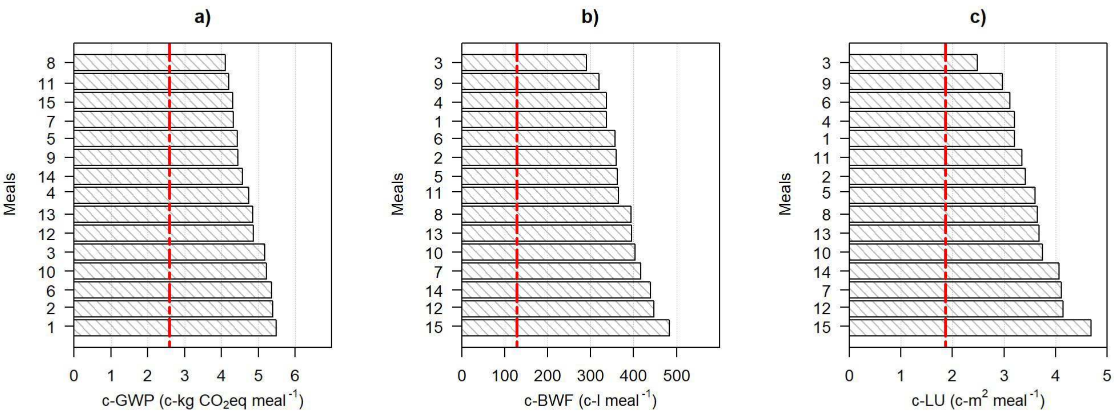

Figure 3:

Corrected-GWP (a), -BWF (b) and -LU (c) of the 15 tapas meals. The red line is the reference value: the planetary health tapas (PHT) meal.

3.3. Comparison with other studies and approaches

Comparing results with other studies is challenging since they may differ in approaches and methodological aspects. From the 13 published LCA studies of meals, shown in Table 5, most are attributional (92%), consider FLW (83%), and half of them apply system boundaries from cradle to plate (C-to-P). Regarding the FU, the most common one is the mass-based, only four articles use an isocaloric FU, and one applies a protein-based FU. The most reported environmental impact (77% of the studies) is GWP and nutrition is not always assessed (only about 60%).

Table 6 shows the GWP of meals, assessed here and elsewhere, with a common mass-based FU of 100g. The GWP of the tapas meals are found within the reported range: between 0.18 and 1.88 kgCO_2 eq per 100 g. However, using a mass-based FU, as well as an isocaloric FU, can underestimate the beneficial impacts of changing meals towards a more sustainable one (see Fig. S5); using the E&N-based FU gives more integrated results. Nevertheless, at the dish level, a weight and isocaloric based FU was used, and no nutritional quality was considered. This is because of the difficulty to define the recommended nutritional values per each tapas dish within one meal. Instead, it was decided to do this integration at the meal level (where combinations of tapas might deliver the recommended result).

Table 5: Review of the published LCA studies of meals. A: Attributional; C: Consequential; C-to-G: Cradle to Grave; C-to-P: Cradle-to-Plate

Article	Country	Type of location	Type of LCA	Comparative LCA			Functional Unit			System boundaries	FLW	Nutritional assessment	Environmental impacts	Integration
				Type of preparation	*Type of meals*	*Other scenarios*	*Mass-based*	*Isocaloric-based*	*Protein content*					
Calderón et al. (2017)	ES	Restaurant	A	x			1000 g			C-to-G	Yes	No	Eco-indicator 99	No
Cooreman-Algoed et al. (2020)	BE	University Canteen	A		x			680 kcal		C-to-P	No	Yes (WNDS)	ReCiPe Single score	Yes
García-Herrero et al. (2019)	ES	School	A		x		Average meal			C-to-P	Yes	No	GWP,POF,AC,EU	No
Hanssen et al. (2017)	NO	-	A	x			507 g			C-to-P	Yes	No	GWP, FLW and Energy Use	No
Jungbluth et al. (2016)	CH	240 Canteens	A				820 g (food), 22 cl (drinks), 40 g (other)			C-to-P	Yes	No	GWP, Ecological Scarcity 2006	No
Lukas et al. (2016)	DE	-	A		x		33% of the daily food intake			?	?	Yes (4 intake indicators)	GWP, WF, LU and material footprint	Yes
Mistretta et al. (2019)	IT	School canteens	A			x	668 g			C-to-P	Yes	No	GWP, AP, EP, GER,POP	No
Saarinen et al. (2012)	FI	School canteens	A	x			Actual lunch	Lunch plate		C-to-P	Yes	Lunch plate model	GWP and EP	Yes
Saxe et al. (2018)	DK	Catering at senior homes	C		x		100g	MJ	kg protein	C-to-G	Yes	No	GWP and monetized impact	No
Schmidt Rivera et al. (2014)	UK	Home	A	x		x	360g			C-to-G	Yes	No	11 LCA-based impacts	No
Schmidt Rivera et al. (2019)	UK	Home	A		x		360g			C-to-G	Yes	No	11 LCA-based impact	No
Sturtewagen et al. (2016)	BE	Canteen and home	A	x	x		530g			C-to-G	Yes	Yes	Resource extraction	No
Virtanen et al. (2011)	FI	School lunch	A		x			Lunch plate (740 kcal)		C-to-P	Yes	Lunch plate model	GWP	Yes

Table 6:

GWP per FU and 100g of this article and from other published LCA studies of meals.

Article	Meals	Mass-based FU (g)	GWP / FU	GWP / 100g
This article	*Average tapas meal*	*518*	*3.38*	*0.65*
	PHT meal	*521*	*2.59*	*0.50*
García-Herrero et al. (2019)	Nursery meal	555	1.11	0.20
	Primary meal	608	1.50	0.25
Hanssen et al. (2017)	RM	507	3.00	0.59
	SPM	507	2.50	0.49
	Home	507	2.80	0.55
Mistretta et al. (2019)	School meal	680	1.43	0.21
Saarinen et al. (2012)	School meal 1c	323	0.57	0.18
	School meal 1a	523	2.06	0.39
Saxe et al. (2018)	Vegetarian	427	0.85	0.20
	Fish/seafood	507	1.26	0.25
	Pork	484	1.40	0.29
	Poultry	475	1.83	0.39
	Beef	464	8.73	1.88
Schmidt-Rivera et al. (2014)	RM1	360	2.80	0.78
	RM2	360	3.90	1.08
	RM3	360	2.40	0.67
	RM4	360	3.60	1.00
	RM5	360	2.90	0.81
	RM6	360	3.60	1.00
	RM7	360	2.40	0.67
	RM8	360	3.60	1.00
Schmidt Rivera et al. (2019)	RM - Cottage pie	360	4,30	1,19
	RM - Fisherman's pie	360	2,80	0,78
	RM - Beef roast	360	3,20	0,89
	RM - Classic lasagne	360	5,00	1,39
	RM - Spaghetti Bolognese	360	4,20	1,17
	RM - Pork roast	360	2,10	0,58

Another challenge in food LCAs is how to present and interpret the results. At the meal level (Table 5), some studies, such as Schmidt Rivera and Azapagic (2019) and Mistretta et al. (2019), show their results per impact category. This may give a better overview of the environmental performance of meals, but more complexity is also introduced at the moment of selecting the best option. Instead, using a single score can simplify and facilitate the decision-making processes, as well as the communication of the results to the general public. The most common single scores are the Eco-indicator 99, the ReCiPe Single Score or the monetized environmental impact (Table5), and several attempts have been done to integrate both the environmental and nutritional aspects within a single score (Cooreman-Algoed et al., 2020; Lukas et al., 2016). However, to get a single score, LCA results have to be weighted. Weighting is a controversial procedure that essentially involves value choices that may differ among cultures, places and other value systems. Even the ISO 14044 LCA standard (ISO 14044, 2006) specifies that weighting has no scientific value. Therefore, the current study shows the results per environmental impact category, corrected by the nutritional aspect, and it suggests that each practitioner has to find a trade-off among impacts.

3.5. Limitations and opportunities for further research

This study has three main limitations. First, the lack of primary data on both energy consumption and food waste at the restaurant stage. This is essential for future research since this study shows the significant contribution of the consumption stage to the environmental impacts, especially to GWP. Second, as suggested by Calderón et al. (2017), this study applied mass allocation to assign the environmental burdens to the dishes served at the restaurant. In this regard, we suggest further investigation to know if economic allocation (or others) should be applied. Third, issues such as the valorization of food waste (i.e. Ahmed et al., 2019) or biogenic sequestration, such as the case of mussels shells (Ray et al., 2017), have not been considered.

The novelty of this study is the integration of both environmental and nutritional aspects within the functional unit of an LCA of meals. To go one step further, it is suggested to add a social aspect within the functionality of eating tapas, since social factors, such as the context or the settings, can play a crucial role when selecting meals. Adopting a more plant-based diet is widely accepted as an essential strategy for food security and sustainability. However, it is crucial to translate these so-called sustainable eating patterns to daily food choices, in order to support society to adopt them. In this regard, restaurants and chefs can have a large impact by giving examples on more healthy and sustainable ways of cooking and eating. Besides, introducing sustainability within the restaurant menus can bring innovation through, for example, new recipes or adopting nudging interventions. In short, it is not just about changing diets' composition, but to make a joyful journey towards sustainable food consumption. Therefore, a critical aspect to consider, in this regard, is the cultural taste and social acceptance. Our study just considered a theoretical tapas meal based on the planetary health diet of the EAT-Lancet Commission (Willett et al., 2019). Hence, we suggest to adapt it to a Spanish style tapas meal, and to further investigate its social acceptance.

4. Conclusions

This study evaluated the environmental performance of 15 tapas meals by applying life cycle assessment (LCA), analysing three environmental impacts - Global Warming Potential (GWP), Blue Water Footprint (BWF) and Land Use (LU) – and one additional indicator - food loss and waste (FLW). These meals differed in energy and nutrient composition. Hence, comparing their environmental performances without considering their nutritional aspects can mislead the results. To overcome this, both environmental and nutritional aspects were integrated within the assessment by applying the energy- and nutrient-based FU. Additionally, benchmarks for the three environmental impacts were estimated, based on the Planetary Health Diet. By doing this, a better interpretation of the performance of the meals can be done, since a reference meal (Planetary Health Tapas meal) is set.

Overall, changing meals towards a planetary health-based tapas meal would reduce all three environmental impacts. Facing this, several lines of strategies are being proposed here: first, to increase the offer of more plant-based tapas dishes within the menus; second, to establish action plans to tackle food waste in restaurants; and finally, to increase the involvement between chefs/restaurants and the academia in order to work together towards more sustainable eating habits.

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SUPPLEMENTARY INFORMATION

TS.1. Summarize of the literature sources used for the life cycle inventories of the food products of the tapas.

Food category	Food product		Main sources of LCI data
Animal-based products	Eggs		Berggren (2013)
	Seafood	Mussels	Aquaculture (Iribarren et al., 2011b) and mussel purification and canning (Iribarren et al., 2010)
		Octopus	Vázquez-Rowe et al. (2012)
	Meat	Chicken	González-García et al. (2014)
Dairy products	Milk		Spain (Iribarren et al., 2011a), Germany (Dalgaard et al., 2016), and Portugal (Castanheira et al., 2010)
Plant-based products	Cereals	Bread	Bread production (Notarnicola et al., 2017b) and consumption (Espinoza-Orias et al., 2011)
		Pasta	Pasta manufacturing (Heidari et al., 2017), and boiling (Ruini et al., 2013)
	Fruits	Olives	Olives production (Russo et al., 2016)
	Legumes		Aguilera et al. (2015)
	Vegetables	Tomatoes	Tomato cultivation (Torrellas et al., 2012)
		Lettuce	Canals et al. (2008)
		Vegetables	Aguilera et al. (2015)
		Tomato sauce	Del Borghi et al. (2014)
	Vegetable fats	Olive oil	Tsarouhas et al. (2015)
Beverages	Beer		Amienyo and Azapagic (2016)

TS.2 Global Warming Potential (GWP; kg CO_2 eq) of all 15 meals for the three FUs.

Meals	Mass-based FU	Isocaloric FU	Energy- and nutrient-based FU
1	3.6	3.9	5.5
2	3.7	3.5	5.4
3	3.4	3.0	5.2
4	3.9	3.5	4.7
5	3.6	3.5	4.4
6	3.7	2.8	5.4
7	3.2	2.9	4.3
8	3.2	2.7	4.1
9	3.3	2.9	4.5
10	3.4	2.7	5.2
11	2.9	2.4	4.2
12	3.0	2.3	4.9
13	3.6	2.8	4.9
14	3.2	2.3	4.6
15	2.9	2.2	4.3

TS.3 Blue Water Footprint (l) of all 15 meals for the three FUs.

Meals	Mass-based FU	Isocaloric FU	Energy- and nutrient-based FU
1	221.7	239.6	337.3
2	246.1	233.2	359.0
3	193.2	168.0	290.7
4	277.4	250.4	336.6
5	291.7	283.4	362.3
6	248.9	186.8	356.4
7	305.8	276.9	416.9
8	308.0	256.2	394.0
9	238.0	211.8	320.2
10	263.0	209.7	403.3
11	253.0	211.0	364.9
12	277.0	208.4	448.0
13	294.0	225.1	395.5
14	308.0	223.0	439.3
15	322.0	247.1	483.8

TS.4 Land Use (m^2) of all 15 meals for the three FUs.

Meals	Mass-based FU	Isocaloric FU	Energy- and nutrient-based FU
1	2.1	2.3	3.2
2	2.3	2.2	3.4
3	1.6	1.4	2.5
4	2.6	2.4	3.2
5	2.9	2.8	3.6
6	2.2	1.6	3.1
7	3.0	2.7	4.1
8	2.9	2.4	3.6
9	2.2	2.0	3.0
10	2.4	1.9	3.7
11	2.3	1.9	3.4
12	2.6	1.9	4.1
13	2.7	2.1	3.7
14	2.9	2.1	4.1
15	3.1	2.4	4.7

TS.5. Environmental impacts of the Planetary Health Tapas (PHT) meal.

Environmental impact	Unit	Amount
Global Warming Potential	kg CO_2 eq	2.6
Blue Water Footprint	l	128.7
Land Use	m^2	1.9

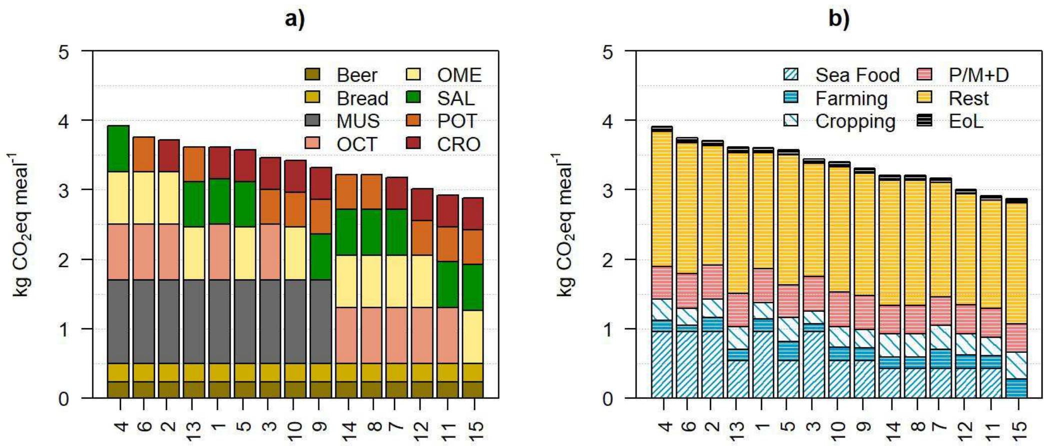

Figure S1:
GWP (kg CO_2 eq meal^{-1}) of the 15 tapas meals, distinguishing among (a) their composition of tapas dishes, and (b) the life cycle stages.

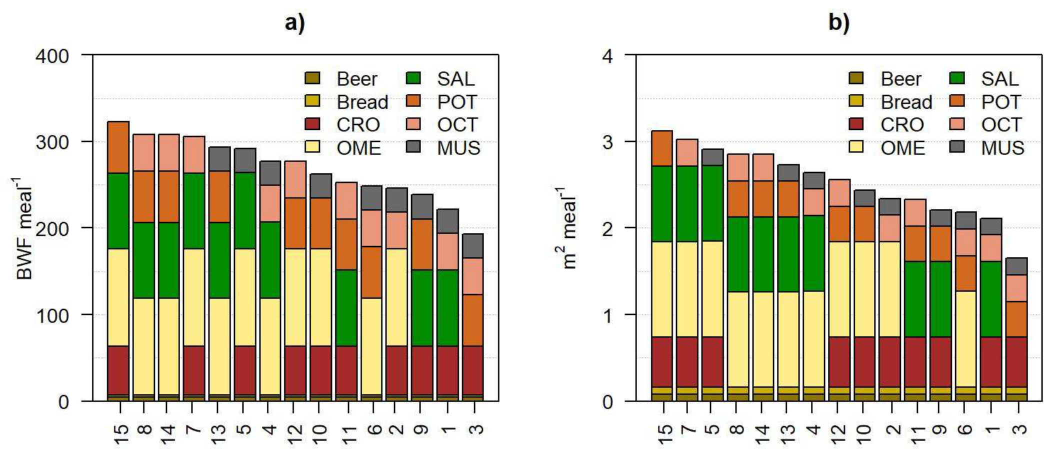

Figure S2:
Non-corrected Blue Water Footprint (BWF; a) and land use (m^2; b) of the 15 tapas meals, distinguishing among their composition of tapas dishes.

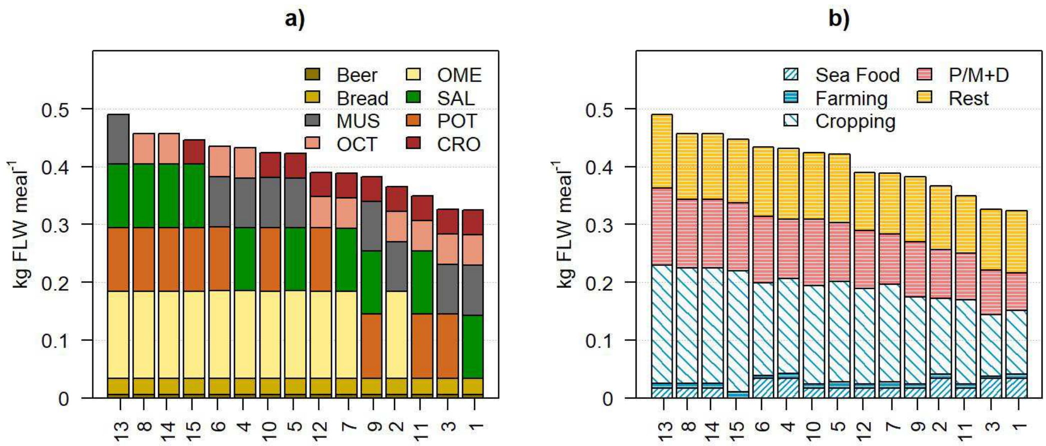

Figure S3:
Non-corrected amount of food losses and waste (FLW) for all the tapas meals per (a) dishes and (b) life cycle stages.

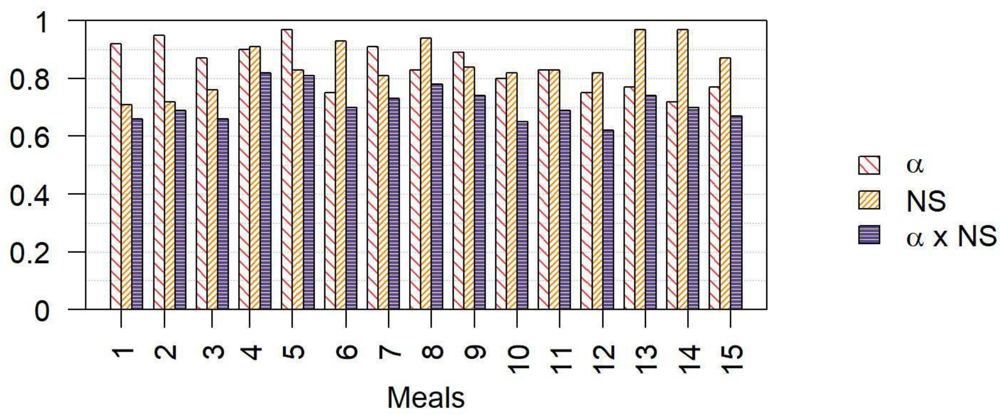

Figure S4:
Energy (α) and nutritional (NS) scores and their multiplication (α x NS)

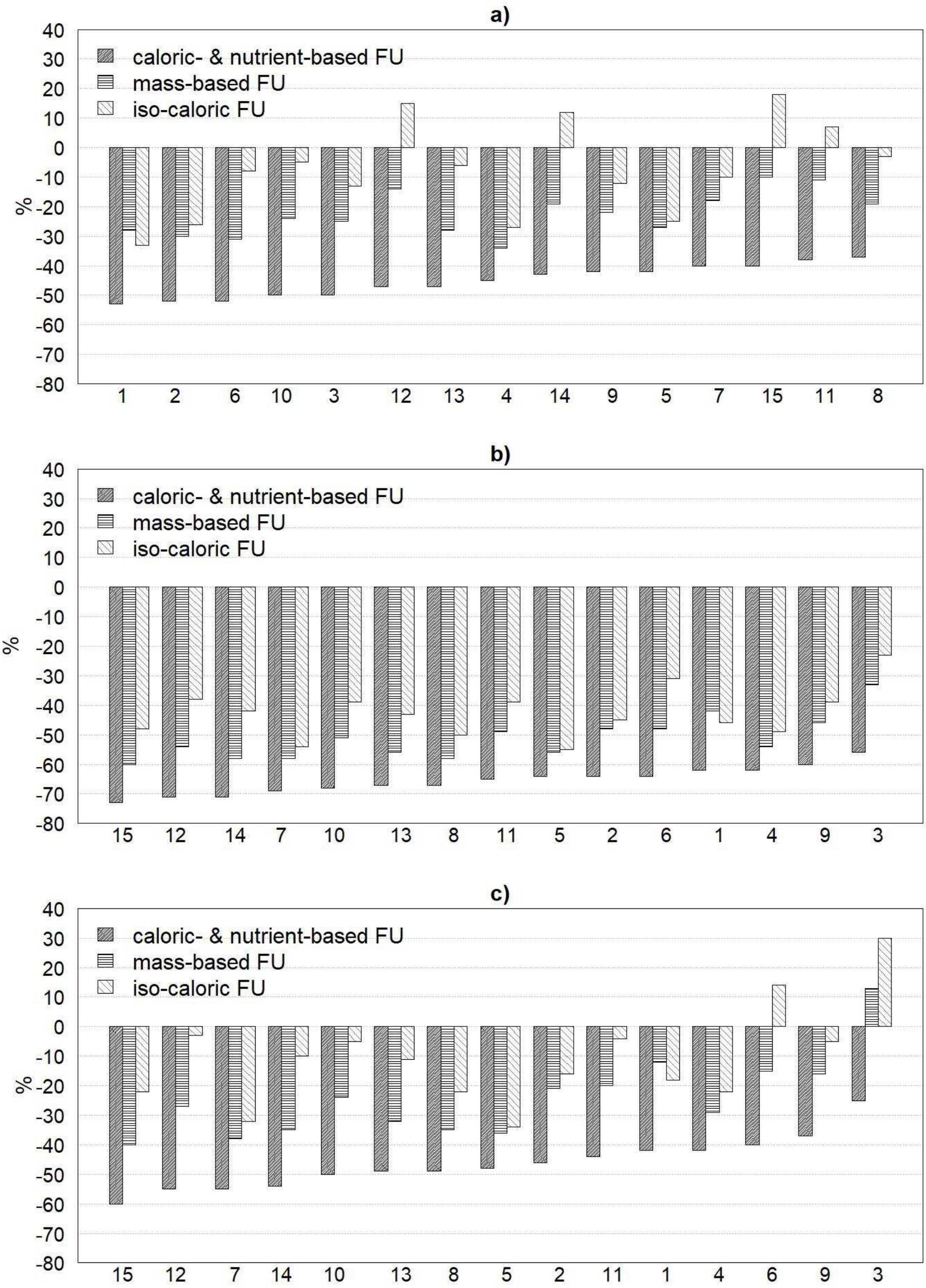

Figure S5:
Environmental changes (%) of moving towards the PHT-based meal on GWP (a), BWF (b) and LU (c) according to 3 different FUs.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☒The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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